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Study of Semi Deterministic Model for Fifth-Generation (5G) Wireless Networks

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Abstract

This paper presents study of path loss models of fifth generation (5G) wireless communication systems. Propagation parameters such as path loss at reference distance (PL(d0)), path loss exponent (PLE) and standard deviation of the zero-mean Gaussian random both line-of-sight (LOS) and non line-of-sight (NLOS) are compared at the frequencies of 28, 38 and 73 GHz. Omni directional propagation large-scale path loss measured data from two downtown Cities are used. This paper also compares with semi deterministic models such as WI model and Xia model for present 4G network in order to develop the semi deterministic model for 5G

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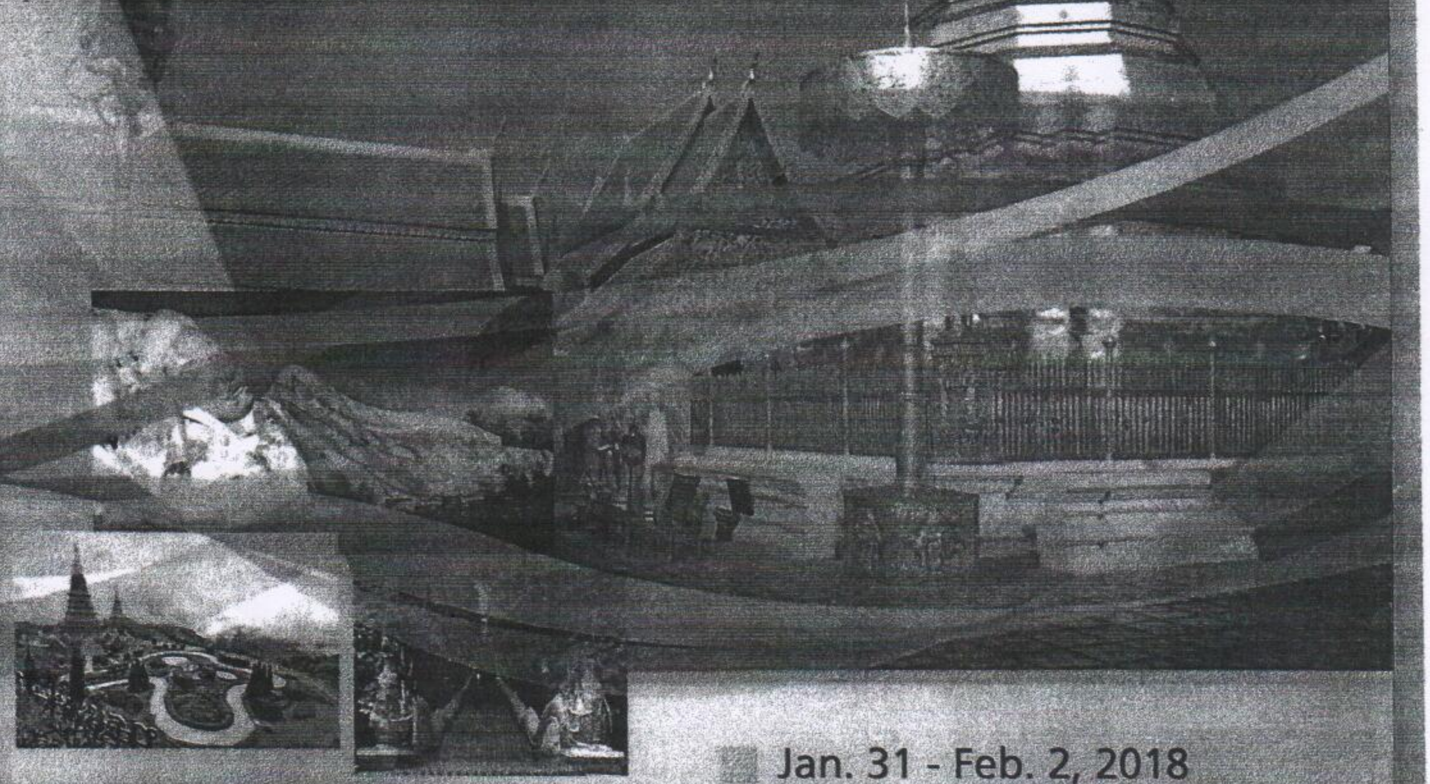

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Acceptance letter

Dear Mr. Supachai Phaiboon:

Congratulations! First of all, thank you very much for submitting your paper to International Conference on Green and Human Information Technology (ICGHIT) 2018 which will be held in Chiang Mai, Thailand Jan. 31 ~ Feb. 2 2018. After collecting reviews, we are happy to inform you that your paper entitled Paper: #1570422915 Title: Semi Deterministic Model for Fifth-Generation (5G) Wireless Networks Authors: Supachai Phaiboon Your paper #1570422915 has been __accepted__ and will be presented in International Conference on Green and Human Information Technology 2018.

