Evaluation of Wireless Communication based on BTS Antenna Gain

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ABSTRACT

Radio wave propagation models are extremely important in radio network planning, design as well as in interference planning.All the models predict mean path loss as a function of different variables such as frequency, distance between transmitting and receiving antenna, antenna heights, etc. Radio propagation is essential for emerging technologies with appropriate design, deployment and management strategies for any wireless network. It is heavily site specific and can vary significantly depending on terrain, frequency of operation, velocity of mobile terminal, interface sources and other dynamic factor. Accurate characterization of radio channel through key parameters and a mathematical model is important for predicting signal coverage, achievable data rates, BER and Antenna gain. Path loss models for macro cells such as Okumura,

Hata and COST 231 models are analyzed and compared their parameters. In order to estimate the signal parameters accurately for mobile systems, it is necessary to estimate a system's propagation characteristics through a medium. Propagation analysis provides a good initial estimate of the signal characteristics.

Large scale path loss modeling plays a fundamental role in designing both fixed and mobile radio systems. Predicting the radio coverage area of a system is not done in a standard manner. Wireless systems are expensive systems. Therefore, before setting up a system one has to choose a proper method depending on the channel's BTS antenna height gain. By proper selecting the above parameters there is a need to select the particular communication model which show good result by considering the these parameters. Finally the comparison of base station antenna height gain is obtained. The comparison of this parameters is being done in Matlab using Matlab editor, command window and figure window.

Keywords

Antenna gain, Correction factor, Empirical models, Personal communication system etc.

1. INTRODUCTION

Wireless access network has becoming vital tools in maintaining communications especially at home and workplaces due to communication models. Propagation models help to understand the interferences in the network, which results in developing a well structured network with better quality. Those can be classified mainly into two extremes, i.e. fully empirical models and Deterministic models. There are some models which have the characteristics of both types. Those are known as Semi-empirical models. Empirical models are based on practically measured data. Since few parameters are used, these models are simple but not very accurate. The models which are categorized as empirical models for macro-cellular environment. These include Hata model, Okumura model, COST231 Hata model. On the other hand, deterministic models are very accurate. Some of the examples include Ray Tracing and Ikegami model. As mentioned earlier, semi-empirical models are based on both empirical data and deterministic aspects. COST231 Walfisch-Ikegami model is categorized as a semi empirical model. All these models estimate the mean path loss based on parameters such as antenna heights of the transmitter and Receiver, distance between them, etc. These models have been extensively validated for mobile networks. Most of these models are based on a systematic interpretation of measurement data obtained in the service area.

2. OKUMURA MODEL

This is the most popular model that being used widely The Okumura model for Urban Areas is a Radio propagation model that was built using the data collected in the city of Tokyo, Japan. The model is ideal for using in cities with many urban structures but not many tall blocking structures. The model served as a base for Hata models. Okumura model was built into three modes which are urban, suburban and open areas. The model for urban areas was built first and used as the base for others. Clutter and terrain categories for open areas are there are no tall trees or buildings in path, plot of land cleared for 200-400m. For examples at farmland, rice fields and open fields. For suburban area the categories is village or highway scattered with trees and houses, few obstacles near the mobile. Urban area categories is built up city or large town with large buildings and houses with two or more storey or larger villager with close houses and tall, thickly grown trees.

Formula for Okumura Model is expressed below:

Lm(dB) = LF(d)+ Amu(f,d) – G(hM) – G(hB) – GAREA

Where;

Lm = (i.e., median) of path loss

LF(d) = free space propagation pathloss.

