American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-02, Issue-07, pp-99-106
www.ajer.org

Research Paper Open Access

Experimental Study of Umts Radio Signal Propagation Characteristics by Field Measurement

Isabona Joseph[1], Konyeha. C.C[2]
1&2Department of Basic Sciences, Benson Idahosa University, PMB.1100, Benin City, Nigeria

Abstract: - Knowledge of propagation characteristics in the mobile channel is important to the design, analysis and optimisation of a cellular system. Such need is of great concern to achieve higher quality standards, lower overall running cost, minimize transmit power, better covering of different areas with different environmental situations. Thus, received signal prediction models play an important role in the RF coverage optimization and efficient use of the available resources in wireless communication. As the demand of location based services (LBS) increases in non-line of site (NLOS) environment, a robust received signal prediction model is needed to enhance the accuracy of the LBS techniques. This paper presents a large scale received signal prediction model for various types of propagation environment from field measured signal data. Based on the experimental data obtained, path loss exponent and standard deviation of signal strength variability are determined. It is shown that the values of these parameters vary from study location to location in the coverage area. The results indicate that different empirical models for mean signal strength should be used in different regions of the coverage area for cellular network planning.

Keywords: *- Signal Propagation Characteristics, Propagation Exponent Received, Signal strength Prediction model, coverage optimisation*

I. INTRODUCTION

Universal Mobile Telecommunication Systems (UMTS) is one of Third Generation (3G) standards. It is an upgrade from GSM via GPRS and EDGE. The standardization work for UMTS is carried out by Third Generation Partnership Project (3GPP) [1][2]. It aims at providing global roaming. It also inculcates various multimedia services for voice, data and video at increased data rates of 384 kbps while moving and 2 Mbps when stationary at specific locations. It also has greater capacity with higher efficiency than first and second generation systems and it can also work in conjugation with Internet protocol. Higher bandwidth here enables a wide range of applications for both customers and business. For the consumer it provides video streaming, TV broadcast, video calls, video clips – news, music, sports, enhanced gaming, chat, location services etc and for business it provides high speed teleporting access, sales force automation ,video conferencing and real-time financial information.

Signal propagation prediction models used in GSM 900/1800 systems are not one to one applicable UMTS due to frequency differences [3]. Path loss prediction models used in GSM system should be extended to find suitable expression for 2100MHz. Another important difference between UMTS and GSM systems in terms of radio propagation is the difference in the carrier spacing which is 5 MHz in UMTS system and 200 kHz GSM system. For this reason, UMTS system is more vulnerable to frequency selective fading than GSM systems.

Particularly, as wireless signal traverse the path from a transmitter to a receiver, they will be diffracted, scattered, and absorbed by the terrain, trees, building, vehicles, people etc. that encompasses the propagation environment. The presence of obstructions along the path may cause signal to experience greater attenuation than it would under free space conditions [4]. Radio signal attenuation and path losses depend on the environment and have been recognized to be difficult to calculate and predict [5].

Past studies of the signal propagation, in both indoor and outdoor environment have used several models with varying degrees of success and or complexity, if we focus on the signals of UMTS; we have to consider the propagation environments we will run into. The quality of coverage of any wireless network design depends on the accuracy of the propagation model, which in turn depends on the factors including distance from the desired base station (BS) and interfering BSs, path loss exponent, shadowing and multipath fading [6], [7].

The propagation characteristics of mobile radio environment are also derived from the field measurement studies [8–10]. Thus, for accurate cellular network design, the propagation models are estimated from signal strength measurement taken in the study area [11], [12].

In this paper, the field measurements of received signal strength (RSS) taken at the frequency of 2100 MHz in a vehicular environment have been analyzed and reported. The received signal levels from the BS were monitored from inside a vehicle moving at a speed of about 30 km/h. Total coverage area chosen for the measurement campaign consisted of a mixture of significantly different propagation environments

II. MATERIALS AND METHOD

Measurement-based Prediction (or MbP) is a unique radio propagation process, which increases the accuracy of conventional propagation model predictions by making use of measured data to improve the model predictions around base station sites. The measurements were conducted from a UMTS network with WCDMA interface transmitters, located BIU Campus, Ugbor Avenue and Gapiona Avenue, all evenly distributed in Government Reservation Area (GRA), Benin City. The driving routes in these different locations are shown in figure 1-3. The measured received signal strength data which is the Received Signal Code Power (RSCP) and transmitter-receiver (T-R) separation distance (d) are recorded in dBm and m. Every measurement points of received signal strength and T-R separation distance are recorded evenly from all the predefined routes of three base stations. Each measurement point is represented in an average of a set of samples taken over a small area ($10m^2$) in order to remove the effects of fast fading [11].

