COMPARATIVE ANALYSIS OF SIGNAL STRENGTH IN SOUTH-SOUTH NIGERIA

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Abstract: Losses has become the major drawback that is being faced by telecommunication sector in Nigeria and the world at large. Many researcher has carried out several researches in this area using different methods. Empirical method was adopted in this research work because it involves the measurement of field data, RF signal tracker was installed in a mobile phone called Samsung galaxy pocket, and this software gave us the distance to site (base station) and the signal strength level of the network provider at a particular distance, cell ID etc. From data obtained, it was noticed that the calculation of path loss using log – distance model which is deterministic is not as accurate as the generated empirical model, the generated model gave a better and more accurate result than the existing ones. Model was developed to calculate the received signal strength in Ujoelem, Ekpoma Nigeria and the model was named "Uzairue model".

Keywords: **Path-loss, Signal Strength, Distance, Location, Model**

I. Introduction:

In Nigeria, there has been more expectation rolled out in rural areas coverings over 50 % government area and at least 5000 communities and villages. The result of this will be the availabilities of spares capacity that can be utilized by other interest for conveying data, video and voice. This advancement informs Nigeria's present rating as the fastest growing telecommunication market in Africa [5]. There is no doubt that the telecommunication sector has united the whole world within a second, business is on the wheel globally [6]. Nevertheless, considering the previous relationship existing questions are now; does this global system for mobile communication have imparted on Nigeria economy? Does it contribute to job creation and crime reduction? [2]. As the word is increasing in population developmental activities and technologies increase daily, also problem begins to arise in the communication services, like traffic in system and signals. Low capacity [4], less coverage area and poor quality of service, telecommunication industries today have a major problem which is losses that occur during transmission of signals from the point of transmission (transmitter) to the receiving end (receiver) [1]. The world is fast becoming a global village and a necessary tool for this process is communication, of which telecommunication is a key player [3]. Nigeria's focus remains technology advancement of the GSM industry and of the Nigeria economy, the interrelationship of the industry has been large and progressive peer check and mediation is the hallmark of dispute resolution in GSM industry at a growth stage, the NCC, to quickly resolve all interconnection issues, not just of data and voice but also SMS. Without missing words, communication is a major driver of any economy [9].

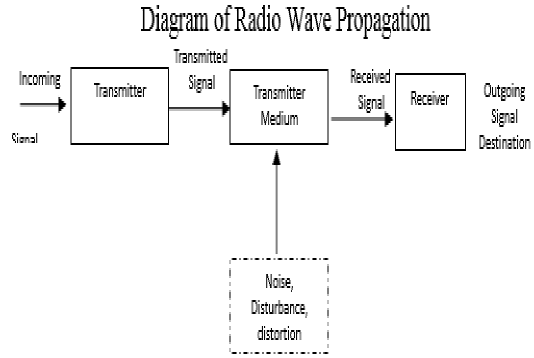

Fig.1: A communication system [12]

Communication system is made up of three main systems: the transmitter (TX), the receiver (RX) and the transmission medium as shown in Fig.1. It is desirable to understand the medium's statistical characteristics in order to predict the medium behavior. The signal processing method then will be developed and used properly to ensure that the transmission medium between the transmitter and the receiver is as reliable as possible. Therefore, understanding the medium characteristics plays an important role in designing and optimizing communication system. The medium is exposed to noise, distortion and other disturbance sources leading to the variation of the received signal power [16, 7]. In wireless channels, the path loss exponent (PLE) has a strong impact on the quality of links, and hence, it needs to be accurately estimated for the efficient design and operation of wireless networks [11]. The wireless channel presents a formidable challenge as a medium for reliable high-rate communication. It is responsible not only for the attenuation of the propagated signal but also causes unpredictable spatial and temporal variations in this loss due to user movement and changes in the environment. In order to capture all these effects, the path loss for RF signals are commonly represented as the product of a deterministic distance component (large-scale path loss) [13].