Amu(f,d) = median attenuation relative to free space

G(hB) = base station antenna heigh gain factor

G(hM) = mobile antenna height gain factor

G(hB) = 20log(hB/200) 1000m > hB > 30m

G(hM) = 10log(hM/3) hM<= 3m

G(hM) = 20log(hM/3) 10m > hM > 3m

GAREA: gain due to type of environment given in suburban, urban or open areas Correction factors like terrain related parameters can be added using a graphical form to allow for street orientation as well as transmission in suburban and open areas and over irregular terrain. Irregular terrain is divided into rolling hilly terrain, isolated mountain, general sloping terrain and mixed land-sea path. The terrain related parameters that must be evaluated to determine the various corrections factors.

HATA MODEL

Hata established empirical mathematical relationships to describe the graphical information given by Okumura. Hata's formulation is limited to certain ranges of input parameters and is applicable only over quasi-smooth terrain. The mathematical expression and their ranges of applicability are as follows:

Carrier Frequency: 150 MHz ≤ fc ≤1500 MHz
Base Station (BS) Antenna Height: 30 m ≤hb ≤200 m
Mobile Station (MS) Antenna Height: 1 m ≤hm ≤10 m
Transmission Distance: 1 km ≤d ≤20 km

$A + B \log_{10}(d)$ for urban areas
L_p (dB) $= A + B \log_{10}(d) - C$ for suburban area
$A + B \log_{10}(d) - D$ for open area

Where:

$A = 69.55 + 26.161\log_{10}(f_c) - 13.82 \log_{10}(h_b) - a(h_m)$
$B = 44.9 - 6.55 \log_{10}(h_b)$
$C = 5.4 + 2 [\log_{10}(f_c / 28)]^2$
$D = 40.94 + 4.78 [\log_{10}(f_c)]^2 - 18.33 \log_{10}(f_c)$

where, $a(h_m) =$

$[1.1\log_{10}(f_c) - 0.7] h_m - [1.56\log_{10}(f_c) - 0.8]$ for medium or small cities
$8.29[\log_{10}(1.54 h_m)]^2 - 1.1$ for large city and fc ≤ 200 MHz
$3.2 [\log_{10}(11.75h_m)]^2 - 4.97$ for large city and fc ≥ 400 MHz

COST 231 MODEL

Most future PCS systems are expected to operate in the 1800-2000 MHz frequency band. It has been shown that path loss can be more dramatic at these frequencies than those in the 900 MHz range. Some studies have suggested that the path loss experienced at 1845 MHz is approximately 10 dB larger than those experienced at 955 MHz, all other parameters being kept constant. The COST231-Hata model extends Hata's model for use in the 1500-2000 MHz frequency range, where it is known to underestimate path loss. The model is expressed in terms of the following parameters:

Carrier Frequency fc 1500-2000 MHz
BS Antenna Height hb 30-200 m
MS Antenna Height hm 1-10 m
Transmission Distance d 1-20 km
The path loss according to the COST231-Hata model is expressed as:
Lp (dB) = A + B log10 (d) +C
Where;

A = 46.3+ 33.9 log10(fc) – 13.28 log10 (hb) – a (hm)
B = 44.9 – 6.55 log 10 (hb)
C= 0 for medium city and suburban areas
3 for metropolitan areas

Calculation of BTS antenna gain

The antenna gain for free space model can be given as

$$G = 4\text{^}Ae/\lambda^2$$

Where;
Ae = Effective aperature of an antenna.
In this work the BTS antenna gain can be calculated as:
$Gt = 20\log(H_b/200)$
Now the BTS antenna gain with correction factor can be calculated as:
$Gt(cf) = 20\log(H_b/200) - cf$
Where,
cf=31 for okumura model
cf $= [1.1\log_{10}(f_c) - 0.7] h_m - [1.56\log_{10}(f_c) - 0.8]$ for Hata and cost231 model

