Comparative Analysis of GSM based Mobile Communication under Radio Propagation Environment

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Abstract: In cellular system, the knowledge of environment characterstics is useful for predicting the path loss. The path loss models which are generally used for achieving the signal attenuation or path loss. This paper deals with comparative parametric analysis of different types of path loss model in macro cell with real time measurement obtained from Bharat Sanchar Nigam Limited (BSNL), a GSM based wireless network in Bhuj, Gujarat(India) has been implemented.

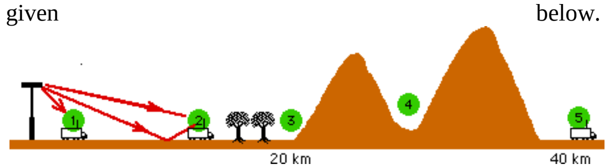
Index – Path Loss, Propagation Model, Lee model, Okumura model.

1. INTRODUCTION

Propagation models have traditionally focused on predicting the received signal strength at a given distance from the transmitter, as well as the variability of the signal strength in a close spatial proximity to a particular location. Propagation models that predict the signal strength for an arbitrary transmitter receiver (T-R) separation distance are useful in estimating the radio coverage area of a transmitter. Conversely, propagation models that characterize the rapid fluctuations of the received signal strength over very short travel distances are called small-scale or fading models. Propagation models are useful for predicting signal attenuation or path loss. This path loss information may be used as a controlling factor for system performance or coverage so as to achieve perfect reception [3].
The common approaches to propagation modeling include statistical models and empirical models and deterministic model. Deterministic model are accurate model uses Maxwell's equation with reflection and diffraction law. The second type model is Empirical model which uses the existing equation obtain from measurement data and other parameters. The last one Statistical model. In this paper, only empirical models are considered. Empirical models use measurement data to model a path loss equation. To conceive these models, a correlation was found between the received signal strength and other parameters such as antenna heights, terrain profiles, etc through the use of extensive measurement and statistical analysis[3].

2. PATH LOSS MODELS

Path Loss is attenuation electromagnetic waves between the transmitter and receiver in the communication system. Path loss Models are used to calculate the Path loss in different environment .The degradation in signal is known as path loss. Some of them are described and compared in this paper is given below.



2.1. Free space path loss model

Path loss in free space FSPL defines how much strength of the signal is lost during propagation fromtransmitter to receiver. FSPL is diverse on frequency and distance. The calculation is done by using thefollowing equation[1][8].

$$PL(dB) = 32.4 + 20\log(d) + 20\log(f)$$

Where,
f: Frequency (MHz)
d: Distance between transmitter and receiver (m)
Power is usually expressed in decibels (dBm).

2.2 Okumura-hata model

The Okumura model [5] is empirical model to measure the radio signal strength in urban areas. The model was built by the collected data in Tokyo city. This model is applicable for frequencies in the range of 150 MHz to 1950 MHz and distance of 1 km to 100 km. it can beused for the base station antenna heights ranging from 30m to 1Km.To determine path loss using Okumara's model, the free space path loss between the points of interest is first determined and then the value of $A_{mu}(f, d)$ is added to it along with correction factors according to the type of terrain.
The expression of the model

$$PL(dB)=L_F+A_{mn}(f,d)-G(h_{te})-G(h_{re})-G_{AERA}(1)$$

Where
PL is path loss [dB], L_F is Free space path loss [dB] Amn (f,d) is Median attenuation relative to free space [dB], $G(h_{te})$ is Base station antenna height gain factor [dB], $G(h_{re})$ is Mobile station antenna height gain factor [dB] , G_{AREA} is Gain due to the type of environment [dB], h_{te}:transmitter antenna height [m] hre: Receiver antenna height [m], d is Distance between transmitter and receiver antenna [km]

$$G(h_{re}) = 10 \log_{10} (h_{re}/200) \qquad h_{re} < 3m$$

$G(h_{re}) = 20 \log_{10} (h_{re}/200) \quad 10m>h_{re}>3m$

$G(h_{te}) = 20 \log_{10} (h_{te}/3)$

Okumura Model is considered to be among the simplest and best in terms of accuracy in predicting the path loss for early cellular system. The major disadvantages of this model are its slow response to rapid changes in terrain profile. Therefore the model is fairly good in urban and suburban areas, but not good for rural areas[2].

