Proposed Propagation Model for Dehradun Region

Pranjali Raturi, Vishal Gupta, Samreen Eram

***Abstract*— This paper presents a review of the outdoor propagation prediction models for GSM 1800 MHz in which propagation model was developed after a measurement drive was undertaken for the purpose of data collection. The appearance of the foliage medium in the path of communication link has found to play a significant role on the quality of service (QoS) for wireless communication over many years. Four GSM base stations operating at 1800 MHz band were used for the purpose of measurement in sub-urban region of Patel Nagar and kargi, Dehradun. The measured values that were first fitted using fitting tool were compared with Free Space Path Loss model, COST 231 Hata model, Hata model and COST 231 Walfish-Ikegami (W-I) model. These outdoor propagation models discussed helps to measure accurate path loss prediction within a particular scenario also a good outdoor propagation model facilitates optimized network planning, design and implementation process of a wireless network .**

Index Terms—**propagation model, X model, QoS**

INTRODUCTION

A number of propagation prediction models for mobile radio communication system were developed. However selection of the most suitable model for a given geographical region is not a simple task because descriptions of terrain and effect of vegetation can vary widely from one place to other.

Therefore in wireless communication, propagation measurement is necessary to develop prediction model for application in particular coverage region. An experiment was performed by conducting propagation measurement in Dehradun region.

The main objective of this experiment is to analyze various path loss prediction model and to investigate the accuracy of outdoor model which one is applicable for range of 900-1800 MHz band like free space model, COST 23 Hata model, Hata model and COST 231 WI model, with in the Dehradun region.

A. Free Space Path Loss Model(FSPL)

Path loss in free space PL_{FSPL} defines how much strength of signal is lost during propagation from transmitter to receiver. FSPL is depends on frequency and distance. The following equation gives free space path loss [1]:

$$PL_{FSPL}(dB)=32.45+20\log_{10}(d)+20\log_{10}(f) \quad (1)$$

Where,
f: Frequency (MHz)
d: T-R separation (m)

B. Figure COST 231 Hata Model s

The Hata model is introduced as a mathematical expression to mitigate the best fit of the graphical data provided by the classical Okumura model [3]. Hata model is used for the frequency range of 150 MHz to 1500 MHz to predict the median path loss for the distance d from transmitter to receiver antenna in 20 km range and height of transmitting antenna is considered 30 m to 200 m and receiver antenna height is 1 m to 10 m. the COST 231 Hata model [4] developed as an extension to Hata-Okumura model. This model can operate in the frequency range of 1500 MHz to 2 GHz. This model is useful to predict path loss in three different environments like urban, suburban and rural. It contain correction factor for these three environments. The path loss equation for this model can be expressed as:

$$PL(dB)=46.3+33.9\log_{10}(f)-13.82\log_{10}(h_b)-ah_m+(44.9-6.55\log_{10}(h_b))\log_{10}d+c_m \quad (2)$$

Where,
f: Frequency (MHz)
h_b: Transmitter antenna height(m)
d: T-R separation (km)

The parameter c_m has different values for different environments like 0 dB for suburban and 3 dB for urban areas and the remaining parameter ah_m is defined in urban areas as:

$$ah_m=3.20(\log_{10}(11.75h_r))^2-4.79 \qquad \text{for } f \geq 400 \text{ MHz}$$

The value for ah_m in suburban and rural (flat) areas is given as:

$$ah_m=(1.11\log_{10}f-0.7)h_r-(1.5\log_{10}f-0.8)$$

Where,
h_r: Receiving antenna height(m)

C. Hata Model

Hata model is based on the Okumura model and it can operate in the frequency range of 150 MHz to 1500 MHz. This model represented the urban area propagation loss as the standard formula along with the additional correction factor

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application in other environment like suburban and rural. It's computation time is short and only four parameters are required. The path loss equation for this model can be expressed as [2]:

$$PL(dB)=69.55+26.16\log_{10}f-13.82\log_{10}(h_{te})-a(h_{re})+(44.9-6.55\log_{10}h_{te})\log_{10}d \quad (3)$$

