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Design and Study of Propagation Models in Wireless Communications (GSM) using Free Space Path Loss Model and Hata- Okumura Model with GUI

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Abstract— Radio propagation is essential for emerging technologies with appropriate design deployment and management strategies for any wireless network. It is site specific and can vary significantly depending on terrain, frequency of operation, velocity of mobile terminal, interface sources and other dynamic factors. Propagation analysis provides a good initial estimate of the signal characteristics. Estimation of path loss is very important in initial deployment of wireless network and cell planning. Channel modeling is required to predict path, loss and to characterize the impulse response of the propagating channel. The path loss is associated with the design of base stations, as this tells us how much a transmitter needs to radiate to service a given region. These papers proposes a study of different propagation models such as free space path loss model and Okumara-Hata model to calculate path loss and their results are simulated using Graphical User Interface application, which helps in finding out the coverage area and predicts path loss in rural areas / urban areas using different frequencies

***Index Terms*— Hata Model, Channel modeling Okumura Model, propagation models, GUI.**

I. Introduction

Propagation path loss models are used to calculate path loss during transmission of a signal so as to predict the mean signal strength for an arbitrary transmitter-receiver. In the present day's scenario of communication, the path loss propagation models become an active area of research. Path loss is the reduction in power density (attenuation) of an electromagnetic wave as it propagates through space. Path loss is a major component in the analysis and design of the link budget of a telecommunication system[1]. Path losses arise when an electromagnetic wave propagates through space from transmitter to receiver as shown in Fig1. The power of signal is reduced due to path distance, reflection, diffraction, scattering, free-space loss and absorption by the objects of environment. It is also influenced by the different environment (i.e. urban, suburban and rural). Variations of transmitter and receiver antenna heights also produce losses. The losses present in a signal during propagation from base station to receiver may be due to surroundings and sudden changes in the climate. This path loss information may be used as a controlling factor for wireless communication system performance to achieve the perfect network planning. While all these models aim to predict signal strength at a particular receiving point or in a specific location vary widely in their approach, complexity and accuracy. Most of these models are based on a systematic interpretation of measurement data obtained in the service area.

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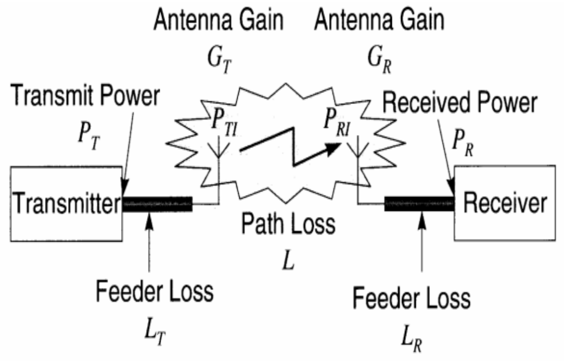

Fig.1 Path Loss Model[3]

II. Procedure for Paper Submission

A. *Free Space Path Loss Model (FSPL):*

Path loss in free space defines how much strength of the signal is lost during propagation from transmitter to receiver. FSPL is diverse on frequency and distance. The calculation is done by using the following equation: The free space path loss

$$PL_{db} = G_t - G_r + 32.44 + 20\log(d) + 20\log(f) \quad (1)$$

Where, G_t is transmitted antenna gain in dBm
G_r is received antenna gain in dBm
d is T-R separation in Km.
f is frequency in [MHz].

B. *Hata-Okumura Model:*

The Okumura model is used for Urban Areas is a Radio propagation model that is used for signal prediction [4]. The frequency coverage of this model is in the range of 200 MHz to 1900 MHz and distances of 1 Km to 100 Km. It can be

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applicable for base station effective antenna heights (ht) ranging from 30 m to 1000 m. The Okumura model is a well known classical empirical model to measure the radio signal strength in build up areas. This model is perfect for using in the cities having dense and tall structure. The Hata model is an empirical formulation of the graphical path-loss data provided by the Okumura and is valid over roughly the same range of frequencies, 150-1500MHz. This empirical formula simplifies the calculation of path loss because it is closed form formula and it is not based on empirical curves for the different parameters[7]. The Okumara Hata model is the combination of both the above models.

The standard formula for empirical path loss [dB] in urban areas under the Okumara Hata model is given by:

$$PL_{db} = A + B\log(d) \quad (2)$$

Where, d is distance in Km.

A is fixed loss depends on frequency f.