3. RESULTS

1) Comparison of Okumura model based on BTS antenna gain

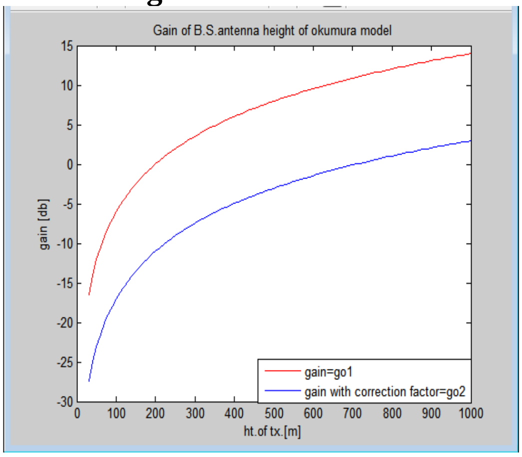

Fig1 comparison of BTS antenna gain with and without correction factor of Okumura model.

2) Comparison fo HATA model based BTS antenna gain

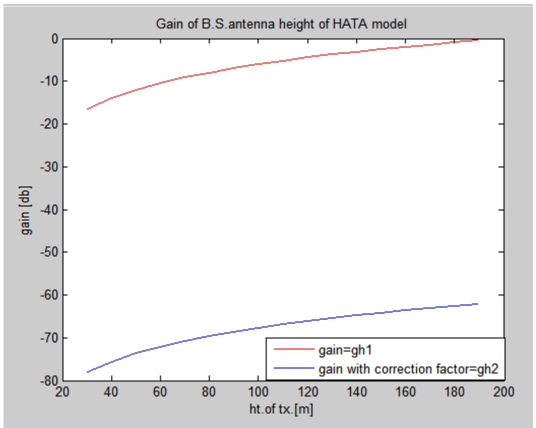

Fig 2 comparison of BTS antenna gain with and without correction factor of Hata model.

3) Comparison of Cost 231 model based on BTS antenna gain

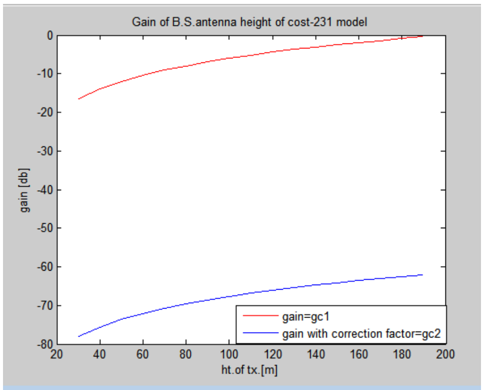

Fig3 comparison of BTS antenna gain with and without correction factor of Cost 231 model.

4) Comparison of Okumura, HATA and Cost 231 model based on BTS antenna gain with correction factor.

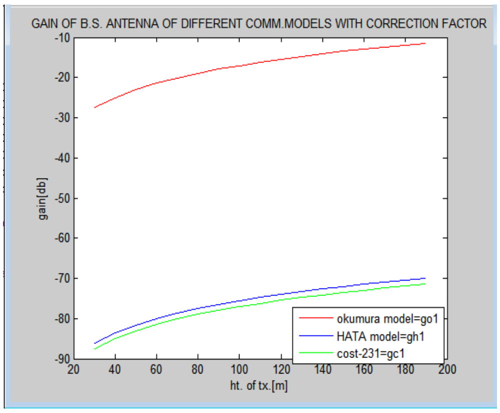

Fig 4 comparison of communication Models based on BTS antenna gain with correction factor

Table 1 comparison of communication Models

Ht. of BTS Antenna(m)	Gain of Okumura(db)	Gain of hata(db)	Gain of cost(db)
50	-23.04	-81.60	-83.06
100	-17.02	-75.58	-77.04
150	-13.49	--72.05	-73.52

4. CONCLUSION

The individual gain of Okumura , Hata and Cost 231 model shows increasing trend. The normal gain shows larger results as compared to gain with correction factor. In comparison of three models Okumura model shows better resuls as compared to Hata and Cost 231 model as shown in above table. Okumura model can be employed where there is requirement of large BTS antenna gain if the correction factor taken into consideration.

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