2.3 Walfisch- Ikegami model:

This model is a combination of J. Walfish and F. Ikegami model. The COST 231 project further developed this model. Now it is known as a COST 231 Walfish-Ikegami (W-I) model. This model is most suitable for flat suburban and urban areas that have uniform building height. Among other models like the Hata model, COST 231 W-I model gives a more precise path loss. This is as a result of the additional parameters introduced which characterized the different environments. It distinguishes different terrain with different proposed parameters. The equation of the proposed model is expressed as,

For LOS condition

$$(PL)_{LOS} = 42.6 + 26\log(d) + 20\log(f) \qquad (15)$$

And for NLOS condition

$$(PL)_{NLOS} = \{L_{FSL} + L_{rts} + L_{msd}\} \qquad (16)$$

for urban and suburban

This is the extended version of COST-231 this model consists rooftop losses and building losses[4][7].

2.4ECC 33model

The ECC-33 model is developed by Electronic communication committee (ECC). This is generally used for FWA (Fixed Wireless Access) system. The path loss is defined as

$$PL\ (dB) = A_{fs} + A_{bm} - G_b - G_r \qquad \ldots\ldots(4)$$

Where,

A_{fs}, A_{bm}, $G_b$and $G_r$are the free space attenuation, the basic median path loss, the BS height gain factor and the terminal height gain factor. They are the individually defined as,

A_{fs}= 92.4 + 20 $\log_{10}(D)$ + 20 $\log_{10}(f)$

$$A_{bm} = 20.41 + 9.83 \log_{10}(D) + 7.894 \log_{10}(f) + 9.56[\log_{10}(f)]^2 \qquad \ldots\ldots(5)$$

$$G_b = \log_{10}(h_b/200)\{13.958 + 5.8[\log_{10}(D)]^2\} \qquad \ldots(6)$$

And for medium city environments,

$$G_r = [42.57+13.7 \log_{10}(f)][\log_{10}(h_r) - 0.585] \qquad \ldots(7)$$

Where

$f$is the frequency in GHz, D is the distance between Transmitter and Receiver in km, $h_b$is the BS antenna height in meters and $h_r$is the CPEantenna height in meters. The predictions using the ECC-33 model with the medium city option are compared with the measurements taken in suburban and urban environments [6][7].

2.5 Ericssion Model

To predict the path loss, the network planning engineers are used a software provided by Ericsson company is called Ericsson model [9]. This model also stands on the modified Okumura-Hata model to allow room for changing in parameters according to the propagation environment. Path loss according to this model is given by .

$$PL(dB) = a0 + a1\log_{10}(d) + a2\log_{10}(h_b) + a3\log_{10}(h_b)\log_{10}(d) - 3.2\{\log_{10}(11.7h_r)\}^2 + g(f)$$

whereg(f) is defined by [9]

$$g(f) = 44.49\log_{10}(f) - 4.78 \log(f)^2$$

where

f: Frequency [MHz]

hb: Transmission antenna height [m]

hr: Receiver antenna height [m]

The default values of these parameters (*a0, a1, a2 and a3*) for different terrain are given in

Table 4.2: Values of parameters for Ericsson model

Environment	*a0*	*a1*	*a2*	*a3*
Urban	36.2	30.2	12.0	0.1
Suburban	43.20*	68.93*	12.0	0.1
Rural	45.95*	100.6*	12.0	0.1

3. PATH LOSS CALCULATION

Path loss is derived by the Transmission path from a base transreceiver station to the mobile station. it is shown by as

$$PL(db) = P_{TX} + G_{TX} - L_{TX} - P_{RX} - L_{RX} - L_M$$

P_{TX} = Transmitted Output power

G_{TX}= Transmitter antenna Gain(dbi)

L_{TX} = Transmitter Losses (db)

P_{RX} = Received Power (dbm)

L_M= miscellaneous losses (db)

$$EIRP = P_T - L_c + G_b$$

where EIRP is the effective isotropic radiated power of the base station, P_T is the BS transfer output power, L_c is antenna cable loss and G_b is BS antenna gain[10].

The difference between the measured path loss and the predicted path loss is known as Error. The relative error is defined as

Relative error = $\frac{PL(\text{measured}) - PL(\text{predicted})}{PL\ (measured)}$

4. PERFORMANCE ANALYSIS

4.1 Base station data

the table 2 shows the base station data which is known as base station transmitted power, mobile antenna height, cable loss, freq and others.

Table 2: simulation parameters

Sr.no.	Parameters	Values
1	Base station Transmitted power	43 dbm
2	Base station antenna height	40m
3	Mobile antenna height	1.5m
4	Transmitter antenna gain	18db
5	Cable loss	3.9db
6	Penetration Loss	11db
7	Body loss	4db
8	Connector loss	2db
9	Frequency	900MHz

The Relative error and Path loss exponent shows how much path loss between the transmitter and receiver and the table 3 shows the Error and path loss exponent for different models.

Table 3

Path loss model	Relative Error	Path loss Exponent
Hata –Okumura	.389	3.44
ECC- 33	.434	3.712
Egli	.475	4.000
SUI	.496	4.1675
COST-231	.41	3.45

path loss measurement of different model is given in Table 4 which is shown below.