The data collection tool consisted of ERICSSON TEMS (Test Mobile Systems) Cell-Planner tool with an antenna mounted on a moving vehicle 1.5 meter above ground level, Global Positioning System Receiver Set (GPS system) and a personal computer and a piece of compass. The personal computer houses the operating system and the data collection software (ERICSSON TEMS Investigation 8.0). The personal computer serves as the communication hub for all other equipments in the system. . The GPS operates with global positioning satellites to provide the location tracking for the system during data collection position on a global map which has been installed on the personal computer. The compass help to determine the various azimuth angles of the base station transmitters. Average height of transmit antenna is about 30 – 32 meter above ground level, with the same transmit power. Sampling rate of the collected data, on the average, is about 2 – 3 samples per meter.

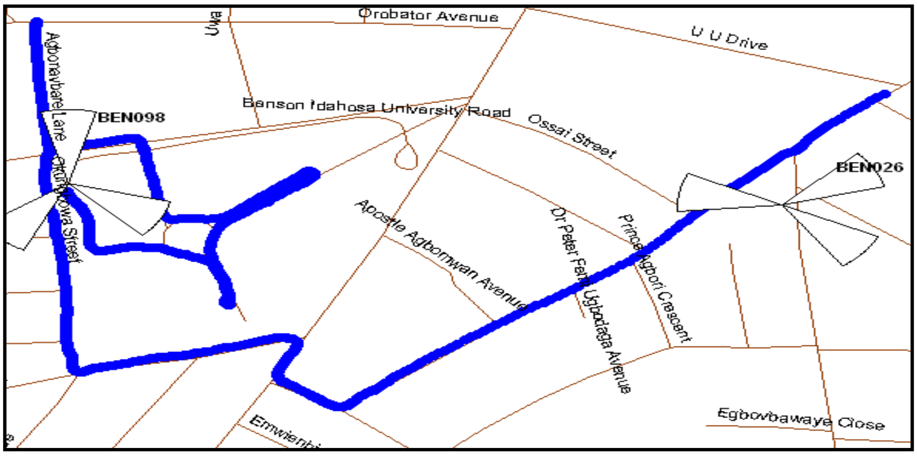

Figure 1: Measurement routes in Ugbor Avenue

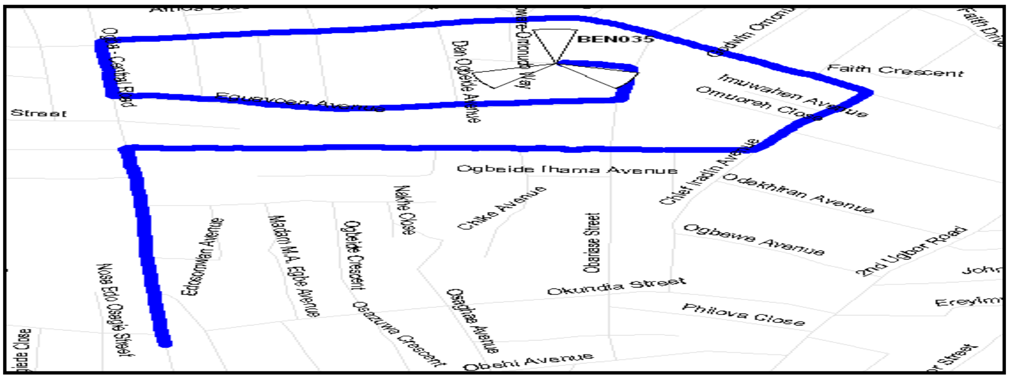

Figure 2: measurement routes in Garpiona Avenue

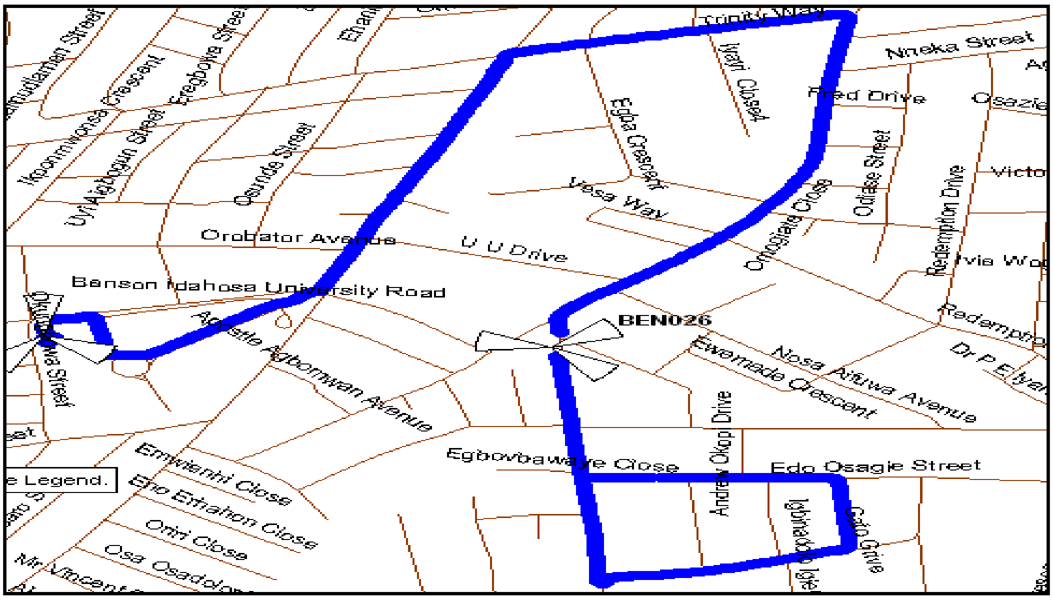

Figure 3: measurement routes in BUI Campus environ

III. RESULTS AND DISCUSSIONS

III.1. Modeling of Measured RSS data

Generally, the log-distance propagation model via linear regression is a statistical method often used to make predictions about signal strength from the sample data. In this section, linear regression analysis is carried out on the measured data. In the analysis, simple regression was fitted to the set of data, which is essentially a linear least squares curve fitting procedure. The mean signal strength in dB at mobile station (MS) as a function of distance d from base station (BS is modelled as follows [12], [13]:

$PL(d) = A \log d + C$ (1)

Or it can be written in the known following form:

$PL(d) = 10n \log(d/d_0) + PL(d_0)$ (2)

where n is the path loss exponent, and $PL(d_0)$ is the reference path loss at distance d_0.

Now, the predicted signal $PL(D)$ can be obtained as

$PL(D) = EIRP_T - PL(d)$ (3)

And $EIRP_T = P_T - L_C - G_T$ (4)

Where $EIRP_T$, is the effective isotropic radiated power of the UMTS base station, P_T is the base station transfer output power, L_C is antenna cable loss, and G_T is transmitting antenna gain. These powers, loss, and gain are added in dBm.

From the fitting parameters, $PD(d)$ can be obtained as follows

$PD(d) = -A \log d + C = PL(d) = -10n \log d + C$ (5)

Similar to equation (2), the large-scale received signal prediction model $PD(d)$ in *decibel* for an arbitrary BS-MS separation (d) can be expressed as following:

$PL(d) = PD(d_0) - 10n \log(d/d_0)$ (6)

Where $PL(d_0)$ is the reference predicted signal at distance d_0 and it is written as:

$PD(d_0) = C - 10n \log(d_0)$ (7)

Iii.2 Modeling Of Rss Uncertainty

In reality, the RSS does not have a deterministic behaviour, but present random variables. This is most likely due to the radio hardware imperfection and to the incomplete description of the RF communication link. Regardless of the RSS uncertainty source, it is of great importance to describe and characterizes the RSS uncertainty and distribution. Therefore it is important to explore the RSS uncertainty with respect to the distribution type.