These parameters are given by empirical formula.

$$A = 69.55 + 26.16\log f - 13.8\log(h_b) - a(h_m) \quad (3)$$

$$B = 44.9 - 6.55\log(h_b) \quad (4)$$

Where,

f is frequency measured in MHz

h_b is height of base station antenna in meters.

h_m is height of mobile station antenna in meters.

$a(h_m)$ is correlation factor in dBm.

For effective mobile antenna height a(hm) is given by

$$a(h_m) = [1.1\log(f) - 0.7]h_m - [1.56\log(f) - 0.8] \quad (5)$$

The path loss model for highway is given by

For without noise factor

$$PL(_{db}) = PL(_{db})urban - 2[\log(f/28)]^2 - 5.4 \quad (6)$$

For with noise factor

$$PL_{db} = PL_{db}urban - 2[\log(f/28)]^2 \quad (7)$$

C. COST-231 Hata Model:

Hata model is used for the frequency range of 150 MHz to 1500 MHz to predict the median path loss for the distance d from transmitter to receiver antenna up to 20 km, and transmitter antenna height is considered 30 m to 200 m and receiver antenna height is 1 m to 10 m [5]. To predict the path loss in the frequency range 1500 MHz to 2000 [MHz], COST 231 Hata model is initiated as an extension of Hata model. To extend Hata-Okumura- model personal communication system (PCS) applications operating at 1800 to 2000 MHz, the European Co-operative for Scientific and Technical Research (COST) came up with COST-231 model. This model is derived from Hata model and depends upon four parameters for prediction of propagation loss: frequency, height of received antenna, height of base station and distance between base station and received antenna. It is used to calculate path loss in three different environments like urban, suburban and rural (flat)[8]. This model provides simple and easy ways to calculate the path loss. Although our working frequency range (3.5 GHz) is outside of its measurement range, its simplicity and correction factors still allowed to predict the path loss in this higher frequency range.

The standard formula to calculate path loss in urban areas under COST-231 Hata model is given by

$$PL_{db} = 46.33 + 33.9\log(f) - 13.82\log(h_b) - a(h_m) + [44.9 - 6.55\log(h_b)]\log(d) \quad (8)$$

Where

$$a(h_m) = [1.1\log(f) - 0.7]h_m - [1.56\log(f) - 0.8] \quad (9)$$

The path loss model for highway under COST-231Hata is same as for Hata-Okumara model[9] that is given by

For without noise factor

$$PL(_{db}) = PL(_{db})urban - 2[\log(f/28]^2 - 5.4 \quad (10)$$

For with noise factor

$$PL(_{db}) = PL(_{db})urban - 2[\log(f/28)]^2 \quad (11)$$

D. Hata-Okumura Extended Model or ECC-33 Model:

The ECC 33 path loss model is developed by Electronic Communication Committee (ECC), which is extrapolated from original measurements by Okumura and modified its assumptions so that it more closely represents a fixed wireless access (FWA) system [4]. The most extensively used empirical propagation model is the Hata-Okumura model, which is a well-established model for the Ultra High Frequency (UHF) band. The original Okumura model does not provide any data greater than 3 GHz. Based on prior knowledge of Okumura model an extrapolated method is applied to predict the model for higher frequency greater than 3 GHz[6]. The tentatively proposed propagation model of Hata-Okumura model with report is referred to as ECC-33 model. In this model path loss is given by

$$PL(_{db}) = A_{fs} + A_{bm} - G_t - G_r \quad (12)$$

Where

A_{fs} is free space attenuation

A_{bm} is basic medium path loss.

G_t is BS height gain factor.

G_r is Received antenna height gain factor.

