Field Strength Predicting Outdoor Models

Pranjali Raturi, Aarti Pandey

***Abstract*— The main objective of this paper is a comprehensive review of outdoor propagation model in different geographical areas. A wide variety of radio propagation models for different wireless services that specifically address varying propagation environments and operating frequency bands are generally known. A large number of propagation prediction models have been developed for various terrains Irregularities, tunnels, urban streets and buildings, earth curvature, etc**

***Index Terms*— outdoor, propagation model, path loss**

I. INTRODUCTION

Radio Propagation is essential to understand the upcoming any wireless network with its deployment, design and management strategies. Wireless network are more complicated than its wired countered part .due to the nature of the radio channels. Some factors effected radio propagation as it is heavily site specific and varies due to frequency of operation, depends on terrain, mobile terminal velocity, interference due to sources etc. Radio channels characteristics must be accurate by controlling some key parameters. Also by mathematical model some parameters can be predicted such signal as coverage, data which can be achievable, performance parameters of alternative signalling and also its reception schemes [1]. For installing base station antenna, different system analysis is also required for determining the correct location.

Signal strength and transmission power are the two important concepts of mathematical modelling. Radio propagation is the term related to the transfer of the energy which is measured in power or watts. The power which is measured at transmitter is the transmission power and this power is measured at the transmitter as well as receiver. The total amount of the power measured as the receiver is also known as the strength of the signal (signal strength). The letter measurement is less than the former; it is due to the nature of the radio wave propagation because when the signal moves through the air in the form of radio waves it loses its power.

Path Loss

The primary factor which is considered in wireless communication system is the free space propagation. There are no obstacles or obstruction due earth's surface in the case of LOS propagation. [2] A term known as friss free space propagation is used to determined the received power (P_r), at the receiving antenna which is located from a transmitter at a distance d is given by

$$P_r = P_t G_t G_r \left(\frac{\lambda}{4\pi d}\right)^2 \qquad (1)$$

For friss space model, the equation of path loss can be written as

$$L_f = \frac{P_t}{P_r} = \frac{1}{G_t G_r}\left(\frac{\lambda}{4\pi d}\right)^2 \qquad (2)$$

$$L_f(dB) = 32.45 - 10\log G_t - 10\log G_r + 20\log f + 20\log d \qquad (3)$$

where

P_r = received power

P_t = transmitted power

$\lambda = c/f$ = wavelength

c = speed of light (3×10^8 m/s)

f = carrier frequency in Mega Hertz

G_t = gain of the transmitter

G_r = gain of the receiver

d = antenna separation distance in kilometre

L_f = free space loss

The above equations show that the free space path loss is increasing with distance and also frequency depended. Whenever the frequency or length of the path is doubled there is an increase of 6dB in the free space attenuation.

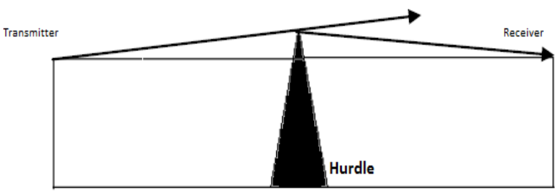
II. MOBILE RADIO PROPAGATION ENVIRONMENT

The signal transmitted from the transmitting antenna to the receiving antenna generally follows complex and small path. [3] The signal is affected by different types of terrain, combination of various environmental factors which are created by human. All these environmental factors lead to change in the levels of transmitting signal by a transmitter, which affect the signal coverage and quality of the network. Some phenomenons associated with the radio wave propagation are described below

A. Diffraction

The phenomenon of diffraction occurs when as electromagnetic wave travels from transmitter to receiver followed by blockage of sharp surface edges. [4] In diffraction a signal propagates behind the blockage NLOS exist is the radio path. Diffraction depends upon the geometry of object, angle of incident, amplitude and phase of signal

Diffraction Mechanism



B. Reflection

The phenomenon of reflection occurs when an electromagnetic wave propagates from rarer medium to denser medium. [5] Various factors such as ground surface,