One possible distribution of measured RSS values as reported in [16] and [17] is the Gaussian or normal distribution with probability function (PDF) given by:

$$PDF\sigma,\mu(x) = \frac{1}{\sigma\sqrt{2\pi}} exp(-\frac{x-\mu}{2\sigma^2})^2 \quad (8)$$

Where μ is the signal mean value, σ is the standard deviation and x is the RSS variable, measured.

Iii.3 Discussions

Here, the mean signal strength in dB at MS as a function of distance d from BS is modelled as in equation (5). The regression analysis of the field measurement data has led to a simple one slope characterization for RSS against distance on logarithmic scale as shown in Figure 2, 4 and 6 respectively. The straight line represents the least squares linear regression fit. Applying regression fit on the entire set of the measurement data, it is found that the overall path loss exponent 'n' varies from 1.6 to 3.3 and standard deviation of signal strength variability ' σ_s ' ranged from 5.57-12.09 dB. The variation in propagation characteristics over different regions is a consequence of the terrain profile, man-made structures and environmental features. For a given system parameters, different values of path loss exponent and standard deviation of signal strength variability will cause radically different predicted performance parameters of the cellular networks, particularly the handover performance. Table 1 provides typical values of *n* under different environments. The value of the path loss exponent is an indicator of how fast energy is lost between transmitter and receiver. The higher the path loss exponent, the faster the signal strength drops with respect to distance, therefore in modeling the propagation of signal for a particular environment, there is the need to determine the path loss exponents for that environment. For $n < 2$ is a measure of the guiding effect of the channel and when $n > 2$ the channel is considered to be scattering energy [14].

Table 1: Pathloss Exponent for different environments [14]

Environment	Pathloss Exponent ‘n’
Free Space	2
Urban	4.2
Log-normally shadowing area	2-4
Shadowed Urban	3 to 5
In building line-of sight	1.6 to 1.8
Obstructed in building	4-6
Obstructed factory	2-3

