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SIGNAL STRENGTH ESTIMATION OF WIRELESS COMMUNICATION SYSTEM

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***Abstract* — Indian Telecom Market is witnessing Data Boom. More and more people are shifting towards Wireless Communication.Due to this , service providers are concentrating on it to generate better revenue.Wireless broadband is going to be a force to reckon with. The cellular mobile technology will be big contributor for wireless broadband due to emergence of Third Generation (3G)and Fourth Generation(4G) mobile technology. It is the fundamental task to predict the coverage of the proposed mobile system. Coverage in a cell depends upon the area covered by the signal. Radio propagation characterstic determine the extent to which a signal can travel in given area. The signal strength estimation using propagation models is dealt in this paper . Radio propagation varies from region to region . A wide variety of approaches have been developed over the years to predict coverage using propagation models. Propagation models are useful for predicting signal attenuation or path loss which may be used as a controlling factor for system performance or coverage so as to achieve perfect reception. The various path loss models like Free Path Loss , Hata, Okumara , COST 231 Hata and ECC 33 models are analyzed and compared. The received signal strength is calculated with respect to distance to determine the model that can be adopted to minimize the number of hand offs .EDX Signal Software is used for simulation purpose. The received signal strength depends on the path loss and the parameters of the transmitter and receiver . Quality of call establishment is based on received signal strength. Signal strength varies based on the environment and the intermediate losses.**

***Index Terms*—Mobile Internet Access, Propagation Models,Path Loss, Signal Strength, Wireless communication, Wireless broadband.**

I. INTRODUCTION

In wireless communication systems, accurate propagation characteristics of the environment should be known in advance to implement the designs and confirming the planning . Propagation models usually provides two types of information parameters corresponding to the large-scale path loss and small-scale fading statistics. The path-loss information is vital for the determination of coverage of a base transceiver station (BTS) location and in optimizing it. The small-scale parameters usually provide statistical information on local field variations and this, in turn, leads to the calculation of important parameters that help improve receiver (Rx) designs and combat the multipath fading. Without propagation predictions, these parameter estimations can only be obtained by field measurements which are time consuming and expensive. [1] Therfore it is valuable to have the capability to determine the optimum Base Station Location, Optimum data rates and coverage estimation without extensive, expensive and time consuming propagation measurement [2].

II PROPAGATION MODELS

The path-loss prediction models can be roughly divided into three types, i.e., the empirical, theoretical, and site-specific models. Empirical models are usually a set of equations derived from extensive field measurements .Empirical models are simple and efficient to use. They are accurate for environments with the same characteristics as those where the measurements were made. The input parameters for the empirical models are usually qualitative and not very specific, e.g., a dense urban area, a rural area, and so on. One of the main drawbacks of empirical models is that they cannot be used for different environments without modification, and sometimes they are simply useless. For example, the empirical model for macrocells cannot be used for indoor picocells. The output parameters are basically range specific, not site specific. Site-specific models are based on numerical methods such as the ray-tracing method and the finite-difference time-domain (FDTD) method. The input parameters can be very detailed and accurate. The disadvantages of the site-specific met$a^2 + b^2 = c^2$hods are the large computational overhead that may be prohibitive for some complex environments. Theoretical models are derived physically assuming some ideal conditions. For example, the over-rooftop diffraction model is derived using physical optics assuming uniform heights and spacing of buildings. Theoretical models are more efficient than the site-specific models and more site-specific than the empirical models [1]

A. FREE SPACE PATH LOSS MODEL

The Average Large scale received power for Transmitter(Tx) and Receiver(Rx) separation in wireless communication is given by [3]

$$P_t(d) = P_t(d_0)\,\{d/d_0\}^n \qquad (1)$$

where n is path loss exponent and equals to 2 for freee space and 4 for two ray trace model.From here we can define Path Loss as the measure of average attenuation suffered by a RF signal when it reaches the receiver after traversing a path of several wavelengths.This is defined by [2]

P_L (dB) = 10 log (P_t /P_r) (2)

where P_t and P_r are Transmitted power and received power.

