International Journal of Electronics and Communication Engineering.
ISSN 0974-2166 Volume 4, Number 2 (2011), pp. 225-232

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A Modified Approach to Calculate the Path Loss in Urban Area

[1]Purnima K. Sharma and [2]R.K. Singh

[1]Doctoral Candidate, UTU, Dehradun, India
E-mail: purnima_kadali@rediffmail.com
[2]Professor, KEC, Dhawarahat, India
E-mail: rksinghkec12@rediffmail.com

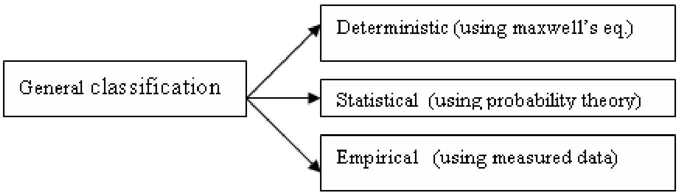
Abstract

The propagation path loss models may give different results if they are used in different environments other than in which they were designed. In this paper we compare the different path loss propagation models with measured field data and find out the model which is giving results nearer to the field measured data. In this we used many path loss models For comparative analysis. The field measurement data is taken in urban (high density region) environment in INDIA at 900 MHz &1800 MHz frequency with the help of spectrum analyzer. After analyzing the results Okumara model shows the better results in the specified environment. To attain more reliability in the existing Okumara model for the area specified we given correction factor using some existing assumptions.

Keywords: Path loss, Okumura's Model, Received signal strength, field measured data, correction factor.

Introduction

In the present days scenario of communication the path loss propagation models become an active area of research. Indirectly we can say path loss is the attenuation of the radio-waves presented in the communication channel in between transmitter and receiver. Due to existing channel signal strength reduction that signal suffers when propagating from transmitter to receiver. the losses present in a signal during propagation from base station to receiver may be due to surroundings and sudden changes in the climate and already exiting. General classification includes three forms of modeling to analyze these losses:



In the above models Deterministic models are better to find the propagation path losses. This model uses Maxwell's equations along with reflection and diffraction laws. The Statistical models Uses Probability analysis By finding the probability density function. The empirical models uses Existing equations obtained from results of several measurement efforts [1]. The field measurement data was taken in the urban area Krishna nagar (sector-c); Rewari (State: HARYANA, Country: INDIA) for its GSM based BSNL system.

Path loss

Path loss is an important parameter in the analysis and design of a radio communication system and it plays a vital role in the wireless communication at Network planning level. The definition explains Path loss or path attenuation is an unwanted introduction of energy tending to interfere with the proper reception and reproduction of the signals during its journey from transmitter to receiver [2]. The strength of electromagnetic wave decreases as it propagates through space, this happens due to losses exist in path. The signal path loss effects many parameters of the radio communications. Due to this, it is necessary to recognize the reasons for radio path loss, and to be able to determine the levels of the signal loss for a given radio path[3].

Causes of path loss

Many factors affect the signal by which we get the loss in the signal In this global environment. When Establishing any radio or wireless system in a large scale it is required to have a good knowledge about the parameters give rise to the path loss, and in this way design the system accordingly. The general causes of path loss are given below. [4-6].

Free space: According to the conservation of energy theorem the energy of any signal reduces when it travels larger distances in the space.

Absorption: Some of the signal strength is absorbed when the radio signal passes into a medium like large buildings, hills and foliage which are not totally transparent to radio signals.

Diffraction: This type of losses occurs when an obstruction unexpectedly appears in the path. The signal diffracts around the object, and losses occur. Radio signals tend to diffract more at sharp edges.

Multipath**:** The signal follows a number of paths from starting of journey from transmitter to till the ending of journey at the receiver. During their journey from transmitter to receiver via a number of paths the signals will be reflected and they will reach the receiver via a number of different paths. These signals may add or subtract from each other depending upon the relative phases of the signals. This entire process of journey leads to a loss which is multipath loss.

Atmosphere**:** The atmosphere is also a cause for radio path loss. It affects at lower frequencies, especially below 30 - 50MHz, the ionosphere has a major effect, reflecting them back to Earth. At frequencies above 50 MHz and more the troposphere has a major effect on the radio signal path. For UHF broadcast this can extend coverage to approximately a third beyond the horizon.

Calculation of the path loss

The calculation of the path loss is not that much easy because the path loss depends on many parameters during the signal journey from the transmitter to receiver but we can predict the path loss by considers some factors into account.