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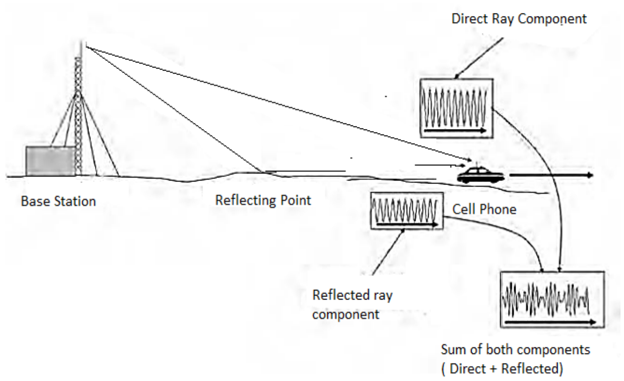
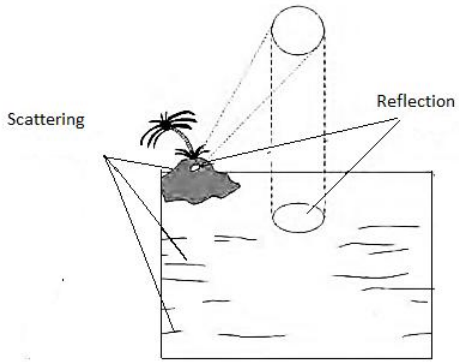
wails and equipments create reflection of electromagnetic waves



C. *Scattering*

Whenever a radio wave encounters small variation is a medium which can changes the direction of signal scattering occur, generally scattering cannot be predicted easily. Scattering is mainly caused by rain, snow, hot etc



D. *Refraction*

Refraction occur due to the variation is air temperature and the density of atmosphere. Due to variation is the medium, the original path of wave is not followed by it as it deviates from its path.

III. PATH LOSS PREDICTION MODEL

The necessary requirement for the establishment of mobile system prediction of path loss is needed; exact accurate methods are used to determine the parameters in the mobile radio system. Due to these prediction models the coverage of particular service area can be analyzed. [6] For analyzing designing a wireless communication the path loss model which is also called predicting model acts as a fundamental tool. Site measurement method is costly to design a system. Due this problem alternate propagating model were developed having convenient features such as low cost and suitable in any environment. This alternate path loss model is easy in evaluation and this realization of models provides the details about the path followed by the transmitted signal from transmitting to receiving antenna

A. *Empirical Model*

The Experimental measurement data is used by empirical model to produce a relationship between propagation circumstances and expected field strength or time dispersion result. Development of empirical model can do by laboratory measurement or with scale models of propagation environment. [7] This type of approach can achieve by using fitting curve or analytical expression that recreate set of measured data. The propagation factor includes both known and unknown, through actual field measurement. However, establishment of validity of empirical model at transmission frequency or other than model driven environment can be done by adding data which is measured at new environment at the required transmission frequency.

Mathematical model fails to explain every situation; in this situation approximation is done to protect same data. To overcome this problem empirical model was introduced, which is totally base on the observation and measurements. Data was predicted but it has limitation that this model is not able to explain.

It has two subcategories time dispersive and non-time dispersive.

The time dispersive model detail it data is the form of time – dispersive characteristics such as delay spread of channel during multipath. Examples are SUI model. Whereas COST 231 Hata model. Hata and ITU –R model are falls under the example of non time dispersive empirical model.

B. *Theoretical Model*

Theoretical model are based on assumption that taken about environment of propagation. These are also known as statical model. These models are used for analyze the behavior of communication system having various channel response circumstances. [8] Through, they are not able to deal with specific propagation information. They are not employed to plane a communication system use to serve a particular area. Hence they are used to relay an assumption for mathematical formulation.

C. *Physical Model*

Physical model are based on basics of physics and deals with propagation environment. These models can either site specific or not site specific. A not site specific physical model based on the propagation principle of electromagnetic wave that predict signal level in generic environment to take account of development of relation shift between characteristics of environment and propagation. [9]

Example of these model by W.I Kegami and H.L Beritoni for mobile radio system in urban area, where series of diffraction screen considered by roof edge with including diffraction from building roof to the select level.

In other way, a physical and site specific model uses physical low of electromagnetic wave propagation as well as have technique from which mapping of real propagation as well have technique from which mapping of real propagation environment can be done into model propagation environment. Prediction of presence of attenuation in a signal is achieved by Epstein-Peterson method, Deygent method, Longely rice method and Anderson 2-dimensional model. Example of physical and site specific model is ray tracing model which proves dispersion information and angle of arrival information

D. *Okumura Model*

Okumura model is generated by empirical method in which various test are conducted to collect the data in different

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situation like irregular terrain and other environmental obstacles. This collected data was analyzed and checked in form of Diagrams. In the urban areas the Quasi smooth terrain give the information about median field strength. Along with urban area, an open area or suburban are requires the correction factors. Like rolling hilly terrain an isolated mountain mixed land sea paths, direction of streets, slope of terrain and it predicts the actual field strengths. [10]

In the area of urban environment many studies have been done up to 1935 about the losses arises in the radio wave propagation, but the study of Yoshihisa okumura was widely focused on the above. In 1968 Tokoyo, Japan Yoshihisa okumura tested the propagation between the mobile station & base station. With a variation in the urban geometry many tests were conducted for the transmission of signal. Different frequencies were used in the measurement like 200, 453, 922, 1310, 1430 & 1929 Mhz. graph is plotted between path distances & varying condition in terms of measured field value curve for each frequency. For the representation of the median attenuation which is extended along the transmission path as a function of frequency which fits this plotted data for a series of curves was developed by Okumura & his colleagues.

