A Performance Review of the Different Path Loss Models for LTE Network Planning

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Abstract- Long Term Evolution also called release 8, the 3GPP successor of UMTS, has brought about higher data rates, spectrum flexibility as a result of its TDD and FDD. The concept of path loss and network planning are very important to deployment of telecommunications. Path loss models are used in the initial feasibility studies in telecommunications deployment. In this paper, a comparative analysis of the five path loss models used in LTE networks was simulated using a MATLAB-based simulator; LTE MAC-LAB developed by is-wireless Poland.

Keywords - LTE, path loss, 3GPP, Propagation.

I. INTRODUCTION

The Third Generation Partnership Program (3GPP) defined Long Term Evolution (LTE) as part of its release 8 specifications [1]. LTE, which is standardized by 3GPP as the successor of the Universal Mobile Telecommunication System (UMTS), has a 100Mbit/s and 50Mbit/s peak data rate for its downlink and uplink respectively [2].

The LTE downlink transmission scheme uses Orthogonal Frequency Division Multiple Access (OFDMA); this divides the wide-band frequency selective channel into a set of many flat-fading sub-channels, which combats multipath fading.

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The signal strength of electromagnetic waves weakens during propagation through environment [3]. The difference of signal strengths from transmitter (transmitter) to receiver (destination) antenna is termed as path loss. Path loss (PL) at destination is generally determined by the use of different models i.e., deterministic and empirical [4], [5], [6]. The Path loss (PL) arises when electromagnetic waves are propagated through space from a transmitter to a receiver. PL is due to the path distance, diffraction, scattering, reflection, variations of transmitter and receiver heights, and absorption by objects of environment. The environment (i.e. urban, suburban and rural) also influences the signal strength.

In general path loss is expressed as

$$PL = \frac{POWER\ TRANSMITTER}{POWER\ RECIEVER} \text{ in dB}$$

Propagation models are tools used for feasibility studies during the initial stage of network planning [3]. Numerous propagation models are available for predicting path loss; some are limited to lower frequency bands (up to 2GHz) such as Hata Model and Okumura Model. Several path loss models are outlined in literature suitable for different types of environments such as suburban, urban, and rural [7].

II. OVERVIEW OF PROPAGATION MODELS

Actual environments are too complex to model accurately. In practice, most simulation studies use empirical models that have been developed based on measurements taken in various real environments. Propagation models can be classified mainly into two extremes, i.e. fully empirical models, and Deterministic models. There are some models that have the characteristics of both types. Those are known as Semi-empirical models. Empirical models are based on practically measured data used to predict the behaviour approximately. 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 include Hata model, Okumura model, COST-231 Hata model. On the other hand, deterministic models are very accurate.

This makes use of laws governing electromagnetic wave propagation in order to determine the received signal power. 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. Cost-231 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 [8] [9] [10].

III. SIMULATIONS AND RESULTS

In this paper we used the LTE MAC-LAB (developed by IS-Wireless Poland) a MATLAB based LTE Simulator to compare and analyse five path loss models (e.g. 3GPP model, COST 231 Hata model, Modified Hata model, User and Winner model) for in urban and suburban environment. The simulation parameters used as shown below.

Table 1: simulation parameters

Variables	Values
Height of ENodeB	20 - 200metres
Height of mobile station antenna	1 – 10metres
Frequency	1800Mhz
Distance between ENodeB and User Equipment	1 – 20km
Environment	Urban and Suburban

From Figure 2 and 3, it is evident that generally all systems have a lower path loss plot for the suburban terrain compared to the urban terrain. Also from the graphs it is evident that COST231 has a higher path loss for both terrains.

From figures 4 and 5, we discover that the 3GPP model has the best performance in both terrains, while the user model and modified hata model have similar performances at 10km and 20km.