$$A_{fs} = 92.4 + 20\log(d) + \log(f) \quad (13)$$

$$A_{bm} = 20.41 + 9.83\log(d) + 7.89\log(f) + 9.56\log(f)^2 \quad (14)$$

$$G_t = \log(hb/200)[13.958 + \{5.8\log(d)\}]^2 \quad (15)$$

$$G_r = [42.57 + 13.7\log(f)][\log(h_m - 0.585] \quad (16)$$

Where, f is frequency in GHz

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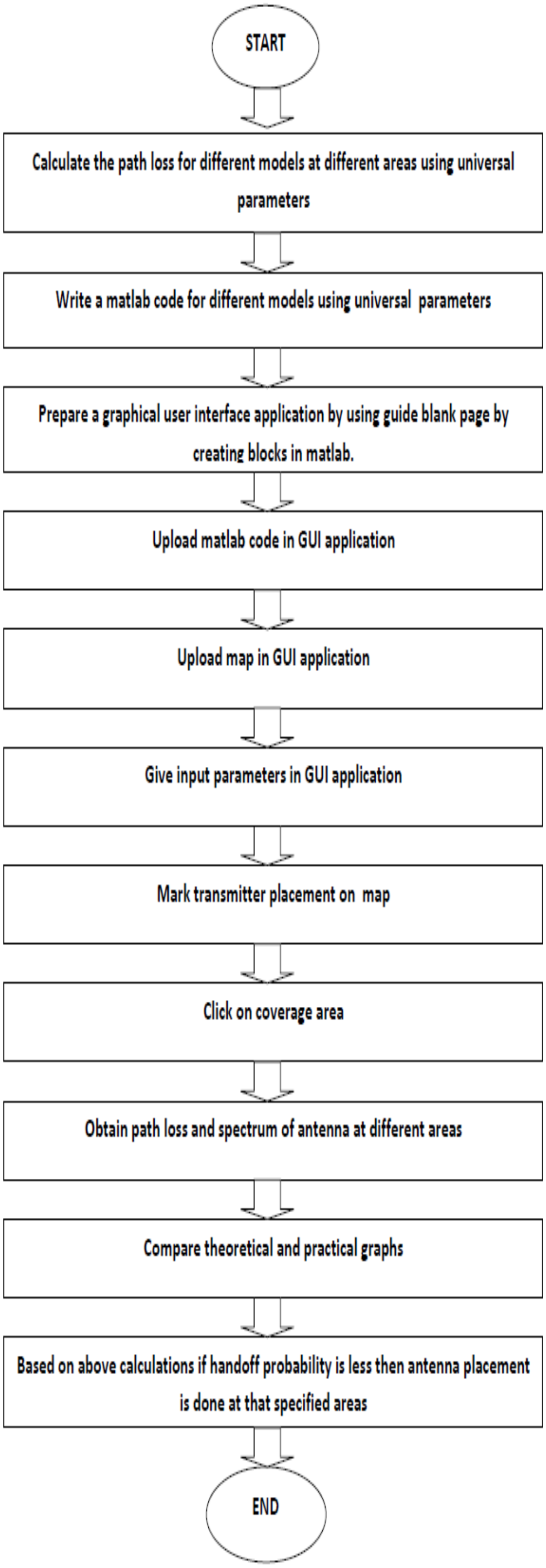