The reviews are below or can be found at https://edas.info/showPaper.php?m=1570422915. ======= Reviewer comment 1 =======

*** Relevance: Relevance(4: Excellent; 3: Good; 2: Average; 1: Weak; 0: Poor) 3 (3)

*** Clarity: Clarity(4: Excellent; 3: Good; 2: Average; 1: Weak; 0: Poor) 2 (2)

*** Language: Language(4: Excellent; 3: Good; 2: Average; 1: Weak; 0: Poor) 2 (2)

*** Significance: Significance (4: Excellent; 3: Good; 2: Average; 1: Weak; 0: Poor) 2 (2)

*** Originality: Originality (4: Excellent; 3: Good; 2: Average; 1: Weak; 0: Poor) 2 (2)

*** Scientific Quality: Scientific Quality (4: Excellent; 3: Good; 2: Average; 1: Weak; 0: Poor) 2 (2)

*** Overall Judgement: Please indicate your judgement Accept (3)

*** Referee's Familiarity with the Topic: Referee's Familiarity with the Topic Medium (1)

*** Comments to Author(s): Please give comments of the paper: The aim of this paper is to compare various propagation path loss models of empirical and semi-deterministic models in order to develop the semi deterministic model for 5G networks in the next step. The topic is acceptable for the conference. (typo error) In the section of V. Conclusion, "The results shown that..." ===> "The results show that..."

======= Reviewer comment 2 =======

*** Relevance: Relevance(4: Excellent; 3: Good; 2: Average; 1: Weak; 0: Poor) 3 (3)

*** Clarity: Clarity(4: Excellent; 3: Good; 2: Average; 1: Weak; 0: Poor) 3 (3)

*** Language: Language(4: Excellent; 3: Good; 2: Average; 1: Weak; 0: Poor) 4 (4)

*** Significance: Significance (4: Excellent; 3: Good; 2: Average; 1: Weak; 0: Poor) 4 (4)

*** Originality: Originality (4: Excellent; 3: Good; 2: Average; 1: Weak; 0: Poor) 4 (4)

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Study of Semi Deterministic Model for Fifth-Generation (5G) Wireless Networks

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***Abstract*— This paper presents study of path loss models of fifth generation (5G) wireless communication systems. Propagation parameters such as path loss at reference distance (PL(d_0)), path loss exponent (PLE) and standard deviation of the zero-mean Gaussian random both line-of-sight (LOS) and non line-of-sight (NLOS) are compared at the frequencies of 28, 38 and 73 GHz. Omni directional propagation large-scale path loss measured data from two downtown Cities are used. This paper also compares with semi deterministic models such as WI model and Xia model for present 4G network in order to develop the semi deterministic model for 5G networks.**

***Keywords*— Empirical model, semi derterministic model, two downtown cities, Millimeter-Wave Omni-directional Path Loss.**

I. INTRODUCTION

Mobile communication is moving to fifth generation (5G) at millimeter wave (mmWave) frequencies in order to provide multi-Gigabit-persecond (Gbps) data rates to a mobile device for video and the Internet-of-Things (IoT). In order to install communication station, the propagation path loss models are one of important things. There are three types of the path loss models namely, empirical model, semi-deterministic model and deterministic model. The empirical models for 5G [1][2] are widely used since they need only frequency, PLE and distance to compute the path loss for macro and micro cell planning while the deterministic models need the details of digitize map and material of buildings. Additionally they use a lot of time for computing. Finally the semi-deterministic models [3][4][5][6][7][8][9] are also widely used since they are not only need the parameters of the empirical model but also require some information about buildings such as dimension and type of them together with wide and direction of road. This model provides more accuracy path losses and is used for planning and solving the communication system. For semi-deterministic models, there are previous studies as follows; Xia et al.[3][4] proposed path loss formulas for micro-cells in low-rise and high-rise building environments. Additionally, COST 231 WI model [5][6][7] is also a popular prediction tool for micro cell environments. However, they need environment data base details. In case of the Xia model for non light of sight (NLOS), it requires a set of model parameters such as distance from the last roof top to receiver, average building height, and antenna heights as in our research [8][9], while the WI model requires the road parameters such as height of buildings, width of the roads, building separation and road orientation with respect to the direct radio path. The aim of this research is a study the millimeter wave empirical path loss model also compares with semi deterministic models such as WI model and Xia model for present 4G network in order to develop the semi deterministic model for 5G networks in the next step.

In this paper, we present path loss models in Section 2.Measurement and locations are presented in Section 3.The results and analysis are presented in Section 4. Finally, the conclusion is drawn in Section 5

II. PATH LOSS MODELS

A. Empirical path loss model

This model does not utilize the parameter of specific area except the frequency and distance.

$$PL_{LN}(dB) = PL(d_0) + 10n\log_{10}\left(\frac{d}{d_0}\right) + x_\sigma \quad (1)$$

Where n is the path loss exponent, that indicates the attenuation rate at the distance (n = 2 for free space), $PL(d_0)$ is the path loss at a reference distance 1 m. and X_σ is a zero mean random variable, that have Gaussian distribution with standard deviation σ. The $PL(d_0)$ is found from eq. (2)

$$PL_{FS}(dB) = 32.44 + 20\log_{10}(f) + 20\log_{10}(d) \quad (2)$$

It can find frequency f in unit of GHz and the distance d in meters. This case is valid for the free space and far-field region. If the ground reflection over an earth plain was included, the model becomes.

$$PL_{GR}(dB) = PL_{FS}(dB) - 20\log_{10}\left[2\left|\sin\left(\frac{\beta h_T h_R}{d}\right)\right|\right] \quad (3)$$

h_T and h_R are the transmitter and receiver antenna heights, respectively. $\beta = 2\pi/\lambda$ and λ is the wavelength. This case is valid for large distances from the transmitter, and $\gg \beta h_T h_R$, that only depends on d, h_T and h_R, and the attenuation which correspond to the free space.

