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4G Signal Strength Measurement and Simulation for Outdoor Environment at 1.8 GHz and 2.6 GHz

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Abstract: This paper presents the signal strength measurement of the 4G network for an outdoor environment. The signal strength is measured at the Universiti Teknologi Malaysia (UTM) at 1.8 GHz and 2.6 GHz. The signal measurement is compared with the simulation using WinProp software. The database was created for the simulation, and the received signals were recorded at certain locations. The measured and simulated results show that the signal is comparable, where the highest signal is -56 dBm at 1.8 GHz and -49 dBm at 2.6 GHz.

Keywords: 4G network, signal strength, 1.8 GHz, 2.6 GHz.

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1. INTRODUCTION

The 4th generation (4G) mobile communication technologies, which provides high-speed wireless access with over 1 Gbps in stationary conditions and over 100 Mbps in highly mobile environments, was available in the first quarter of 2010 [1]. LTE –Advanced is the next step of development in wireless communications. It is selected as the candidate for 4G by the International Telecommunication Union (ITU) and International Mobile Telecommunications (IMT)-Advanced [2]. The system is based on Orthogonal Frequency Division Numerous Access (OFDMA), Multiple Input Multiple Output (MIMO), and Coordinated Multipoint (CoMP) transmission/reception techniques that coordinate multiple cell sites. In order to meet the needs of 4G in LTE-A, it differs from prior wireless technologies [2, 5]. Before 4G, 3G is created but the technology are not capable to provide data rate higher than 2 Mb/s. These systems are fourth-generation (4G) systems with transmission rates of up to 155 Mb/s [4], which is particularly impressive in an indoor context. Apart from high data rates, 4G systems should support higher capacity and lower cost per bit, excellent quality of service (QoS), and sufficient coverage with variable transmission rate, as well as next-generation Internet protocols (IPv6) and a reliable interface with 3G systems and wireless local area networks (WLANs) [3].

Before establish these technologies, there are several factors that need to be consider such as the path loss. Several propagation models for predicting path loss exponents from base to mobile and base to relay station links have been presented [6]. Path loss causes attenuation, which is caused by frequency, distance between Transmitter (Tx) and Receiver (Rx), ground operation, and antenna height [10]. Besides path loss, the transmitter antenna height and receiver antenna height must be considered in the planning of a radio communication network for short-distance communication, as well as the emitted power and cell radius area (urban, suburban, or rural), all of which are strongly influenced by the amount of attenuation that occurs along the channel (pathloss) [9]. Radio propagation parameters, such as route loss, delay spreads, and attenuation owing to power leakage through walls of buildings, play a crucial role in system design, especially on an experimental basis [7]. Because the wavelength of the used frequencies varies, objects of various sizes might affect radio channel propagation at midbands and high bands [8]. As a result, accurate path loss modelling is required for reliable and high-efficiency wireless network planning [11]. As for Malaysia, 4G networks are using two frequency bands namely 1.8 GHz and 2.6 GHz.

In this paper, the simulation and measurement of signals strength at 1.8 GHz and 2.6 GHz has been analyzed and compared. The database of the area is being created from Open Street Map on the internet.

2. SIMULATION

The simulation is carried out at the Universiti Teknologi Malaysia (UTM). The area has many terrains such as vegetation, buildings and hills. The simulation is done by using WinProp software. The input simulation parameters are mentioned in Table 1. As for the transmitter location, the location has been looked up, and there are several base stations around UTM for different telecommunication providers namely Celcom, Maxis, Digi and U-Mobile. Figure 1 shows the location of the transmitter location. Six places have been selected inside UTM for the simulation readings. Figure 2 shows the location with 'U', 'V', 'W', 'X', 'Y' and 'Z' are selected for the reading.