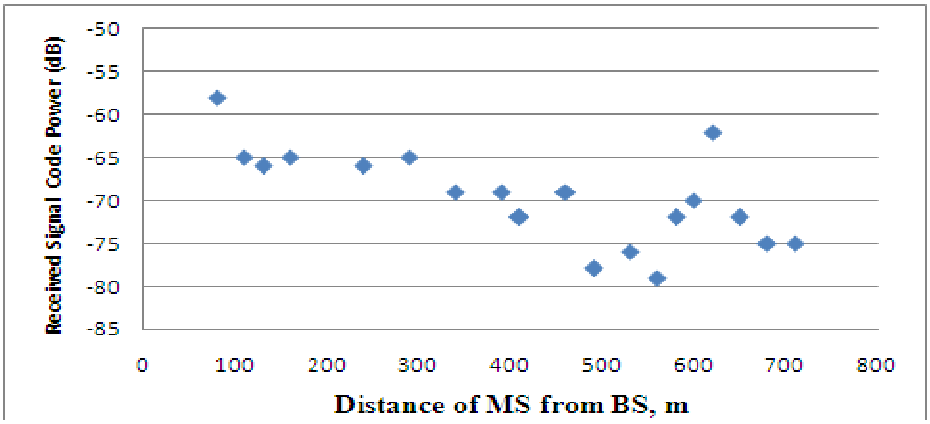

Figure 1: Signal strength data variability in Gapiona Avenue

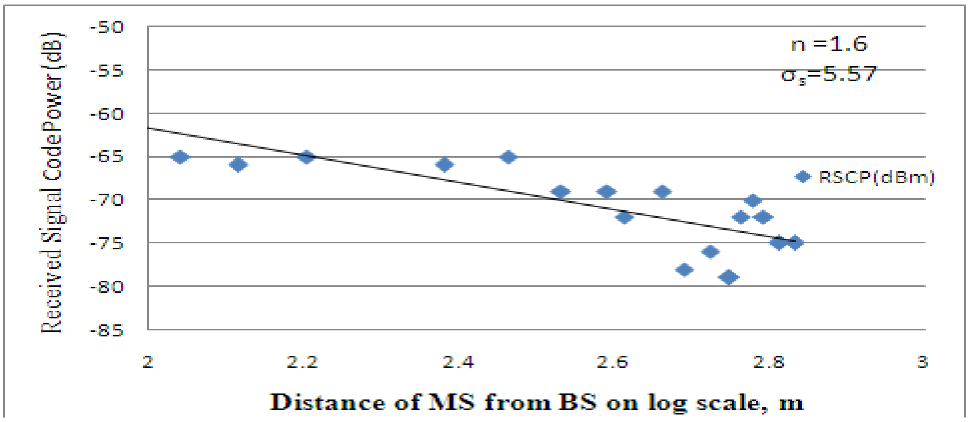

Figure 2: Signal strength data variability and regression fit in Gapiona Avenue

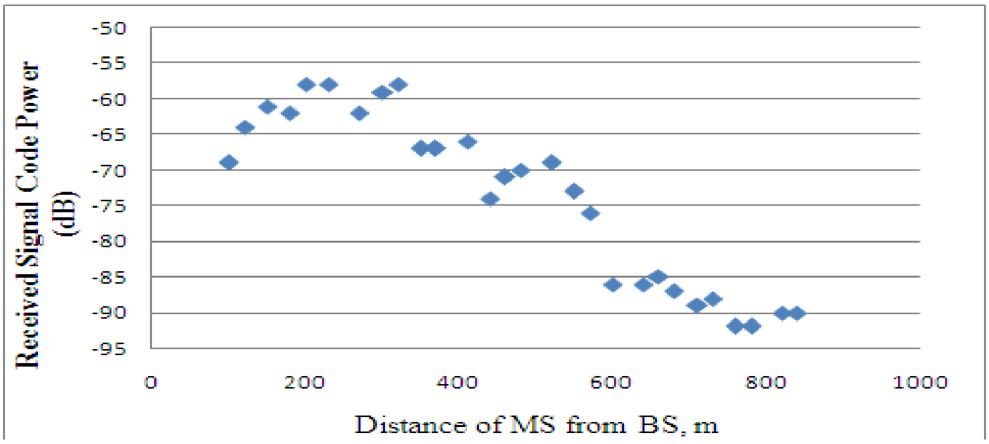

Figure 3: Signal strength data variability in Ugbor Avenue

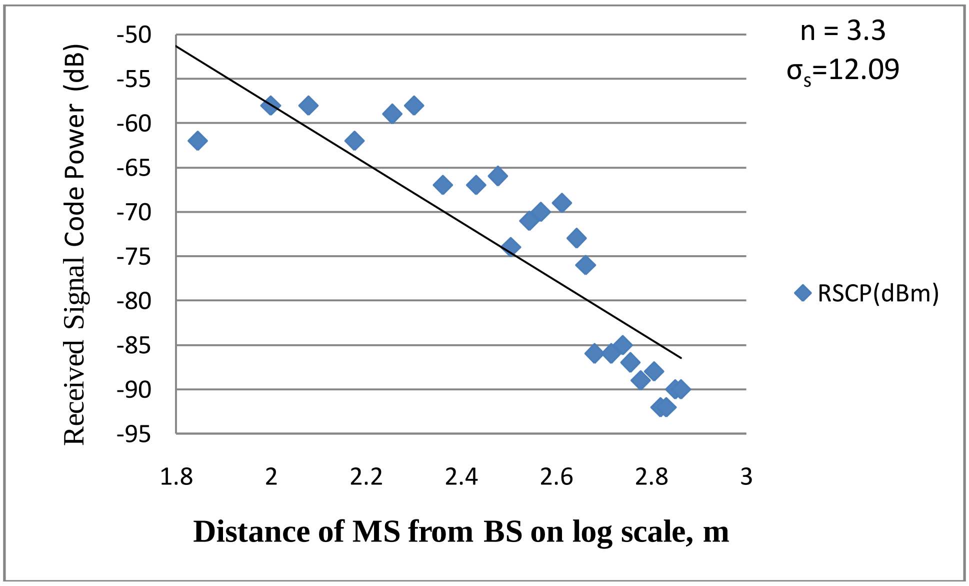

Figure 4: Signal strength data variability and regression fit in Ugbor Avenue

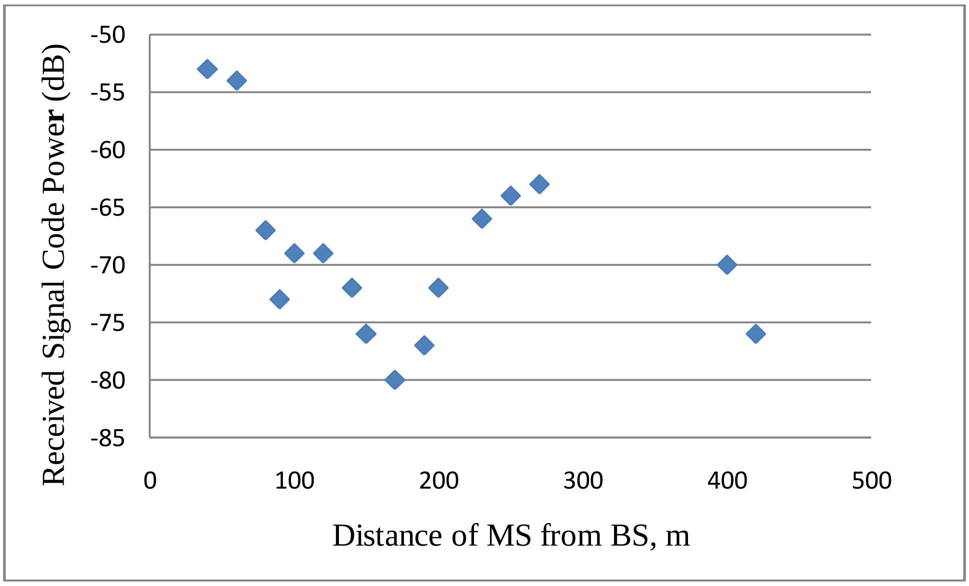

Figure 5: Signal strength data variability in BIU Campus

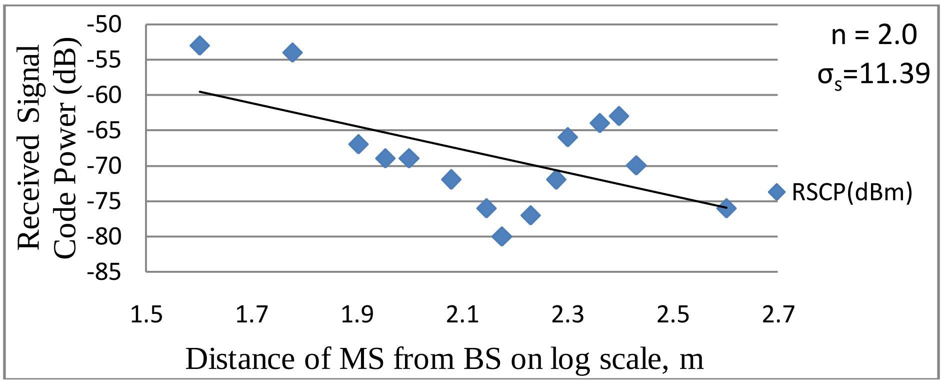

Figure 6: Signal strength data variability and regression fitting in BIU Campus

We also observed from the graphs in figure 1-6 that the radio signals of mobiles closer the BS experiences larger signal attenuation loss values than those far away from the BS in all the study locations. This may be due to different scattering bahaviour of radio signal in the near field and far field regions of the transmitting BS antenna. The term near-field refers to the field pattern that exists close to the antenna, while the term far-field refers to the field pattern at large distances.

Figure 7 (a)-(c) presents the results for three different $PDF\sigma,\mu(x)$ cases, calculated through equation (8). The results demonstrate that our measured RSS values does not follow the Gaussian distribution and this agrees with results reported in [18], but however disagree with the null hypothesis that RSS values does follows Gaussian distribution in [16] and [17].