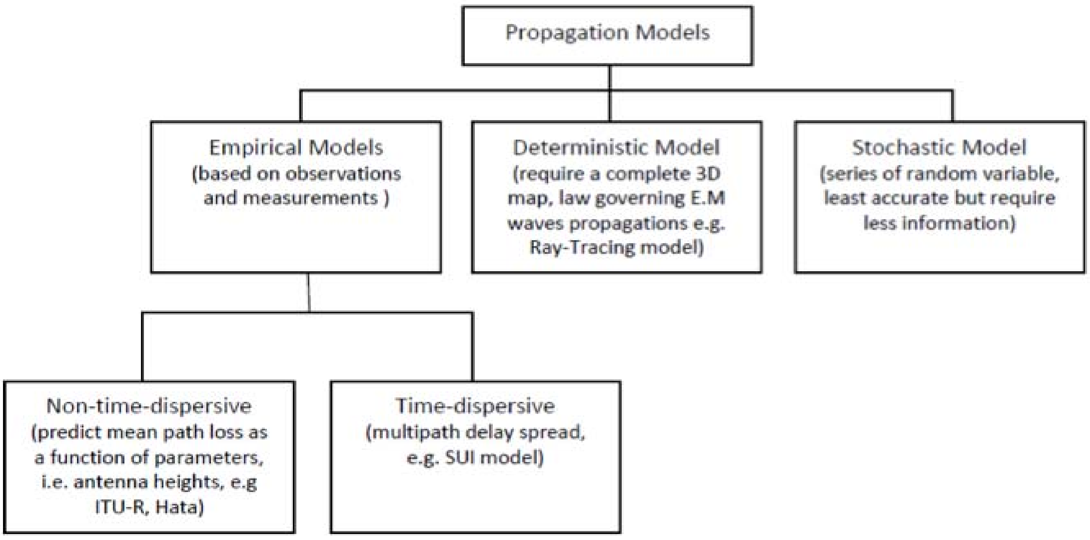

Figure 1: Propagation Model

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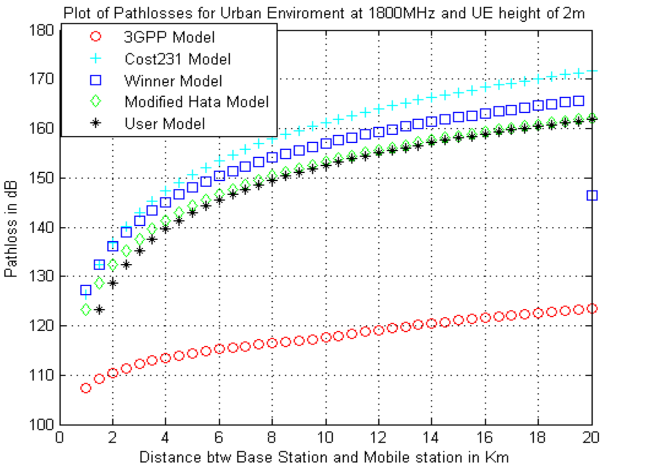

Figure 2: Urban Environment Path loss performance of the selected Models

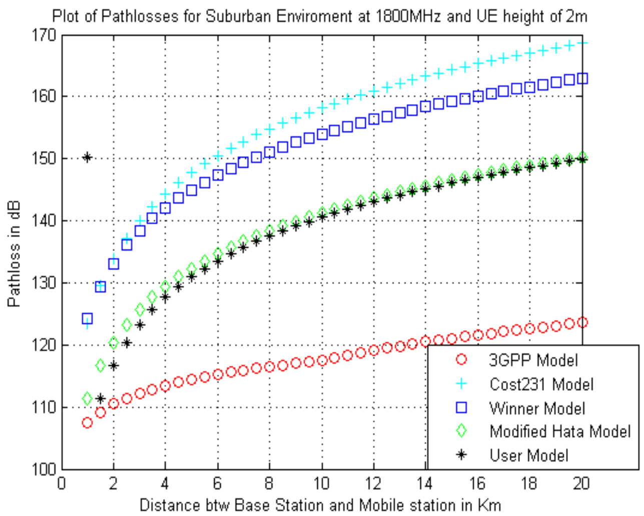

Figure 3: Suburban Environment Path loss performance of the selected Models.

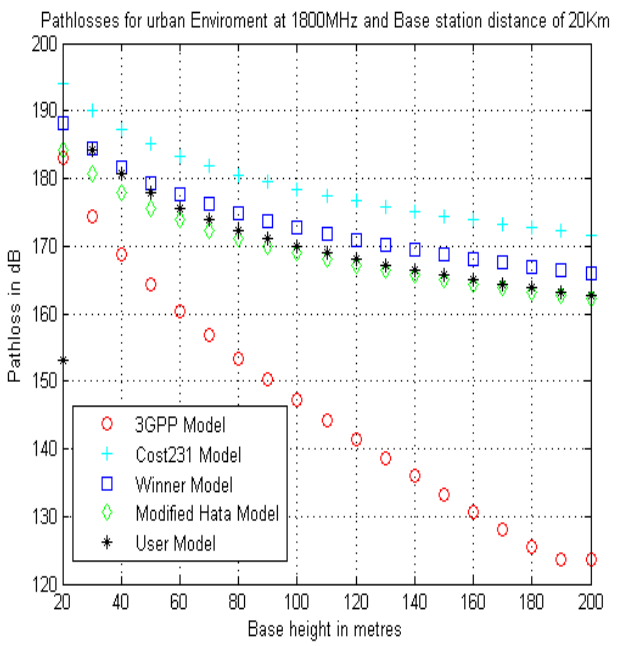

Figure 4: Urban Environment Path loss Performance for varying base station heights at 20km between UE and ENodeB