Table 4

Path loss model/ distance	Free space model	ECC-33 model	W-I model	Ericssion model	Oku-hata model
1	91.5248	138.44	108.79	137.17	124.677
1.5	95.0466	144.42	115.48	142.52	130.736
2	97.545	149.54	120.23	146.31	135.035
2.5	99.4836	153.92	123.91	149.25	138.369
3	101.067	158.02	126.92	151.65	141.093
3.5	102.406	162.28	129.47	153.69	143.397
4	103.566	165.81	131.67	155.45	145.392
4.5	104.589	167.93	133.61	157.01	147.152
5	105.504	170.77	135.35	158.39	148.726

5. RESULTS

The following graphs plot for the 1.5m Mobile receiver antenna height, 40m Base station antenna height and frequency is 900MHz. The figure I shows graph between the path loss and distance from transmitter to receiver for Urban Environment. Similarly figure 2 and figure 3 graphs shows for Rural and Suburban environment.

Fig 1 Pathloss for Rural area

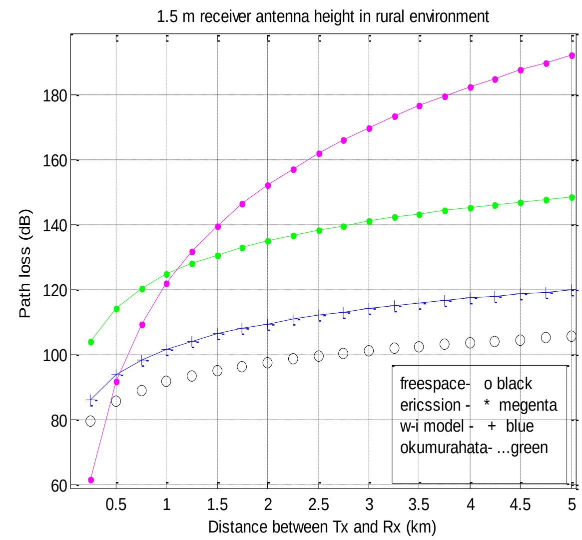


Fig 2 Pathloss for suburban area

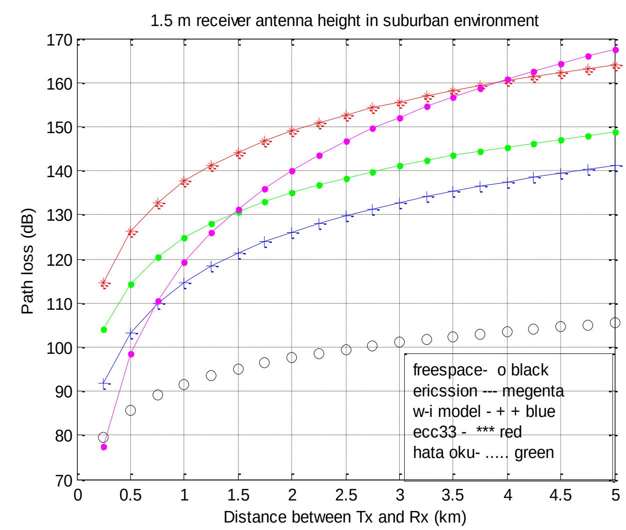
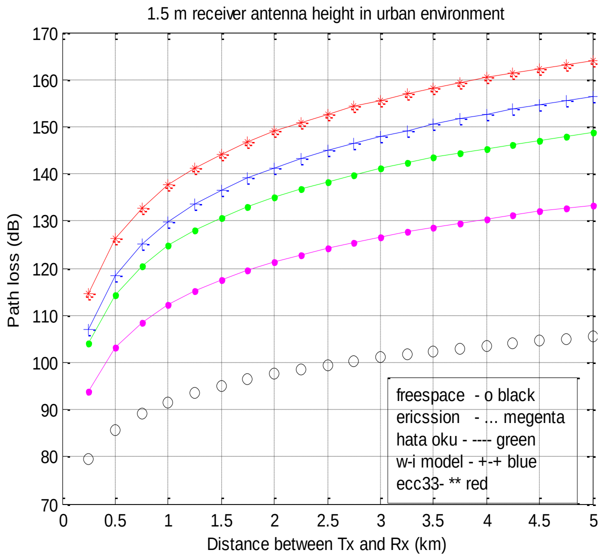


Fig 3 Pathlossfor urban area



6. CONCLUSION:

In this paper we compare different types of propagation model with their path loss equation and graphs. Some of them model are used in urban, suburban area but some are in rural areas. For example Hata Model is better in suburban areas and the ECC-33 Model in urban areas.

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