Path loss predicting methods

Statistical methods ← → Deterministic & Empirical methods

Statistical methods: These methods predicts the path loss using practically measured values of losses and averaged losses for different types of environments and different types of radio links. In this Different models can be used for different applications. This type of modeling approach is generally used at the network planning level of the cellular system, to estimate the practical coverage and plan for broadcast coverage of Private Mobile Radio (PMR) links. These methods are different in different environments. That means these models are methods depends mainly on the surrounding condition at the time of measurement [3].

Deterministic & Empirical methods: These methods are models uses the basic physical approaches According to the existing theoretical explanations and theorems. These methods consider all the physical parameters within a given area into account to prepare a model or method, and these methods give better and accurate results. But the main problem with these methods is they can be used for short range links where the amount of required data falls within a limited area [3]. The empirical models uses Existing equations obtained from results of several measurement efforts Some of the path loss models are as follows [7]-

a. log distance Model
b. Stanford University Interim (SUI) Model
c. Okumura’s Model
d. Hata Model

e. COST231 Extension to Hata Model
f. ECC-33 model

The above mentioned all the models are designed by calculating field data in different environments One of the most general models for signal prediction in large urban macro cells is Okumura's model [4]. This model is applicable frequency ranges of 150-1920 MHz and over distances of 1-100 Km. Okumura used extensive measurements of base station-to-mobile signal attenuation to develop a set of curves giving median attenuation relative to free space of signal propagation in irregular terrain. The base station heights for these measurements were 30-100 m, the upper end of which is higher than typical base stations today. The path loss formula of Okumura is given by

$$L50(dB) = Lf + Amu(f,d) - G(h_t) - G(h_r) - G_{AREA} \quad (1)$$

where d is the distance between transmitter and receiver, $L50$ is the median (50th percentile) value of propagation path loss, Lf is free space path loss, Amu is the median attenuation in addition to free space path loss across all environments, $G(ht)$ is the base station antenna height gain factor, $G(hr)$ is the mobile antenna height gain factor, and G_{AREA} is the gain due to the type of environment. The values of Amu and G_{AREA} are obtained from Okumura's empirical plots [6,8]. Okumura derived empirical formulas for $G(ht)$ and $G(hr)$ as

$$G(h_t) = 20\log_{10}\left(h_t/200\right), 30m < h_t < 1000\mathrm{m} \quad (2)$$

$$G(h_r) = 10\log_{10}\left(h_r/3\right), h_r \leq 3m \quad (3)$$

$$= 20\log_{10}\left(h_r/3\right), 3m < h_r < 10\mathrm{m} \quad (4)$$

Correction factors related to terrain are also developed in [4] that improve the model accuracy. Okumura's model has a 10-14 dB empirical standard deviation between the path loss predicted by the model and the path loss associated with one of the measurements used to develop the model. Okumura's model is wholly based on measured data and doesn't provide any analytical explanation. The major disadvantage with the model is its slow response to rapid changes in the terrain; therefore the model is fairly good in urban and suburban areas, but not good in rural area.

Comparative Analysis of Path Loss Models with Field Measured Data

After doing the drive test to measure in the location for which a path loss model is to be designed.The practical field measurement data was taken in the highly congested area of the urban area Krishna nagar (sector-c); Rewari (State: HARYANA, Country: INDIA) for its GSM based BSNL system. All the practical data was taken for the mobile terminal using navigation tool. The power transmitted from the base station terminal is 43dBm. The distance is taken starting from 1km, measurements were taken in successive intervals of 0.5 km upto 4.5km. The table 1 contains the details of measurements.

Network specifications taken from Bharat Sanchar
Nigam Limited (BSNL, Rewari):
Base station transmitter power: 43dBm
Mobile transmitter power: 30dBm
Base station antenna height: 35m
Mobile antenna height: 1.5m
Frequency: 900 MHz

Table 1: Navigation tool results.

Distance from the transmitter (km)	Received signal strength (dBm)
1	-69
1.5	-73
2	-76
2.5	-79
3	-81
3.5	-83
4	-85
4.5	-86

The field measured path loss is compared with different path loss models and plotted in fig. 1. From seeing fig. 1 we can say in the particular field the okumara model is giving the result which is near to the field measured data.

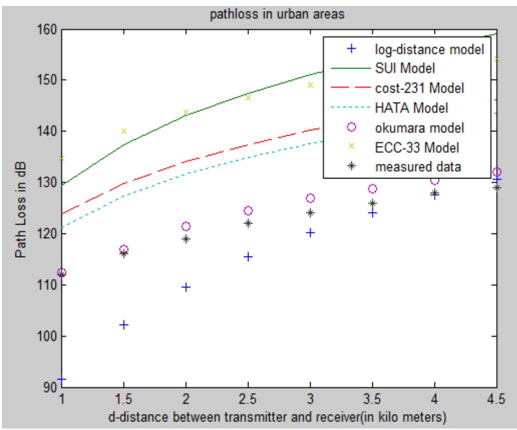


Figure 1: Comparative analysis of different path loss models.