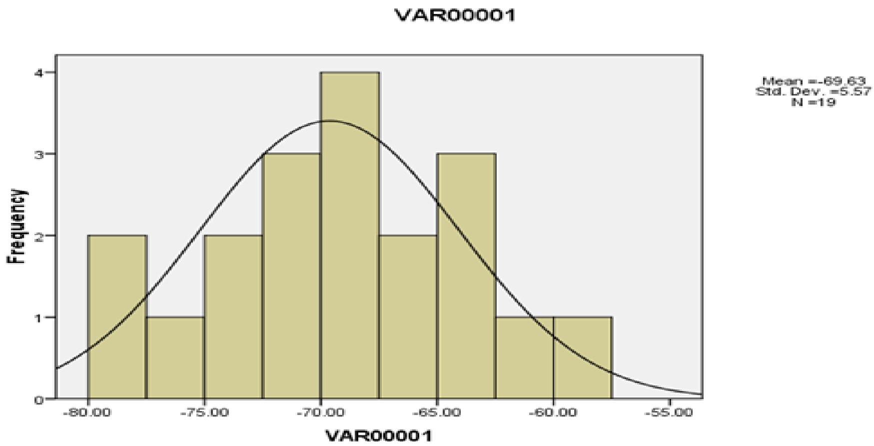

Figure 7 (a): Gaussian distribution of RSS in study location 1

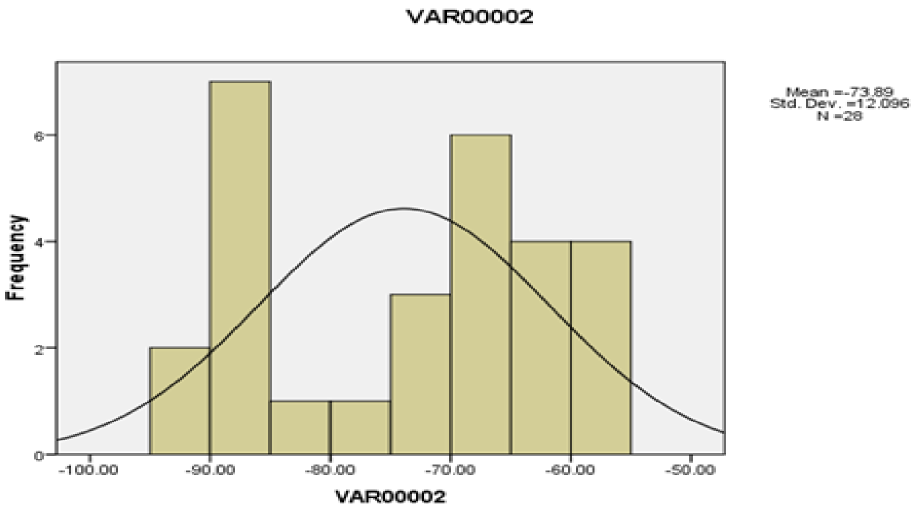

Figure 7(b): Gaussian distribution of RSS in study location 2

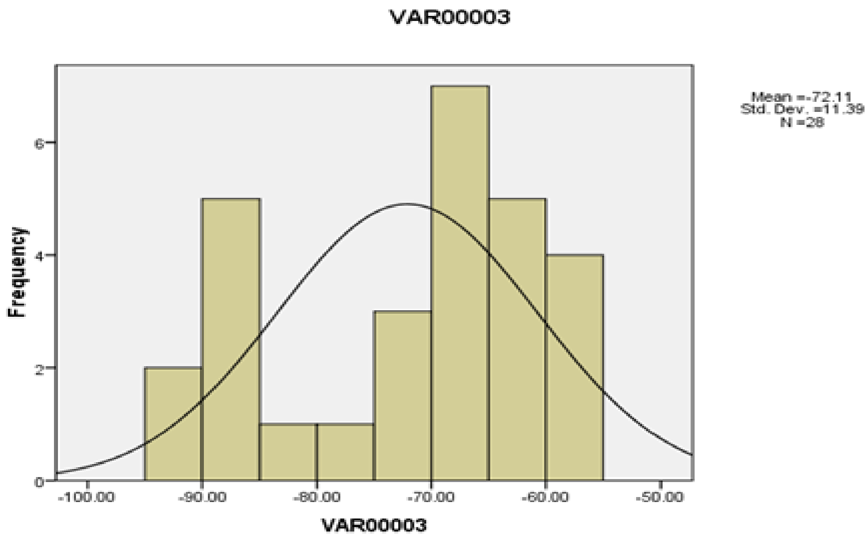

Figure 7 (c): Gaussian distribution of RSS in study location 3

IV. CONCLUSION

Study of radio wave propagation in different environments is an essential pre requisite for designing mobile communication systems. Radio wave propagation channels are modelled in statistical way using real propagation measurement data. In this paper, the field measurement of received signal power conducted at frequency of 2100 MHz for UMTS network in GRA Benin city, Nigeria and statistical analysis measurement results has been reported. The path loss exponents for different areas are obtained by utilizing the least squares method. The path loss exponents obtained lie in the range from 1.6 to 3.3. The results may be utilized as reference in the system level simulation for network planning and optimizing the design parameters of handover initiation algorithms.