Where,
f: Frequency(MHz)
h_{te}: The effective base station antenna height(30m)
h_{re}: effective mobile antenna height(1m-10m)
d: T-R separation (m)
$a(h_{re})$: the correction factor for effective mobile antenna height

for small to a medium sized city, the mobile antenna correction factor is given by

$$a(h_{re})= (1.11\log_{10}f-0.7)h_{re}-(1.56\log_{10}f-0.8)$$

for large city it is given by

$$a(h_{re})=8.29(\log 1.5h_{re})^2-1.1 \quad \text{for } f<300 \text{ MHz}$$
$$a(h_{re})=3.2(\log 11.75)^2-4.79 \quad \text{for } f>300 \text{ MHz}$$

Path loss in suburban area can be obtaine by modifying hata standard formula as:

$$PL(dB)=PL(urban)-2[\log(f_c/28)]^2-5.4$$

Hata's model does not have any of the path specific correction which is available in Okumura model. This model is well suited for large cell mobile syatem, but not personal communication [5]

D. COST 231 Walfish-Ikegami (W-I) Model

This model is developed by combination of J. Walfish and F. Ikegami model. The COST 231 project further developed this model. Thus it is known as 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 model like the Hata model this model gives precise path loss. Due to this additional parameters introduced, which characterized the different environments. It gives the categorization of different terrain with different propised parameters. The path loss equation of this model is given by [6]

For LOS condition

$$PL_{LOS}(dB) = 42.6 + 26\log(d) + 20\log(f) \quad (4)$$

For N-LOS condition

$$PL_{LOS}=L_{FSL} + L_{rts} + L_{msd} \quad \text{for urban \& sub-urban}$$
$$PL_{LOS}= L_{FS} \quad \text{if } L_{rts} + L_{msd}> 0$$

Where,

L_{FSL}: Free space loss
L_{rts}: Roof top to street diffraction
L_{msd} : Multi screen diffraction loss

I. MEASURED RECEIVED POWER

The measurement of signal strength shows that the received signal level depends on the distance between transmitter and mobile station. The variance on the signal depends on the transmitter behavior and also on environment.

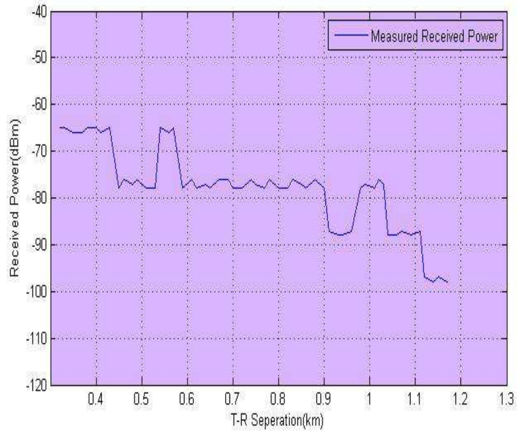

Figure1 Received Power in dBm

The design parameters highly influence the sensitivity of received power. The variation on signal depends on clutter, user and also on propagation model. The performance of propagation model can observe by difference in decibel (dB) value scale between the measurement plot and prediction model. This difference in value is called excess path loss. The study of signal received from transmitter is carried out within six different clutters to measure the received power and also to approximate the excess path loss. The effect of diffraction will not be quantified due to lack of available clutter data base.

II. PATH LOSS CALCULATION

The measured signal power can be converted into path loss using following equation:

$$L_P= EIRP-L_M+G_{RX}-P_{RX} \quad (5)$$

EIRP represent Effective Isotropic Radiated Power and expressed as:

$$EIRP=P_{TX}+G_{TX}-L_{TX} \quad (6)$$

The path loss and EIRP can be calculated by substituting the parameter's value. The measured and predicted path loss is shown in figure2.