A propagation model was developed by okumura which is based on the calculations &the collection of data by him, this model incorporates the correction factors for the locations of transmit & receive antenna, type of environment, city size, terrain type. The model proposed by okumura has disadvantage as it was complex & time consuming as the user has to refer to the okumura mathematical curves for the calculations of losses & correction factors.

1) Generally Okumura illustrate correction factors for open area & suburban area.

2) Its model can predict the path loss up to 3 GHz in urban, suburban & Rural Area.

$$PL(dB) = L_f + A_{mn}(f,d) - G(h_{te}) - Gh_{re} - G_{AREA} \quad (4)$$

where

PL = media path loss (dB)

L_f = free path loss (dB)

$A_{mn}(f,d)$ = Median attenuation relative to free space (dB)

$G(h_{te})$ = base station antenna height gain factor (dB)

$G(h_{re})$ = mobile station antenna height gain factor (dB)

G_{AREA} = gain due to the type of environment (dB)

f = frequency (MHz)

h_{te} = transmitter antenna height (m)

h_{re} = receiver antenna height (m)

d = distance between transmitter and receiver antenna (km)

E. Hata Model

The limitations of okumura model was corrected in 1980 by Masaharu Hata who simplified it & reduces the user input to only four parameters by developing a set of equations. A fairly accurate prediction of propagation loss is obtained with only frequency, transmitted distance height of the base station antenna, height of mobile antenna in the earlier Okumura model. Hata model has limiting factors that it predicts only a short range of transmitted distance & frequencies. The limitations are overcome by the modification of Hata model into many models to extend the output over greater transmission distance & frequencies more accurately. [11] The combination of a scaling term independent of distances, correction factors logarithmic like and open air, suburban urban is given by Hata model up to the transmission distances of 30 km. Other studies show that the curves match for Hata & Okumura model within the acceptable parameters. Beyond 30km both the curves approximately separated by 15db difference near about 100km. Today the most widely used loss model for urban propagation is Hata model in comparison with the other loss model.

Hata okumura model is based on the okumura model which is most widely used empirical propagation model. This model generally used for ultra high frequency (4Hf) band. [12] Earlier it was working up to 3Ghz but IT4-R extended it up to 3.5 GHz. Earlier okumura model used another method called extrapolates method for higher frequency greater than 3 GHz for prediction Hata Okumura model is also referred as ECC-33 model.[13]

F. Okumura Model

The model is a systematic arrangement of Okumura Hata model as this was formed in Tokyo City so urban area is subdivided into large and medium city. [14] This model is generally beneficial for macro cellular system.

Few specification of this model is:-

1) 30-200m, Antenna height of the base station
2) 1-10m antenna height of the mobile station
3) 1-20 km distance between Base station & mobile station.

G. COST -231-Hata Model

COST-231 Hata model generally follows empirical model due to this the frequency range of Hata model is increased to 1500-2000MHz. it is applicable for suburban an urban area so called as outdoor propagation model. [15] This model is used for flat terrain and base on huge measurement. Limitation of this model is that it fails to situation where node's antenna height is above top level adjacent to the node. [16] This model gives accurate prediction within 1 dB for distance ranging 1 to 20Km.

This is applicable for urban, suburban or open area. It works in frequency range of 1500-2000MHz. it has 30-200m base station antenna height and 1-10n mobile station antenna height. 1-20km is distance between the base and mobile station.

IV. CONCLUSIONS

Due to the recent research in propagating signals, various models have been developed, analyzed that predict path losses associated with the urban and suburban environment, but their accuracy generally exists for specific parameters that are involved in predicting the model in wireless radio communication. To fulfill the upcoming requirement an accurate radio propagation model is essential with appropriate design and management strategies in a wireless network. This is important for predicting signal coverage, achievable signal or data, specific performance attributes of alternative signaling, reception schemes, analysis of interference from different systems and determining the optimum location for the installation of base station antennas

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