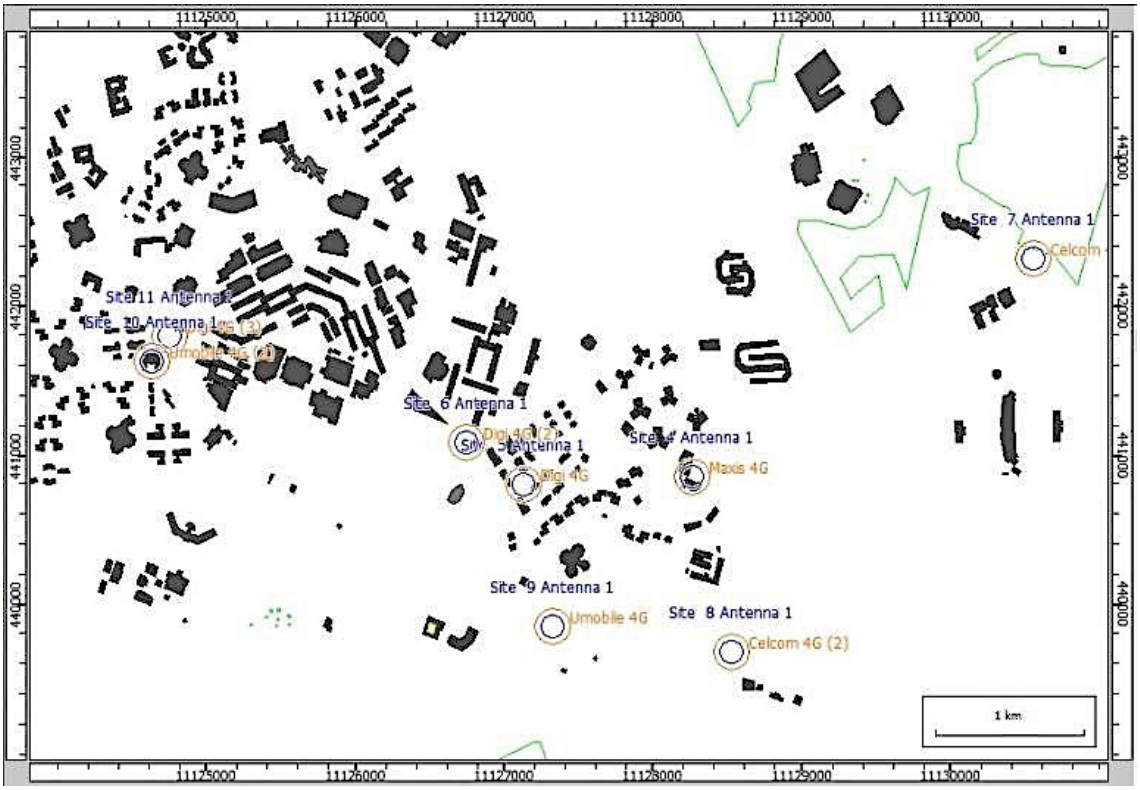


Figure 1. The location of transmitter base station around UTM

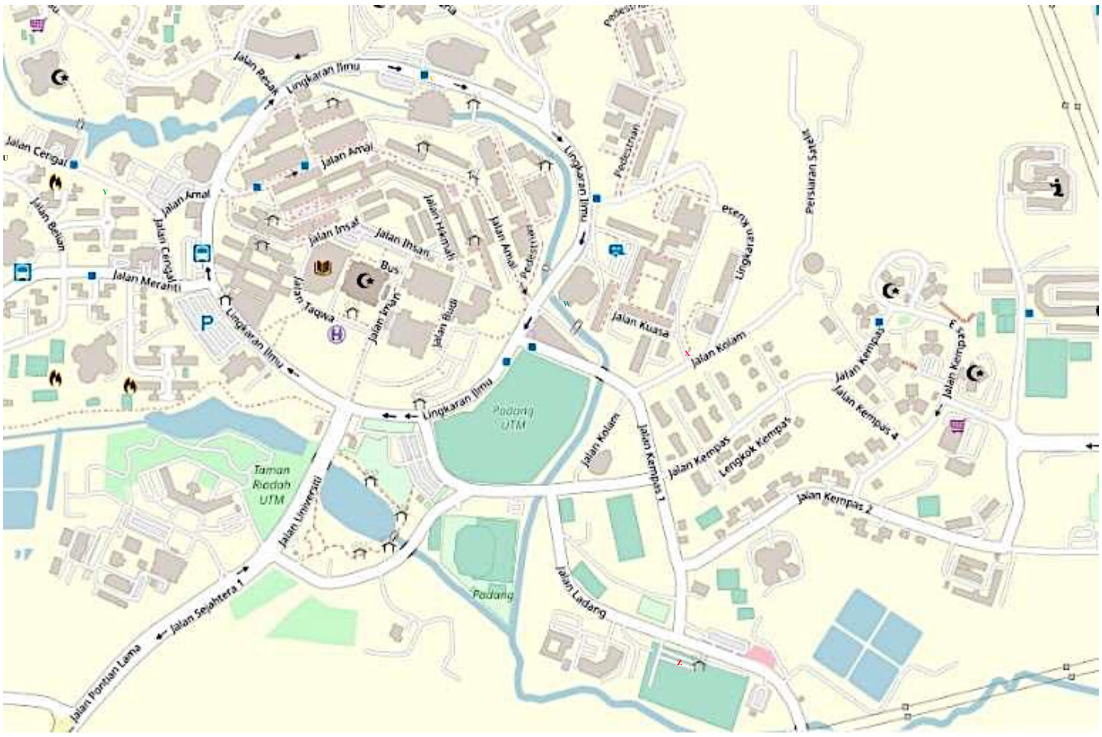


Figure 2. Placement of location for the simulation reading

Table 1. Simulation parameters.

Parameters	Values
Tx power	40 dBm
Transmitter antenna height	15 m
Frequency	1.8 GHz, 2.6 GHz

3. MEASUREMENT

The field measurement of the signal strength has been conducted for validation of the simulation readings. The measurement is conducted by using HF-60100 V4 Aaronia Spectrum Analyzer, as shown in Figure 3. The specification of this device is shown in Table 2. The measurement is conducted at the same location as the readings for the simulation. The measurement has also been done using MCS Spectrum software. This software is provided by Aaronia. In order to use this software, the spectrum analyzer must be connected to a laptop or desktop for the measurement. The measurement is more accurate than using the analyzer only, as shown in Figure 4.