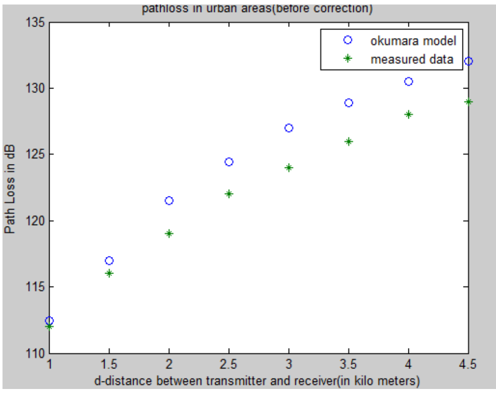


Figure 2: Okumara model and Field measured data (Before correction factor).

Modified Path Loss Model

From the above plots we can conclude that okumara model is giving better results than other models but for accuracy in the mentioned field or for the particular urban area the okumara model need some correction. In this field according to Log-distance path loss model the correction factor which is suitable is [6]

$$f(d)=10n\log(d/do)$$

Where do is reference distance which is 1km and n is path loss exponent which is ½ in this field.The modified okumara model is given below

$$L50(dB) = Lf + Amu(f,d) - G(h_f) - G(h_r) - G_{AREA} + f(d)$$

Where f(d) is the function of d i.e. the distance between the transmitter and receiver and whose value is found to be 5logd. Than the modified okumara model having the correction factor which is practical found is given below

$$L50(dB) = Lf + Amu(f,d) - G(h_f) - G(h_r) - G_{AREA} + 5\log d$$

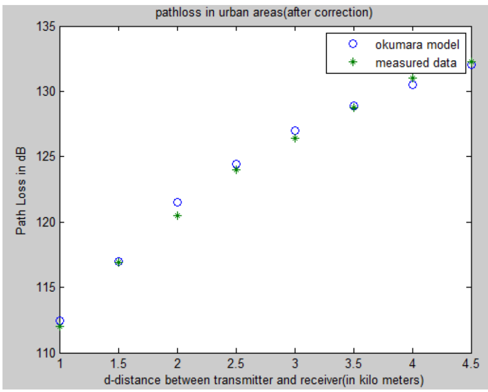


Figure 3: Okumara model and Field measured data (After correction factor).

Results and conclusions

Practically measured data was taken in the urban area using spectrum analyzer at 900MHz frequency. The power from the transmitter is 43dBm. The data was taken in the highly congested area of the urban area Krishna nagar (sector-c); Rewari (State: HARYANA, Country: INDIA) for its GSM based BSNL system using spectrum analyzer. The close-in reference distance taken is 1km.Measurements were taken in regular intervals between 1km and 5km. By observing the practical received power strength in the figure 1 we got a conclusion that The path loss from the field data is near to the okumara model. The accuracy of the any existing model is going to suffer when they are used in the surroundings or the fields other than they were designed so the okumara model need some correction to get the accurate results in the particular environment mentioned above at which we have taken the field measured data. The correction in the okumara model is given after observing the all the plots and with the concept of log distance method in the mentioned field environment.

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Biographies

Mrs K. Purnima Sharma was born on 2nd june1983 in Eluru, Andhra Pradesh (India). She received her M.Tech.degree in Communication and Signal Processing Engineering from NAGARJUNA UNIVERSITY (A.P.),India. She is a Associate Member of the IETE. He has published several Research papers in national and international journals/conferences. She is presently research scholar in UTTARAKHAND TECHANICAL UNIVERSITY, Dehradun (INDIA). Her present research interest is in Image Processing and Wireless Communication.

Dr. R.K. Singh Professor, KEC, Dwarahat, Almora, Jointly submitting research and development project in UCOST, Uttranchal. He is member of academic staff of Kumaon Engineering College, Dwarahat, Almora, where he is a professor in the department of Electronics and Communication Engineering. Dr. Singh has given his contribution to the area of Microelectronics, Fiber Optic Communications, and Solid State Devices. He has published several research papers in seminar/conference and journal papers. He is member of several institutional and educational and educational bodies. Before joining Kumaon Engineering College, Dwarahat, he has worked in Birla Institute of Technology and Sciences (BITS), Pilani, and Central Electronics Engineering Research Institute (CEERI) Pilani. At present he is serving as OSD, in newly established Technical University of Uttarakhand known as Uttarakhand Technical University, Dehradun.