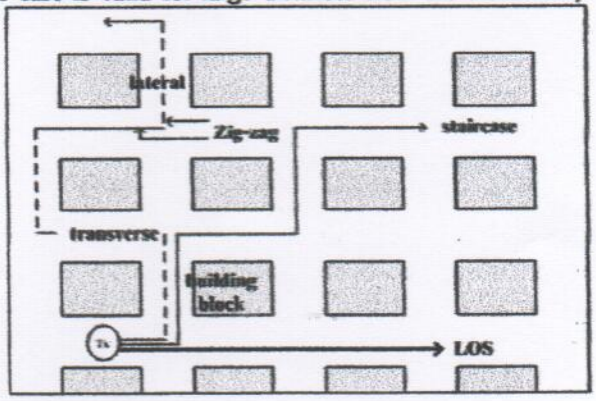

Fig. 1 Geometry of Xia model

B. Semi-deterministic path loss model

There are two approach models which are used for a 2 D map, are compared as follows:

- Xia model

The original Xia model for low-rise environments with one five story building was applied to predict path loss becauuse it needed 2 D maps of buildings for calculation. There are three routes for prediction namely, staircase route, transverse route and lateral route as shown in Figure 1. A transmitter (Tx) was located on the street in the middle of a building block. The original Xia path loss formulas for all non line of sight cases were written as,

$$PL(d) = [139.01 + 42.59 \log fG] - [14.97 + 4.99 \log fG]\mathrm{sgn}(\Delta h)\log(1+|\Delta h|) + [40.67 - 4.57\mathrm{sgn}(\Delta h)\log(1+|\Delta h|)]\log d + 20\log(\Delta hm/7.8) + 10\log(20/dh) \quad (3)$$

Where d is the mobile distance from transmitter (km). [0.05 < d < 3], fG is the frequency (GHz). [0.9 < fG < 2], Δh is the relative height of transmitter to average building height (m). [-8 < Δh < 6], Δhm is the height of the last building relative to the mobile (m), dh is the distance of mobile from the last rooftop (m), hb is the transmitting antenna height from ground level (m), hm is the mobile antenna height from ground level (m) and λ is the wavelength (m).

- WI model

WI model is written in case of non line of sight as follows:

$$L(NLOS) = 32.4+20\log(f)+20\log(d)+L(diff)+L(mult)+3 \quad (4)$$

Where

$$L(diff) = -6.9+10\log(w)+10\log(f)+20\log(dhm)+Lori \quad (5)$$

When f is frequency (MHz), d is distance (km.), W is width of road (m.), hb is base station antenna height (m.), hm is mobile height (1.8 m.) hroof is average height of roof top, dhm is distance between hm and hroof.

$$Lori = -10+0.354\phi \text{ for } 0 \le \phi < 35$$
$$= 2.5+0.075(\phi-35) \text{ for } 35 \le \phi < 55$$
$$= 4-0.114(\phi-55) \text{ for } 55 \le \phi < 90 \quad (6)$$

where ϕ is the angle between incidences coming from base station and road

$$L(mult) = k0+ka+kd\log(d)+kf\log(f)-9\log(W) \quad (7)$$

Where k0= 0, kd= 18-15(dhb/hroof), ka = 54-0.8 (dhb), and kf = -4+0.7[(f/925)-1] in case of sub-urban study.

III. Measurement and Location

This paper used measured data in the dense urban environment around New York University's (NYU) Manhattan campus at both 28 GHz and 73 GHz [1] [2],and around the campus of The University of Texas at Austin (UTA) at 38 GHz. These measurements will be Omni directional large-scale line-of-sight (LOS) and non-line-of-sight (NLOS) directional measurements.

In the NYU, the building density is about 65% while the building height is about 5-50 m. In the UTA, the building density is about 55% while the building height is about 5-30 m. The measurement procedure and description of the equipment can be found for details in [1].

The transmitting antenna heights of 28 GHz and 73 GHz are 7 and 17 m while the transmitting antenna heights of 38 GHz are 8, 23,36 m. The receiving antenna heights of 28 GHz and 38GHz are 1.5 m while the receiving antenna heights of 73 GHz are 2.0 and 4.06 m.

IV. Results and Analysis

The empirical path loss model at frequencies of 28 GHz, 38 GHz and 73 GHz are respectively as following.

A. Empirical LOS

$$PL_{28\,GHz}(dB) = 61.3 + 21\log_{10}(d) \quad (8)$$