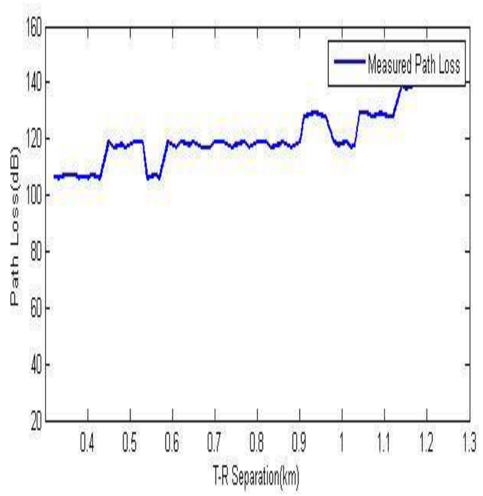

Figure 2 Measured Path Loss

The figure 2 shows that the exact prediction of propagation models can not be done for all type of propagation environment. This is because, the radio wave propagation in built up area is highly influenced by nature of environment, density of building and particular size. The theoretical plot of path loss does not give much information for a good comparison. With this point of view, a least square method was selected to obtain the best fit of measured path loss as a function of distance using linear fitting tool in MATLAB. The measured path loss is plotted with the help of linear fitting technique.

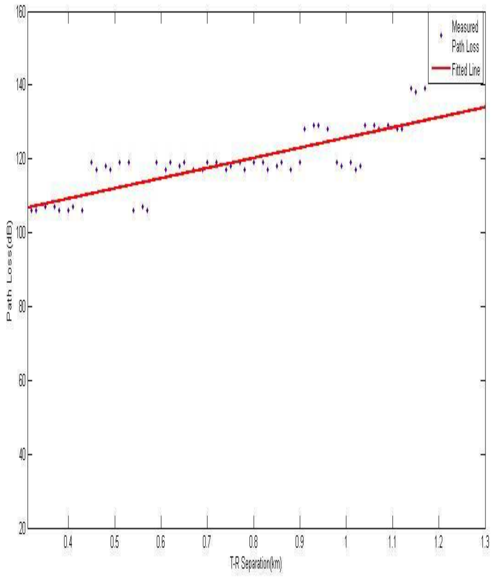

Figure 3Measured path loss plot using linear fitting

A. COMPARISON BETWEEN FREE SPACE (FRIIS) MODEL AND MEASURED PATH LOSS

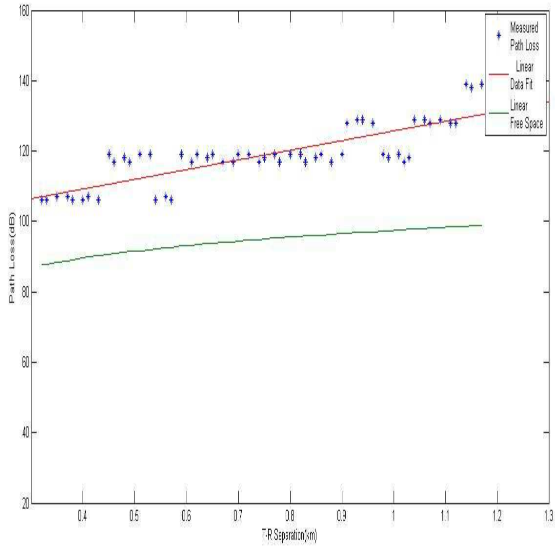

Figure 4 Comparison between Free space path loss and measured Path Loss

The comparison of free space path loss model and measured data is plotted using linear fitting method in MATLAB. This results that free space model and measured data reveal a linear property and allow us to compare both, the free space and measured data more exactly.

The free space path loss prediction is analyzed to quantify the measured received power. In above figure measurement plot is being compared to free space prediction in a range of .3 to 1.4 km from BTS. The free space path loss (FSPL) in signal strength would result from a lone of sight path through free space, with no obstacles nearby to cause reflection or diffraction. It does not include factors like gain of transmitting and receiving antenna and any loss due to hardware imperfection. Practically the base station antenna is located at a height of 30 m and mobile station is located between the building and street, so there is no line of sight path available. Therefore, the received signal is affected by reflection, diffraction and scattering. This results, increment in path loss as compare to the free space path loss prediction.