For free Space Path Loss becomes

$PL\ (dB) = Gt - Gr + 32.44 + 20\log d + 20\log (f)$ (3)

where
Gt and Gr are the gain of Transmitting and receiving Antenna, d is sepration between Transmitter (Tx)and Receiver(Rx) in Km, f is frequency in MHz.

B OKUMARA MODEL

The Okumura model is an empirical model which works at several frequencies having the range of 150 MHz to 1920 MHz . It is the most broadly used model in large urban macro cell for signal prediction over distances of 1 km to 100 km and it is extended up to 3000 MHz [3]. The Okumura model takes into account some of the propagation parameters such as the type of environment and the terrain irregularity. The range of base station antenna heights is 30 m to1000 m and a mobile antenna height of 5 m. The basic prediction formula is as follows:

Path loss is expressed as:

L50(dB) = Lfree + Amu (f,d) – A(hte) – A(hre) – Garea (4)

where L50 is the 50th percentile value of propagation path loss, Lfree is the free space propagation loss and given by the equation (3) , Amu is the median attenuation value relative to free space in an urban area, A(hte)and A(hre) are the height gain factors of BTS and mobile antennas, and Garea is the correction factor due the environment.

Terrain information can be qualitatively included in the Okumura model. For example, the propagation environments are categorized as open area, quasi-open area, and suburban area.Other information such as terrain modulation height and average slope of terrain can also be included.[1]

C HATA MODEL

This method was developed by OKUMARA and HATA.This method was developed using measurement data taken at several frequencies in the Tokyo urban and suburban area. Selection of this method is therefore most appropriate for urbanized areas where the study distance is relatively short (less than 30 km), the effective transmit antenna height is less than 200 meters, the effective receive antenna height is less than 10 meters, and the terrain is relatively [3].Using it for other circumstances or at greater distances may be inappropriate. With Okumura (Hata) methods, we can select local area types as Open, Sub Urban and Urban and have appropriate Hata Correction factor applied.

The Hata equations are as follows[4]:

Basic path loss for urban areas:

$Lu = 69.55 + 26.16\log_{10} f - 13.82\log_{10} hb - ahm + (44.9 - 6.55\log_{10} hb)\log_{10} d$ dB (5)

where:
Lu = path loss in urban area , f = frequency in MHz
hb = base height in meters above the 3-15 km average terrain along the study radial
ahm = mobile height correction factor (see below)
d = distance from the transmitter to the receiver in Km

For a medium-small city:

$ahm = (1.1\log_{10} f - 0.7)hm - (1.56\log_{10} f - 0.8)$ (6)

For a large city:

ahm =8.29(log $_{10}$ (1.54))2 1.1for f<= 200MHz (7)

$ahm = 3.20(\log_{10}(11.75hm))2 - 4.97$ for $f > 400$ MHz (8)

where hm = the height of mobile antenna above ground in meters.

For suburban areas, the urban loss calculated above is corrected as follows:

$Lsu = Lu - 2(\ Log_{10}(f/28))^2 - 5.4$ dB (9)

For rural open areas, the urban loss is corrected as follows:

$Lro = Lu - 4\ 78(\log_{10} f)^2 + 18.\ 33\log_{10} f - 40.\ 94$ (10)

D. COST-231 HATA MODEL

The COST 231-Hata model is a variation of the Hata model .This variation was developed to provide a model that could be used in the 1500-2000 MHz PCS frequency band[4].

The basic urban path loss equation for the COST 231-Hata is:

$Lu = 46.3 + 33.9\log_{10} f - 13.82\log_{10} hb - ahm + (44.9 - 6.55\log_{10} hb)\log_{10} d + cm$ dB (11)

where:
$ahm = (1.1\log_{10} f - 0.7)hm - (1.56\log_{10} f - 0.8)$ (12)
cm = 0 dB for medium sized city and suburban centers with moderate tree density. This correction is used when the “open” or “suburban” categories are selected.
cm = 3 dB for metropolitan centers. The correction is used when the “urban” category is selected.