REFERENCES

[1]. Dilpreet K, Pankaj R, and Amanpreet, K (2010) Analysing Quality of Service in UMTS, International Journal of Computer Applications, Vol. 11– No.12, pp 31-34.

[2]. E.M. Saad, O.M. EL-Ghandour and M.K. Jehan (2008), "Evaluation of QoS in UMTS Backbone Network Using Differentiated Services", 25th National Radio Science Conference (NRSC), Egypt, 2008.

[3]. Selim, S.S, Satı ,Y and Fulya C.K (2010), Comparison of Propagation Loss Prediction Models of UMTS for an Urban Areas, 18th Telecommunications forum TELFOR 2010 Serbia, Belgrade, November 23-25, 2010.

[4]. Tarokh, V., (2009). "New Directions in Wireless Communication Research", pg.1, Springer Dordrecht Heidelberg London New York ISBN 978-1-4419-0672-4.

[5]. Terplan, K., Morrwle, P., (1999) "The Telecommunication Handbook", pp. 2-4, IEEE Press, ISBN 0-8493-3137-4.

[6]. W C Jakes, Ed. 'Microwave Mobile Communications'. New York, Wiley, IEEE Press, 1994.

[7]. K Pahlavan, P Krishnamurthy, A Hatami, Y M Makela, J P Pichna R and J Vallstron. 'Handoff in Hybrid Mobile Data Networks'. IEEE Personal Communications, vol 7, April 2000, p 34

[8]. X Zhao, J Kivinen, P Vainikainen and K Skog. 'Propagation Characteristics for Wideband Outdoor Mobile Communications at 5.3 GHz'. IEEE Journal on Selected Areas in Communications, vol 20, no 3, April 2002, p 507 M J Gans, N Amitay, Y S Yeh, T C Damen, R A Valenzuela, Choelhang Cheon and John Lee. 'Propagation Measurements for Fixed Wireless loops (FWL) in a Suburban Region with Foliage and Terrain Blockages'. IEEE Transactions on Wireless Communications, vol 1, no 2, April 2002, p 302.

[9]. M V S N Prasad and R Singh. 'Terrestrial Mobile Communication Train Measurements in Western India'. IEEE Transactions on Vehicular Technology, vol 52, no 3, May 2003, p 671.

[10]. Takahashi, S., Kato, A., Sato, K., Fujise, M., (2004). "Distance dependence of path loss for millimeter wave inter-vehicle communication" IEEE Vehicular Technology pp. 26-30 vol.1.

[11]. Rosu, I. (2000). Small Antennas for High Frequencies, *YO3DAC / VA3IUL*, http://www.qsl.net/va3iul/

[12]. Iida, T., (2002). "Wireless Communication R and D in the science and technology policy In Japan, IEICE Transaction, pp. 419-427.

[13]. Jakes, C. W. (1994) “Microwave Mobile Communications”, 1st ed., John Wiley and Sons, New York.
[14]. Kaemarungsi, K. (2006) “Distribution of WLAN Received Signal Strength Indication for Indoor Location Determination,” in 1st International Symposium on Wireless Pervasive Computing. IEEE, 2006, pp. 1–6.
[15]. Sheng, Y, Tan, K, Chen, G, Kotz, D. and Campbell, A. (2008) “Detecting 802.11 MAC Layer Spoofing Using Received Signal Strength,” in 2008 IEEE INFOCOM - The 27th Conference on Computer Communications. IEEE, pp. 1768–1776.
[16]. Robitzsch, S and L. Murphy (2012) ‘‘Empirical Analysis of Measured 802.11 Receive Signal Strength Values Using Various Atheros Based Mini-PCI Cards’’ Available online at: http://pel.ucd.ie/files/pdf