B. COST231 EXTENSION TO HATA MODEL IS COMPARED TO MEASURED PATH LOSS

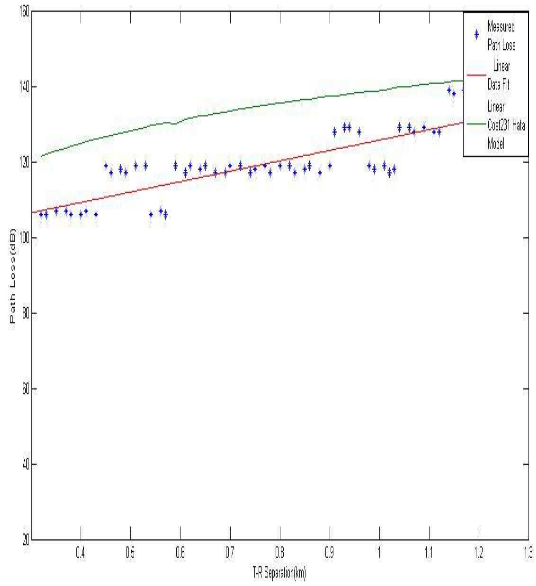

Figure 5COST 231 Hata Extension model and measured data

This model is restricted only for following range of parameter:

f :1500 MHz to 2000 MHz
h_b :30 m to 200 m
h_m :1 m to 10 m
d :1 km to 20 km

The comparison of cost 231 Hata prediction and measured data results that, there is almost constant path loss difference between both values. This may be due to that model assume same density of clutter exist between BS and MS which contribute more losses to received signal as the MS moves away from BS.

C. COST 231 WALFISCH-IKEGAMI MODEL IS COMPARED TO MEASURED PATH LOSS

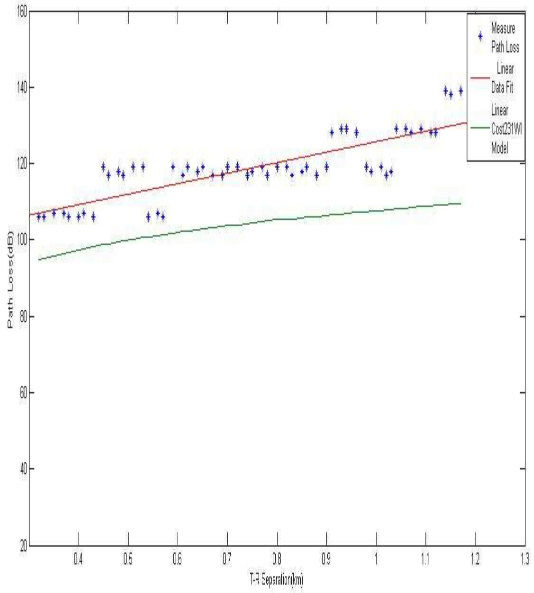

Figure 6 Comparison between Measured path loss and COST231 W I model

Analysis of figure describe that path loss increases linearly with increase in distance between BS and MS. As the distance between BS and MS increases, difference between measured path losses and Cost 231 W I model increases. At the range of 1.1 to 1.2 km the difference between both is maximum. This can be explained by the nature of Cost 231 W I model. Basically this is a flat suburban model and this type of model provides a measure of path loss as function of distance. This model does not include antenna shadowing effect, blockage and terrain roughness.