E. HATA-OKUMARA EXTENDED MODEL or ECC-33

An extrapolated method is applied to predict the model for higher frequency greater than 3 GHz. In this model path loss is given by
$PL = Afs + Abm - Gb - Gr$ (13)

where Afs: Free space attenuation [dB], Abm: Basic median Gb: Transmitter antenna height gain factor, Gr: Receiver antenna height gain factor. These factors can be separately path loss [dB], described by

$Afs = 92.4+20\log_{10}(d)+20\log_{10}(f)$ (14)

$Abm = 20.41+9.83\log_{10}(d)+20\log_{10}(f)+9.56[\log_{10}(f)]^2$ (15)

$Gb=\log_{10}(hb/200)\{13.958+5.8[\log_{10}(d)]^2\}$ (16)

When dealing with gain for medium cities, the Gr will be expressed in

$Gr= [42.57+13.7\log_{10}(f)][\log_{10}(hr)-0.585]$ (17)

For large city $=0.759hr-1.862$ (18)

Where
d: Distance between transmitter and receiver antenna [km], f: Frequency [GHz], hb: Transmitter antenna height [m], hr: Receiver antenna height [m].
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F. SUI Model
Model developed at Standford University. and called SUI (Stanford University Interim) . These models are derived for Multipoint microwave distribution system (MMSD) in the frequency range from 2.5 GHz to 2.7 GHz . These SUI models are categorized into three types of terrains namely terrain A, terrain B and terrain C. Terrain A is the hilly area with medium to very large tree densities in which the path loss is maximum. Terrain C is the flat or open area with light tree densities having minimum path loss category. Terrain B is categorized with either mostly flat terrains with moderate to heavy tree densities or hilly terrains with light tree densities[6] .

The basic path loss equation is given as:

$PL= A+10\,\gamma\log_{10}[d/d0] + Xf + Xh+ s$ for $d > d0$ (19)

Where, d is the distance between access points and customer premises equipment antennas in metres, d0 is 100 m, s is a log normally distributed factor that is used to account for the shadow fading owing to trees and other clutter and has a value between 8.2 dB and 10.6 dB. The other parameters are as follows:

$A= 20\log_{10}(4\pi\, d0 / \lambda)$ (20)

And $\gamma= a- bhb+ c/hb$ (21)

where, hb is the base station height above ground in meters

and the range is from 10 m to 80 m.

III RECEIVED SIGNAL STRENGTH CALCULATION

Received signal strength is a strength which is used to measure the power between the received radio signals. For each base station there is a threshold point below which connection break with active base station. Therefore the signal strength must be greater than threshold point to maintain the connection with active BS. The signal gets weaker as mobile moves far away from active base station and gets stronger signal towards new base station as it move closer. There is an option named Handoff if RSS of active base station decreases below threshold level to maintain the connection. Path loss is an important factor in handoff. The RSS can be calculated with different path loss models like Hata-Okumara, COST-231 etc.[5]
The received signal strength for Okumara Hata model, COST-231 Hata model and ECC-33 model are calculated as

$Pr= Pt+Gt+Gr-PL-$ (22)

Where, Pr is received signal strength in dBm Pt is transmitted power in dBm. Gt is transmitted antenna gain in dBm Gr is received antenna gain in dBm ,PL is total path loss in dBm A is connector and cable loss in dBm .

