

# Analysis of Large Scale Propagation Models & RF Coverage Estimation

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**Abstract** –The main task in designing of any wireless communication system is to predict the coverage of the planned system using some mathematical path loss models before the original design of the system. Propagation path loss models are very much useful mathematical tools to calculate signal attenuation and it can be used as a controlling factor for the system performance and coverage. The propagation 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 large scale propagation models with measured field data and The large scale propagation performance of hata, sui, bertoni and ecc-33 models has been compared by varying mobile station antenna height, transmitter –receiver distance and base station antenna height. During the test drive the field measurement data is taken in urban environment in INDIA at GSM frequency with the help of spectrum analyzer.

**Keywords**— Large scale propagation models, Received signal Strength (RSS), Coverage area.

## I. INTRODUCTION

Propagation path loss models are used to calculate path loss during transmission of a signal so as to predict the mean signal strength for an arbitrary transmitter-receiver separation distance are useful in estimating the radio coverage of a transmitter and are called large scale propagation model. 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 existing. General classification includes three forms of modeling to analyze these losses. First 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 Hisar ( State:HARYANA, Country: INDIA) for its GSM based BSNL system.

## II. COVERAGE AREA

A cellular network is a radio network distributed over land areas called cells, each served by at least one fixed-location transceiver known as a cell site or base station. These cells joined together provide radio coverage over a large

geographic area. This radio network enables a large number of portable transceivers (e.g., mobile phones, pagers, etc.) to communicate with each other and with fixed transceivers and telephones anywhere in the network, via base stations, even if some of the transceivers are moving through more than one cell during transmission. The cell and network coverage depend mainly on natural factors such as geographical aspect/propagation conditions, and on human factors such as the landscape (urban, suburban, rural), subscriber behavior etc. The ultimate quality of the coverage in the mobile network is measured in terms of *location probability*. For that, the radio propagation conditions have to be predicted as accurately as possible for the region [10].

### A. 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 affects 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].

### B. 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.

### C. 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.

(a). *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].

(b). *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 [7,8]-

- (a) Hata Model
- (b) Stanford University Interim (SUI) Model
- (c) Walfisch Bertoni Model

- (d) COST231 Extension to Hata Model
- (e) ECC-33 model

The above mentioned all the models are designed by calculating field data in different environments

### III. COMPARATIVE ANALYSIS OF PATH LOSS MODELS WITH FIELD MEASURED DATA

Calculation of the path loss using different mathematical path loss models is usually called prediction. For practical cases the path loss is calculated using a variety of approximations. The accurate loss prediction models are helpful for the BTS mapping for optimum network design. Among the Radio Propagation Models city models are to be analyzed in this paper to find the best fitting city model [9,10].

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 congested area of Hisar (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 0.5 km; measurements were taken in successive intervals of 0.5 km upto 3.5km. The table 1 contains the details of measurements.

Network specifications taken from Bharat Sanchar Nigam Limited (BSNL, Hisar):

- Base station transmitter power: 43dBm
- Mobile transmitter power: 30dBm
- Base station antenna height: 45m
- Mobile antenna height: 1.5m
- Frequency: 900 MHz

Table 1 Navigation tool results

Distance from the transmitter (km)	Received signal strength (dB)
0.5	-67
1	-77
1.5	-82
2	-87
2.5	-94
3	-95
3.5	-97

The field measured path loss is compared with different path loss models and plotted in fig. 5. The fig. 6 shows the variation of received signal strength with cell radius, which describes the Coverage area.