D. HATA MODEL IS COMPARED TO MEASURED PATH LOSS

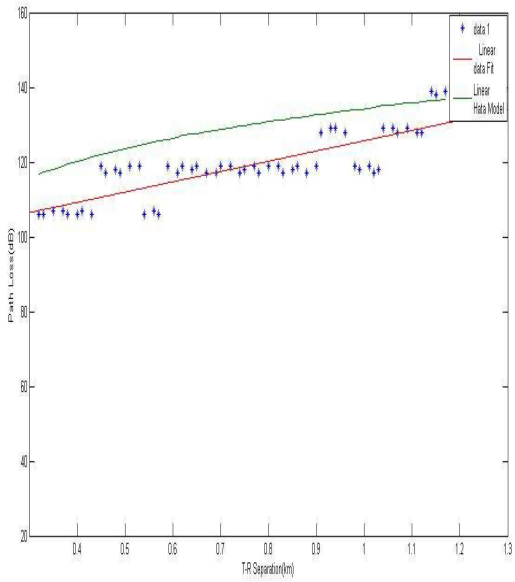

Figure 7 Comparison between Measured path loss and Hata model

The plot of Hata model and measurement illustrate that the measurement results are slightly lower than the theoretical Hata model. There is a difference of 10 dB exist between measured data and hata model. The model shows good agreement with the measured path loss. This is because hata model is more suitable for urban and suburban region an also provide high transmitting /receiving antenna gain.

E. FSPL,COST231 HATA,COST231WI AND HATA MODEL IS COMPARED TO MEASURED PATH LOSS

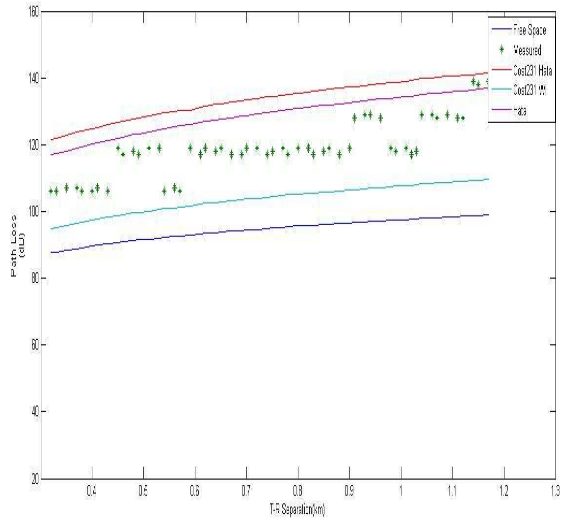

Figure 8Theoretical model is compared to measure path loss

III. CONCLUSION

For radio propagation a number of models are in existence and among those which are applicable for DCS 1800 are described in thesis. The result of experiments depended to large extent on the environmental condition which means for a particular region a specific model is applicable. Also the result may be unrealistic if the same model is applied in different environmental condition, as the quality of service of propagation model may be affected by the foliage that appears in the communication link. This may be related to thick forest or dense settlements with tall buildings. Different models have thus tried to evaluate the path loss for different environmental conditions.

In this paper, experiments were carried for obtaining the radio propagation model for Dehradun urban region. A GSM base station operation at 1800 MHz was used for experiment. The aim is to investigate the effectiveness of various radio propagation model like Hata model, COST 231 Hata model, COST 231 WI model and free space model in the urban area at Dehradun.

During the experiment signal strength was recorded and the corresponding path loss distribution graph was plotted. Dehradun being a valley surrounded and covered by sal and seesham forests, also the thick and fast developing residential housing societies have played an important role in the foliage propagation. Hence, scattering and diffraction of propagated signal leads to path loss. As a result of which theoretical path loss and actual path loss can be related as:

Theoretical path loss- Actual path loss=X

This model is named as 'X Model'. The measurement results were compared with Hata model, COST 231 Hata model, COST 231 WI model and free space model. The result shows that there is least variation in 'X model' and Hata model. The variation is noted as 10.056 dB.

The measurement of 'X model' being 10.056 dB more than Hata model which also means that the path loss in Hata model as compared to 'X model' is given as:

X model =Hata model –X(dB)

Where X=10.056

Thus the result shows that Hata model is very effective for radio wave propagation path loss in urban area of Dehradun, as there is only slight variation. Through this thesis a modified model is proposed which is (Hata model -10.056) and is most appropriate for the urban areas of Dehradun.

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