The different parameter of Transmitter(Tx) and receiver (Rx) used are as following:-
Table 1: Tx , Rx Parameters

Parameter	Value
Transmitted Power of MS (Ptx)	30 dB
MS Antenna Gain(Tx side)	0
MS Antenna Connector or fedder loss	0
EIRP(Mobile Station)	30
MS Antenna Height (hm)	1.5 m
BTS receiver sensivity	-114 dB
BTS Antenna Gain (Gr)	15 db
Body Loss (Bl)	3 dB
Connectoror Feeder Loss (Lf)	3 dB
Interface Margin(Im)	2dB
Fast fade Margin(Fm)	5 dB
Base Station Height	35 m
MS receiver sensivity	-104dB
Frequency in downlink	880 MHZ
Frequency in uplink	835MHZ
Transmiteed Power of BTS	35 dB
MS Antenna Gain (Msg)	15 dB
BTS Height(hb)	30 m/35m

The role of Transmitter and Receiver is changed in uplink and down link. The BTS becomes receiver in uplink and Transmitter in down link.

IV RESULTS

The maximum allowable Path Loss is given as :-

i) Downlink Pr = Ptx+Gtx- Lf-Im-Fm- Bl- Path Losss +Grx

-104 dB = 35+15 – 13+15 – Path Loss or Path Loss = 104 +52 = 156 dB .

ii) Uplink Pr = Ptx –Lf-Im-Fm-Bl- Path Loss+Grx or by putting values we have Path Loss = 114 – 13+30 +15 = 156 dB.

Hence Path loss is equal in both sides so the link is balanced.

iii) HATA MODEL:-

$$Lu = 69.55 + 26.16\log_{10} f - 13.82\log_{10} hb - ahm + (44.9 - 6.55\log_{10} hb)\log_{10} d \text{ dB}$$

$$156 = 69.55 + 26.16\log_{10} 880 - 13.82\log_{10} 30 - 0 + (44.9 - 6.55\log_{10} 30)\log_{10} d \text{ dB}$$

$$29.8361 = 35.2249 \log_{10} d \text{ or } d = 7.03 \text{ Km}$$

iv) Cost 231 Model

$$Lu = 46.3 + 33.9 \log_{10} f - 13.82 \log_{10} hb - ahm + (44.9 - 6.55\log_{10} hb)\log_{10} d + cm \text{ dB}$$

or $156 = 146.1180 - 20.4138 + 35.2249 \log_{10} d + 3$ or $d = 5.94$ Km.

Table 2 : Path Loss For Various Models in dB

Distance	Hata Okumara	Cost 231	ECC 33
1	125.23	124.77	121.18
2	135.71	135.25	131.69
3	141.83	141.37	137.75
4	146.18	145.72	142.12
5	149.55	149.90	146.38

