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Investigations of the Signal Path Loss in 4G LTE Network*

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Abstract. One of the most important parameters in designing and implementing a 4G Long Term Evolution (LTE) network is path loss prediction. Software simulations based on empirical models make it possible to estimate path loss propagation in a mobile environment. The dependence of path loss on distance is measured at a frequency of 1800 MHz in Lozenets area.

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1 Introduction

Path Loss (PL) is an important parameter in the energy budget of each mobile cells. For this reason, it is necessary to estimate or measure path loss with such precision and accuracy as to provide effective and stable connection in the coverage area. In this paper the empirical models are used in the frequency range (1700–1800 MHz) which is necessary for the implementation of 4G LTE networks in Bulgaria. The obtained results show path loss dependence on the distance between the base and mobile stations at different antenna parameters. The results are compared to path loss measurements made at the Faculty of Physics at Sofia University.

2 Path Loss Prediction Models

The selected models COST 231 Hata, Stanford University Interim (SUI) and COST 231 Walfisch-Ikegami describe path loss at a frequency of 1800 MHz and they take into account the specific characteristics of the area chosen for the study (the campus of Sofia University St. Kliment Ohridski, Lozenets area). Software programs were developed to carry out simulations for dependence of path loss on the distance between the base and mobile stations.

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The COST 231 Hata model is suitable for the frequency range of 500–2000 MHz [1]. This model allows for corrections on urban, suburban and rural terrains. The path loss equation in dB is:

$$PL = 46.3 + 33.9 \log_{10}(f) - 13.82 \log_{10}(h_t) - \alpha(h_r) + (44.9 - 6.55 \log_{10}(h_t)) \log_{10} d + c_m, \quad (1)$$

where f is the frequency in MHz, d is the distance between transmitter and receiver antennas in km, h_t is the transmitter antenna height in m, h_r is the receiver antenna height in m. Parameter $\alpha(h_r)$ is set according to the environment.

The parameter c_m depends on the type of environment, as in suburban environment it is 0 dB and in urban it‘s value is 3 dB.

The SUI model has been developed at Stanford University [2]. According to the model, the path loss equation in dB is:

$$PL = A + 10\gamma \log_{10}(\frac{d}{d_0}) + X_f + X_h + s, \quad (2)$$

where d is the distance between the base station and the receiver antenna in m, $d_0 = 100$ m, X_f is a correction factor for frequencies higher than 2 GHz, X_h is a correction factor for the receiver antenna height, s is a shadowing correction factor in dB, and γ is the path loss exponent. The parameter A is responsible for free space loss in dB and is defined as:

$$A = 20 \log_{10}(\frac{4\pi d_0}{\lambda}), \quad (3)$$

where λ is the wavelength in m.

In comparison to the other models, COST 231 Walfisch-Ikegami provides better path loss prediction in a urban environment [3].

For the line of sight (LOS) case, the path loss equation in dB is:

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

For the no line of sight (NOLS) case, the path loss equation in dB is:

$$PL_{\text{NLOS}} = L_{\text{FSL}} + L_{\text{rts}} + L_{\text{msd}}, \quad (5)$$

where L_{FSL} stands for free space loss, L_{rts} represents roof top to street diffraction, and L_{msd} accounts for multi-screen diffraction loss.

3 Theoretical and Experimental Results

Simulations were carried out at different configurations of the receiver and the transmitter antenna heights. Figure 1 shows the dependece of PL on the distance

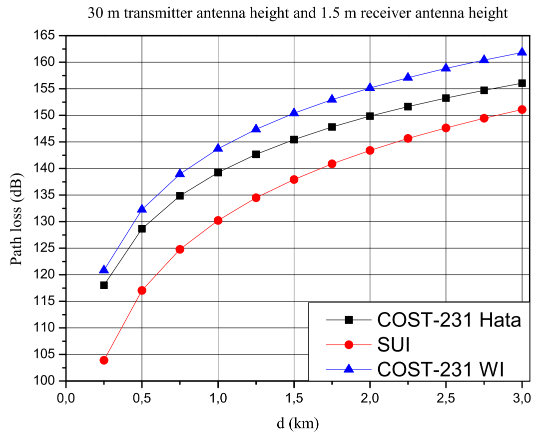

Figure 1: Path loss of the signal at the antenna height of the base station 30 m and height of the receiving antenna 1.5 m.

between the base and mobile stations when the antenna heights are 30 m and 1.5 m, respectively. Path loss increases as the distance between the antennas decreases and this tendency is most pronounced for COST 231 – Walfisch-Ikegami.

Figure 2 illustrates path loss values according to the three models and different receiver height. Results show that PL decreases as the receiver antenna height

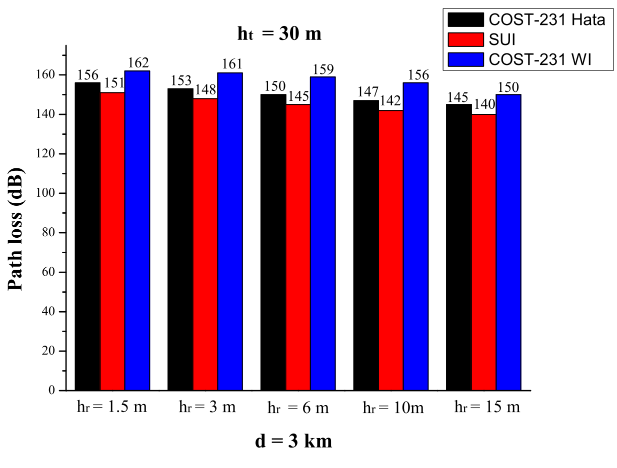

Figure 2: Results for PL at height of the transmiter antenna 30 m and receiving antenna height of 1.5 m to 15 m.

increases but this dependence is weak at all three models. The path loss measurements made in the area of the Faculty of Physics are presented in Table 1 for $h_r = 1.5$ m.

Table 1: Experimental data of the measurements

d (m)	$\overline{S}$ (μW/m^2)	E (mV/m)	PL (dB)
350	0.25	9.71	89
380	0.16	7.77	91
400	0.06	4.76	95
500	0.04	3.9	97
550	0.1	6.14	93

4 Conclusion

The obtained results show the possibility to predict path loss in 4G LTE networks applying the empirical models. The comparison made between the theoretical and experimental results indicate that the SUI model describes well the path loss in the studied area.

References

[1] V.S. Abhayawardhana, I.J. Wassel, D. Crosby, M.P. Sellers, M.G. Brown (2005) *61st IEEE Technology Conference*.

[2] V. Erceg (2000) *IEEE 802.16 Broadband Wireless Access Working Group*, California.

[3] V. Erceg et al. (2001) *IEEE 802.16 Broadband Wireless Access Working Group*, California.