Table 2. Specification of HF-60100 V4

Specification	Values
Frequency range	9 kHz – 9 GHz
Displayed Average Noise Level	40 dBm
Max. power at RF input	+20 dBm
Resolution bandwidth range	200 Hz – 50 MHz
Sample time	1 mS
Accuracy	+/- 1dB

Figure 3. Aaronia Spectrum Analyzer

(a)

(b)

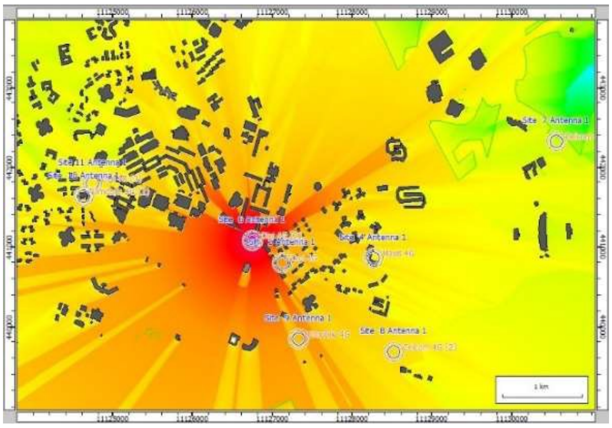
Figure 4. Sample measurement at location ‘Z’; a) at 1.8 GHz b) at 2.6 GHz

4. RESULT AND ANALYSIS

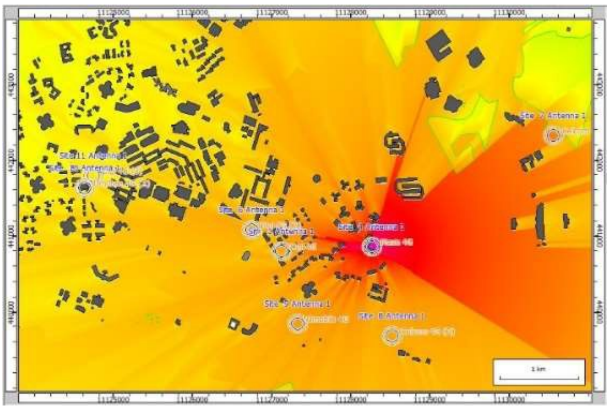
This section outlines the findings for both simulation and measurement. The results between simulation and measurement are compared for both 1.8 GHz and 2.6 GHz

4.1 Simulation Results

The results that have been obtained from the simulation are different for each transmitter base station, as shown in Figure 5 (a) and Figure 5 (b). Therefore, the values for the signal strength are taken from the nearest transmitter base station that are located towards the locations of the readings. Table 3 shows the results of the simulation for 1.8 GHz and 2.8 GHz frequencies.