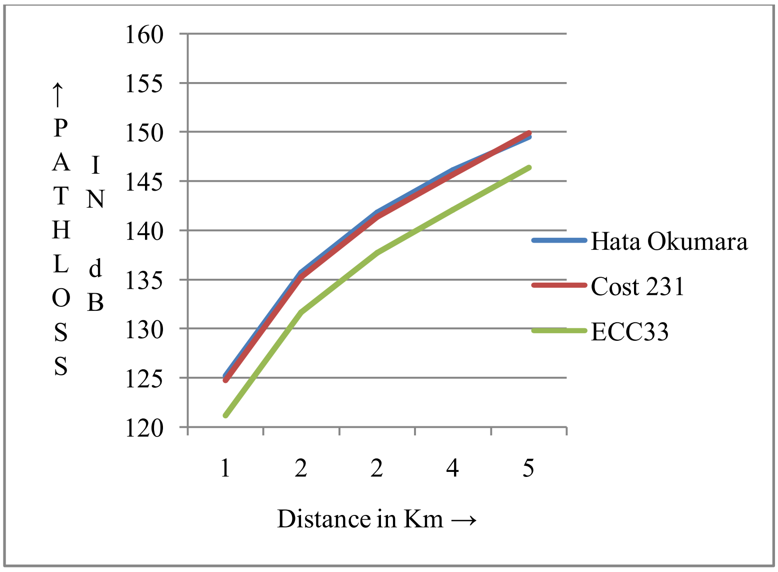

Fig 1 Graph of Path Loss Vs Distance in Urban Area

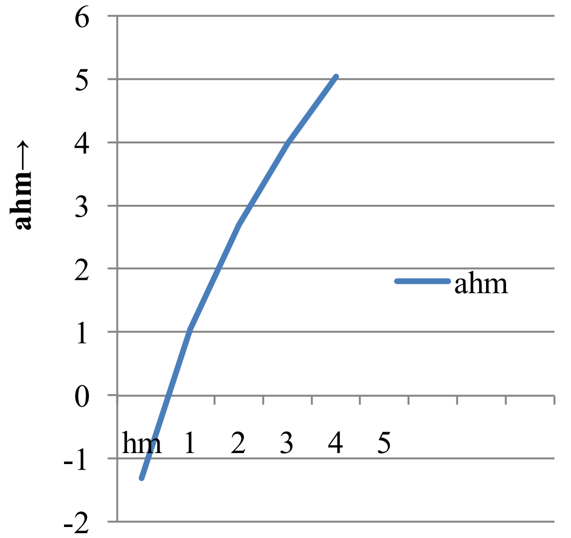

Fig 2 Variation of receiver height factor (ahm) with receiver height (hm

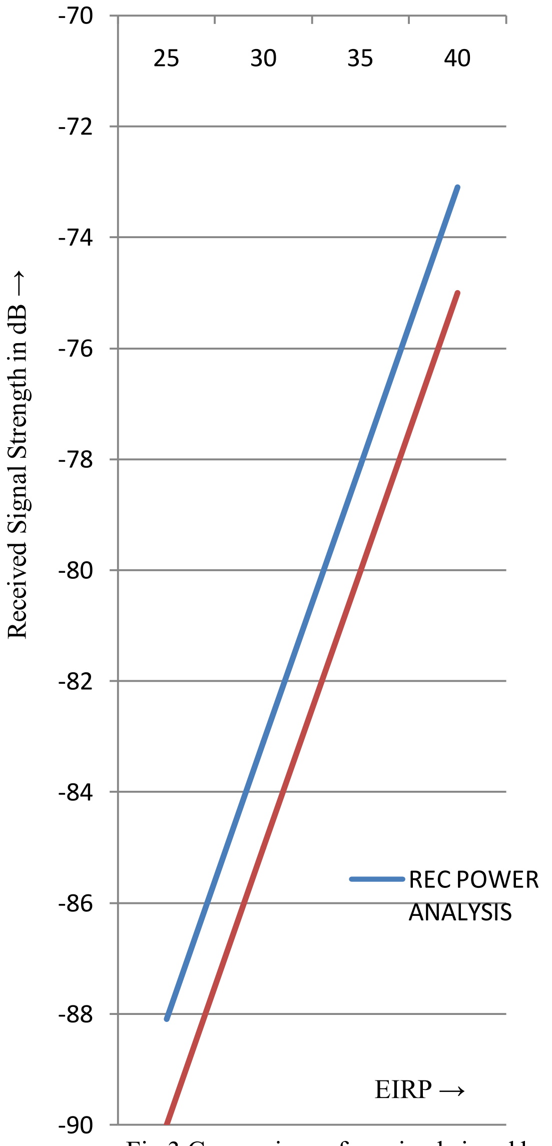

Fig 3 Comparison of received signal by simulation and analysis.

V CONCLUSION

Hata and Cost 231 are used widely for cellular frequency band of 900MHZ and 1800 MHZ Band.The ECC33 model is used for Fixed Wireless Access in between 2-3 GHz.All the three models predicts the path loss in excess.ECC 33 Model is not applicable for Rural area..Hata Model gives signal strength data closely to practical data in urban, suburban and rural area.Hence this model is widely used.For greater Antenna heights , Hata Models are not near practical data. ECC 33 models is appropriate for greater height.

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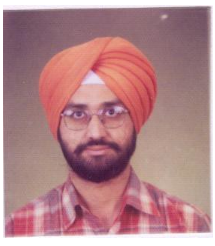

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