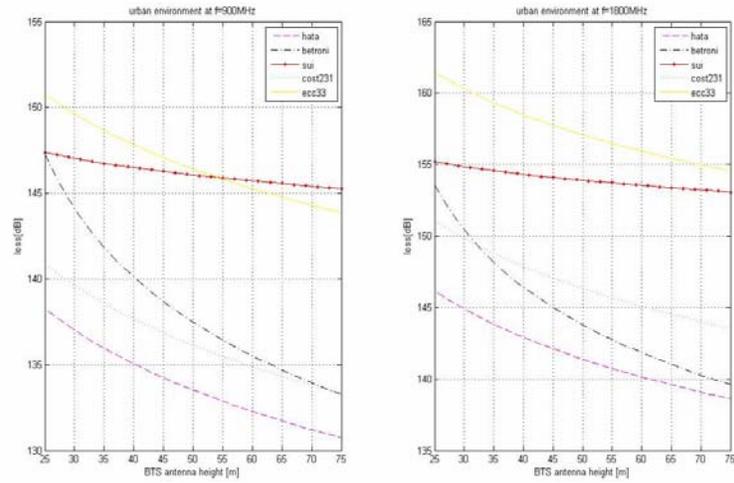


Fig.1 Variation of Path Loss with BTS antenna height

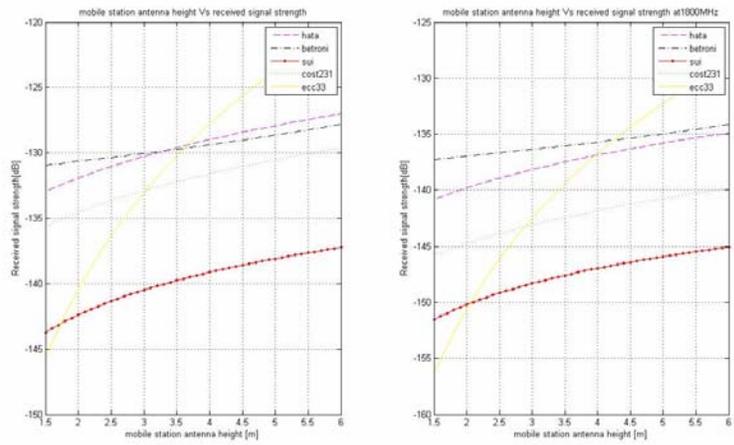


Fig. 2 Variation of Received signal strength with Mobile station antenna height

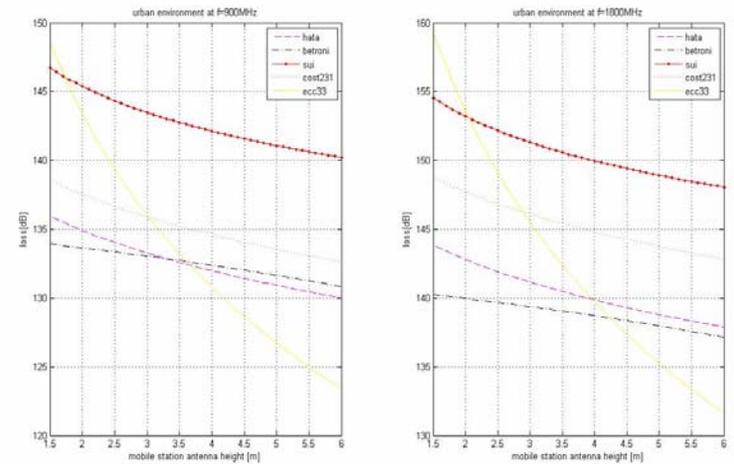


Fig. 3 Variation of Path loss with Mobile station antenna height

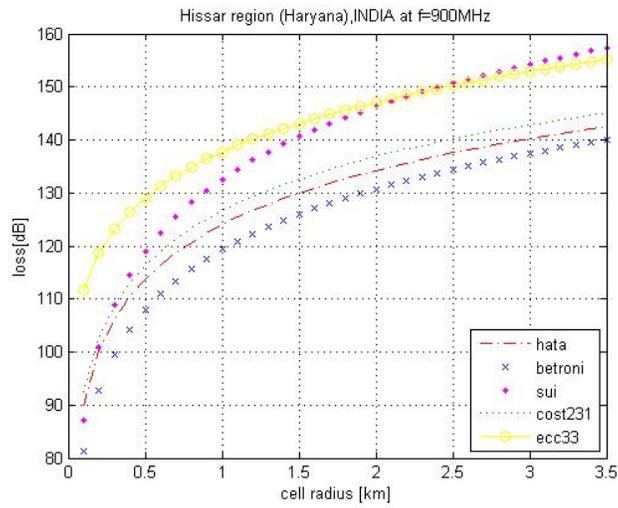


Fig. 4 Comparison of Different Path loss models

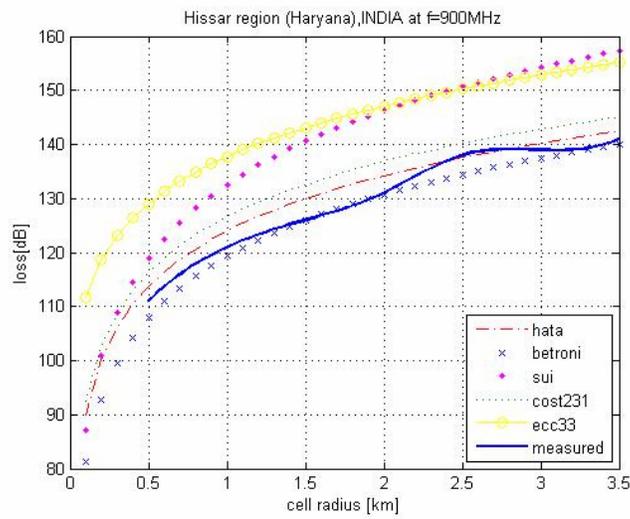


Fig. 5 Comparison of Different Path loss models with Field measured data

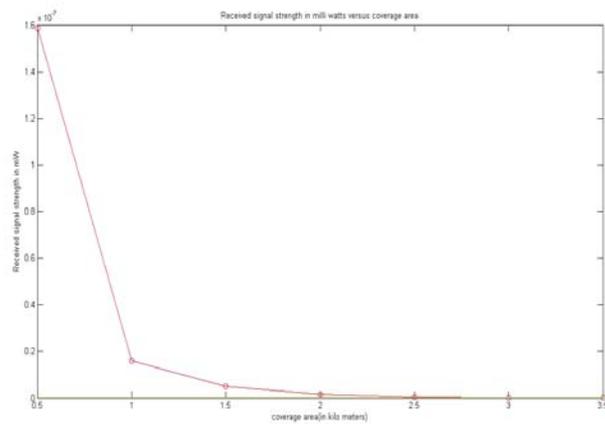


Fig. 6 Variation of Received signal strength (RSS) with distance from the BTS in Hisar

#### IV. RESULTS & CONCLUSION

The analyses and simulation was done to find out the path loss by varying the BTS antenna height, MS antenna height, and the T-R separation. From Fig. 1, it is seen that the propagation path loss decreases due to the increase in BTS antenna height for all the models. And also it is observed that the propagation path loss decreases with the increase in MS antenna height for all the models as shown in fig. 3. The result of this analysis will help the network designers to choose the proper model in the field applications. 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 congested area of the urban area Hisar (State: HARYANA, Country: INDIA) for its GSM based BSNL system using spectrum analyzer. From the fig. 6, the coverage area of Hisar region can be determined to maintain the Quality of the call. From the fig. 5 it clear that the field measured data are very close to the results from the Hata and Bertoni path loss models. Further this analysis can be used to design the propagation path loss model for the region Hisar.

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