(a)



(b)

Figure 5. The signal strength of antenna; (a) Digi (b) Maxis

Table 3. Simulation results for 1.8 GHz and 2.6 GHz.

Place of Reading	Frequency 1.8 GHz (dBm)	Frequency 2.6 GHz (dBm)
U	-74	-60
V	-75	-56
W	-64	-55
X	-71	-54
Y	-56	-49
Z	-75	-61

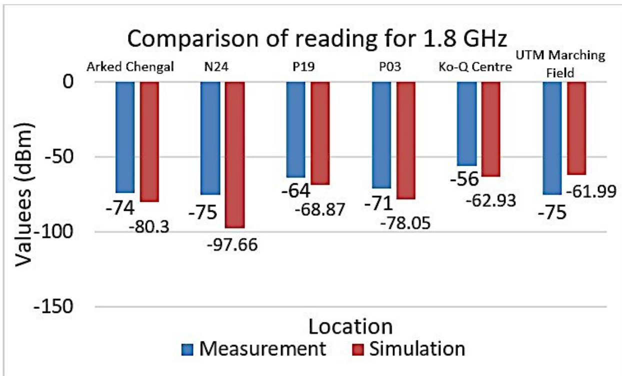
4.2 Measurement Results

This section discusses the results of measurement for 1.8 GHz and 2.6 GHz frequency bands by using Aaronia Spectrum Analyzer at the location that has been selected for the readings. Table 4 shows the results of the measurement at 1.8 GHz and 2.6 GHz.

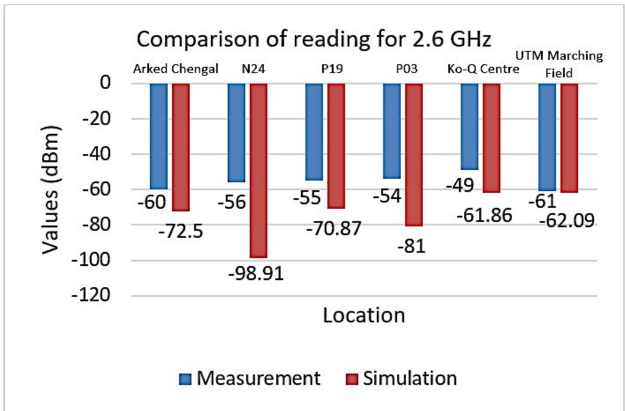
Table 4. Results of measurement reading at 1.8 GHz and 2.6 GHz.

Place of Reading	Frequency 1.8 GHz (dBm)	Frequency 2.6 GHz
U	-74	-60
V	-75	-56
W	-64	-55
X	-71	-54
Y	-56	-49
Z	-75	-61

A comparison of signal strength has been made between the simulation and the measurement for both 1.8 GHz and 2.6 GHz frequencies as presented in Figure 6. From the comparison, it can be observed that the magnitude of received power is higher for measurement compared with the simulation. It happened due to the complex surrounding environment in UTM Campus.



(a) 1.8 GHz



(b) 2.6 GHz

Figure 6. Simulated and Measured result at two different frequencies

5. CONCLUSION

This paper compares the propagation measurement and simulation of 4G wireless networks operating at 1.8 GHz and 2.6 GHz in an outdoor environment. The proposed frequencies for Malaysian LTE operators are in these carrier bands [3]. Both of the frequency bands have different propagation due to the wavelength of the frequency. Due to different propagation, both frequencies have different path loss models and resulted in different magnitudes of signal strength. By referring to the results, we can conclude that there is some difference between simulation and measurement readings. It is due to the terrains and the vegetation that can affect the radio propagation. As in the simulation, some vegetation cannot be seen in the software. It is because the size of the vegetation is too small for the simulation. But in real-time, those vegetation affects the signal strength and make the signal strength differ from the simulation. As the measurement is done at 1.8 GHz and 2.6 GHz, the software is measured from the nearest transmitter base station for a better signal. This can be supported by the simulation done on WinProp. For example, at location 'Z', the result for simulation for the nearest transmitter base station at 1.8

GHz is – 75 dBm. But when using a further base station, the result for the simulation is lower than the nearest base station. It means the further the transmitter, the lower the signal strength.

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