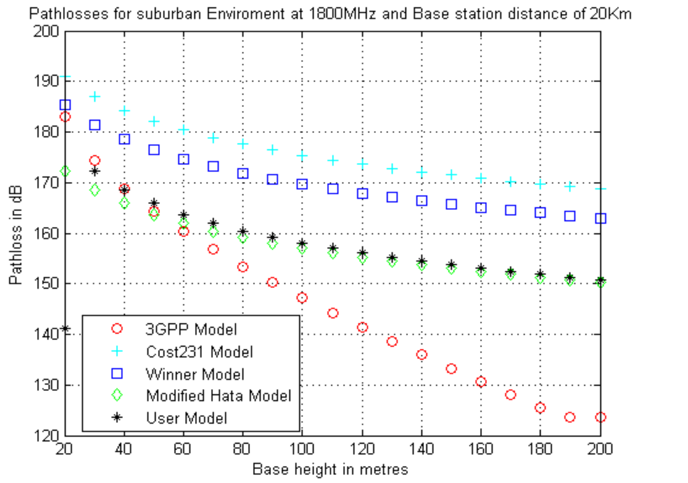

Figure 5: Suburban Environment Path loss Performance for varying base station heights at 20km between UE and E-NodeB

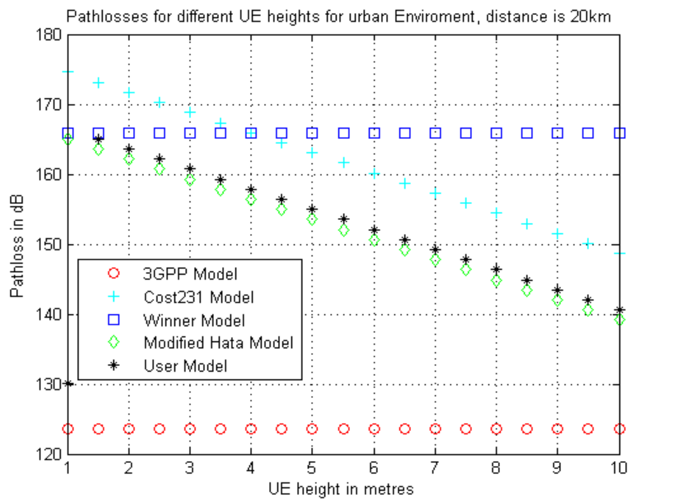

Figure 6: Urban Environment Path loss Performance for varying MOBILE station heights at 20km between UE and ENodeB

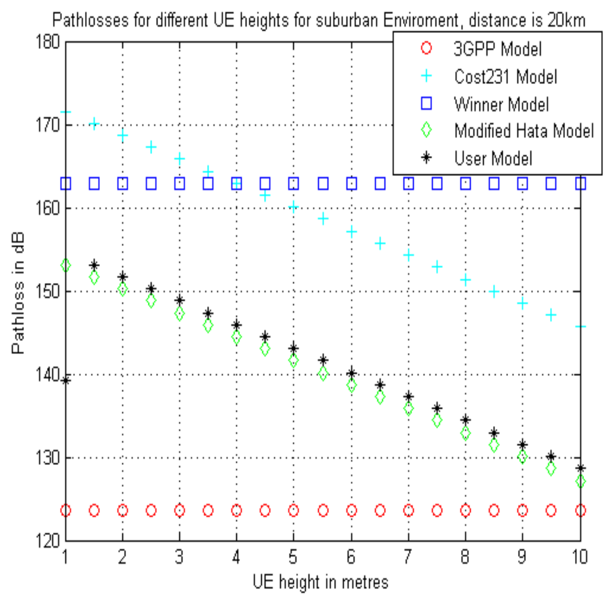

Figure 7: Suburban Environment Path loss Performance for varying mobile station heights at 20km between UE and ENodeB.

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VI. CONCLUSION

Path loss is an important tool for Network planning as it helps the designer/engineer anticipate the way the signals will be propagated as possible losses via simulations. It is clear that the 3GPP model performs better in all scenarios similar to the free space path loss. Also I discovered that winner model showed a constant behaviour when user equipment height was varied at 20km from the ENodeB in all terrains.

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