Fig.2 FLOW CHART for GUI

III. SIMULATION RESULTS USING GRAPHICAL USER INTERFACE APPLICATION (GUI)

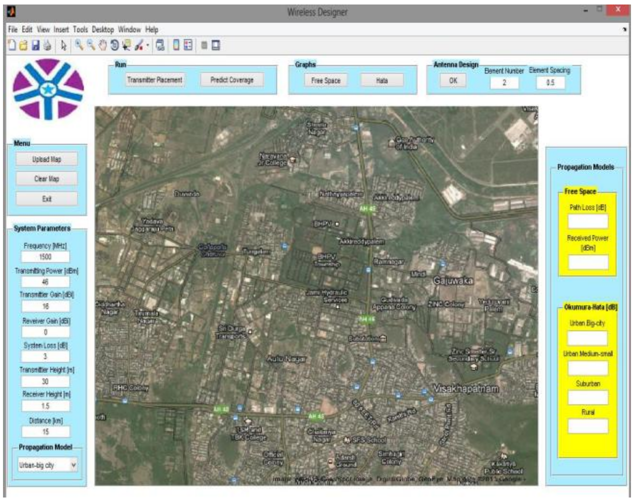

Fig.3 Upload Map In Gui

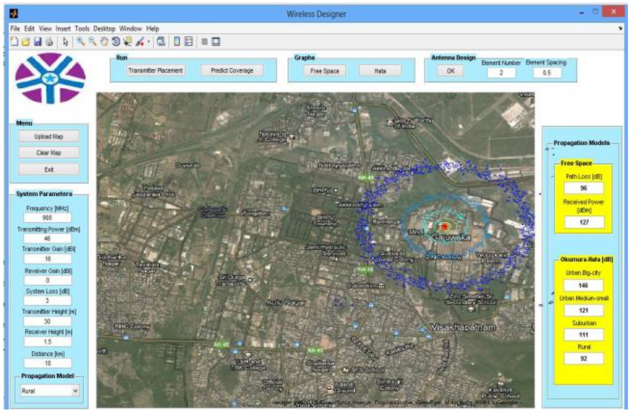

Fig.4 Placement Of Antenna And Predict Coverage In Rural Area

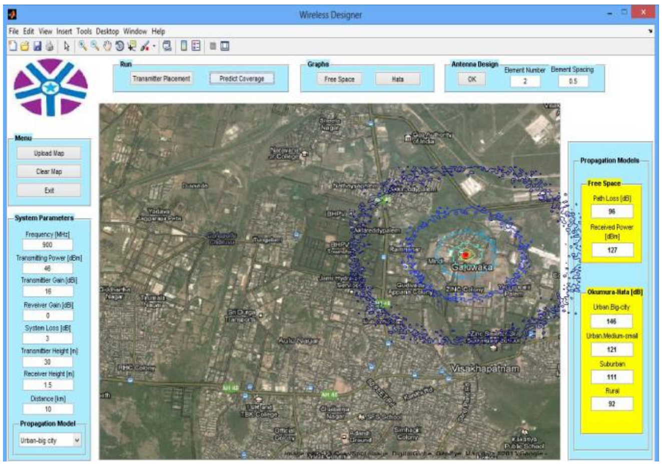

Fig.5 Placement Of Antenna And Predict Coverage In Urban Big City

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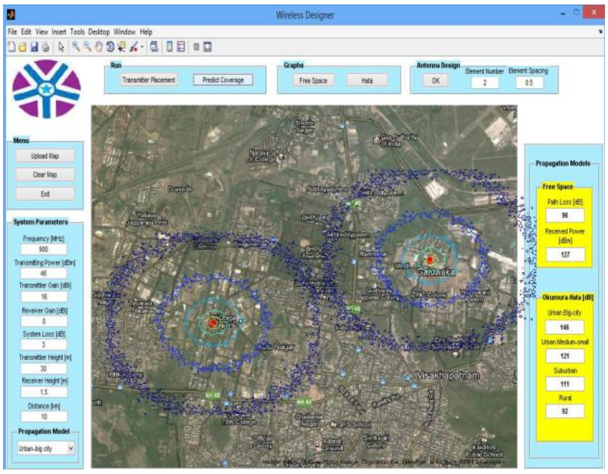

Fig.6 Placement Of Two Antennas With Same Frequencies In Different Areas

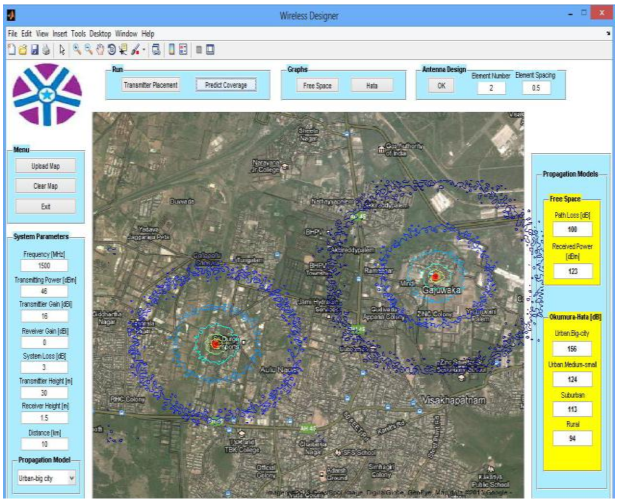

Fig.7 Placement Of Two Antennas With Different Frequencies In Different Area

IV. RESULTS

Comparative Graphs for Free Space Path Loss

In this paper we are showing the comparitve results for Free Space Path loss with different Frequencies i.e 850, 900,1800Mhz as shown in the Fig.8 & Fig.9. When we are calculating the path losses these practicle values are nearer to the theoritical values.

A. Theoretical

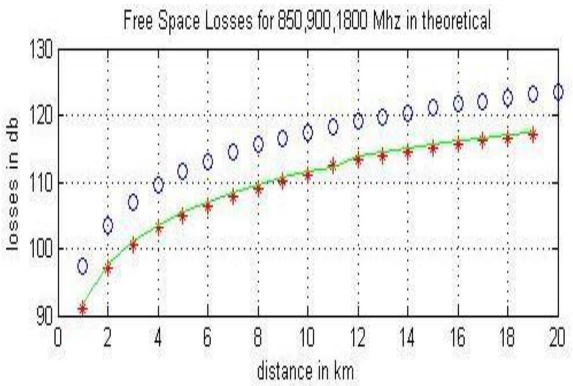

Fig.8 Free Space Losses For 850,900,1800 Mhz In Theoretically

B. Practical

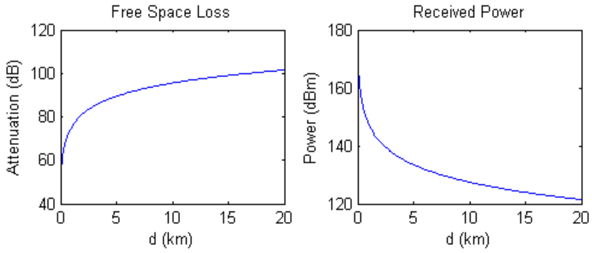

Fig.9 Free Space Losses For 850, 900, 1800 Mhz In Practically

C. Obtained Graphs For Hata- Okumura Model

Fig.5 Pathloss versus distance

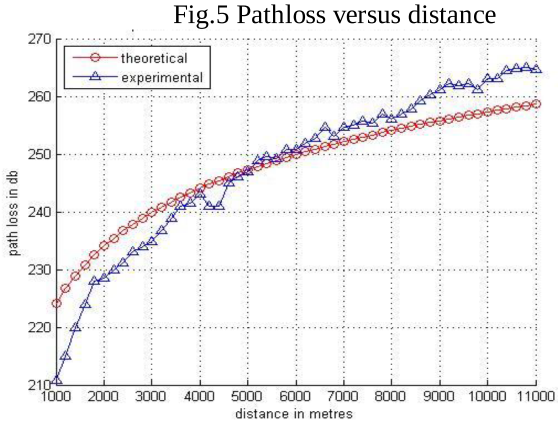

Fig.10 Pathloss versus distance

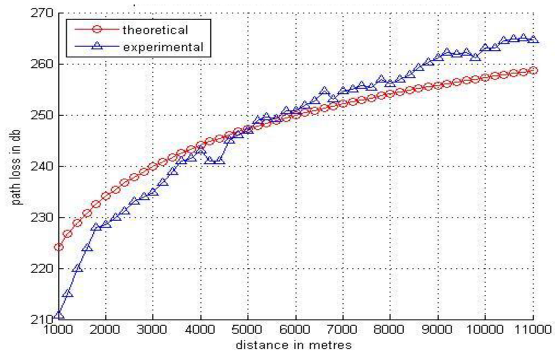

Fig.11 Pathloss Of Okumura-Hata Model For Suburban Area

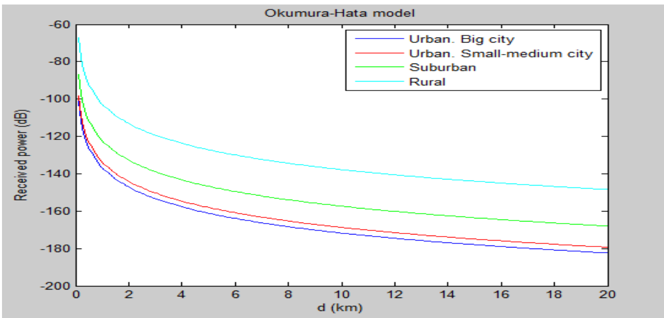

Fig.12 Received power versus distance

V. CONCLUSION

Every year the estimation of signal strength should be known. As the buildings are increasing day by day, signal loss increases due to reflections, fading, time delay etc. Now a day‘s signal strength is being measured by using

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equipments (drive test tools) which take lot of time. So in order to get the path loss measurement in less time and with less cost, we use Matlab**.**

This work was aimed on predicting the mean signal strength at different areas. However, most propagation models aim to predict the median path loss. Today predictions models differ in their applicability over different environmental and terrain conditions. There are many predictions methods based on deterministic processes through the availability of improved data values, but still the Okumura-Hata model is most commonly used empirical propagation model. That is because of the ITU-R recommendation for its proven reliability and its simplicity**.**

By knowing this coverage area we can clearly estimate the handoff call probability at different areas. If handoff call probability is less, then antenna placement is required at that specified areas. It is easy to handle and more flexible. But, it is applicable distance is about 20meters only. By preparing this GUI with different models there is clear idea to know the future estimation of antenna in specified areas where signal loss is more.

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