Considering the losses during transmission of electrical, electronic, microwaves signal from the transmitter to the receiver in our communication industries, and also considering the importance of these industries in our social, physical life and in the growth of world economy, there are needs to determine the path loss of the signal transmitted from the sending end to the receiving end and the penetration level in our home i.e. determining how our house appliances, buildings, trees and other factors affect the signals and with the view of providing the methods in which the losses (path loss) can be minimize [10]. The critical problems that are encountered by communication industries in Nigeria have contributed to the down fall of telecommunication industries worldwide and Nigeria inclusive, here are some of the highlighted problems [14].

a. The GSM problems, which include call rejection.
b. Call fading during communication, example, a situation whereby customer on call suddenly experiences reduction in speech volume from the person making the call to the person receiving the call [1].
c. In the place of microwave links, a situation whereby the uplink and downlink suddenly send and receive at a lower rate or no transmission.
   Due to these effects and how the communication industries have been affected by these effects, there are needs to try as much as possible to eliminate or reduce these drawbacks that affect our communication industries [8].

II. Materials and Methodology

The following steps was adopted in actualizing this research;

a. Measurement of necessary data with software called RF signal tracker; this software gives the GSM signal strength of the network provider; in this work a particular network provider was put into consideration.
b. This software called RF signal tracker with software version 01 was installed in a mobile phone called Samsung galaxy with the model GT – 55300.
c. A fixed distance was taken from the base station to the receiver and in this research work a particular fixed reference distance was taken as 100m from the base station which will be represented as d_0 and a variable distance which is represented as d_i.
d. The following parameters were recorded, distance to site and the signal strength of the network, the distance was in kilometer and the signal strength was in decibel.
e. The data was measured for six months; this period was taken in order to have a clear picture of the variation of the signal strength based on the distance to site and in order to have a clear analysis of the data measured.

A. Measurement Procedure

The general approach was to measure the signal strength level of a particular GSM network provider's signal strength in Ujoelem Ekpoma, South-South, Nigeria. The chosen location attenuations were then computed. The Samsung galaxy pocket handset and A GSM network provider SIM card were used to conduct the measurement campaign. Readings were taken only when there was a change in the distance to site indicated by the RF signal tracker. And these readings were taken from the beginning of the chosen location and the readings were recorded, the corresponding distances to sites and their signal strengths were also recorded. The geographical location parameters and their descriptions were all recorded. These were taken from the beginning of the tested locations and the parameters included: mobile latitude, mobile longitude, mobile heading, site bearing, GPS accuracy and speed. The GPS function of the Samsung galaxy pocket must be switched ON before the RF signal tracker can work otherwise, it will fail to function.

B. Measurement Conditions

Measurements were taken five different times for each of the locations for a period of six months, the average of each of the month at the following distances; 1km, 2km, 3km, 4km and 5km were taken and recorded as shown in Table 1. This was to allow a clear picture of the variation of value.

III. Data Presentation

Mean of the Signal Strength/Received Power for the Different Months

This portion of the research work shows the mean of the signal strength/received power at different distances. The mean of signal strength was calculated by adding the values of the signal strength received on each day of the month and divided by the number of days in the particular month. The mean of the different months was as shown on the table below

Table 1: This shows the mean at each distance of the tested location

Distance (km)	1 km	2 km	3 km	4 km	5 km	Overall
October,2016	-73.8	-73.4	-76.9	-75.0	-77.7	-75.36
November, 2016	-71.2	-69.0	-67.0	-71.7	-71.0	-69.98
December, 2016	-74.2	-75.6	-75.8	-76.5	-74.8	-75.38
January, 2017	-75.6	-72.2	-73.9	-69.6	-78.5	-73.96
February, 2017	-72.4	-75.9	-71.9	-74.3	-76.4	-74.20
March, 2017	-73.3	-69.5	-73.1	-73.3	-75.0	-72.80

IV. Calculation of Signal

This portion of this research deals with determination of signal and it is based on classical theories and empirical data which were collected from measurements, the classical theory is on the log-distance path loss model. The mean value of the path loss exponent for a shadow urban cellular radio was taken for the outdoor calculation/computation. Empirical data gotten were used to derive the model.

These data included;

(i) The received signal strength denoted by P_r

(ii) The transmitter-receiver separation distance which is taken as 100m denoted by d_0

A. Outdoor Calculations

By using log-distance path loss model, the path loss is given as [4].

$$PL(dB) = 10\log\frac{p_t}{p_r} = 10\log\left[\frac{\lambda^2}{(4\pi)^2 d^2}\right] \qquad (1)$$

Operating frequency was taken as 1800MHz

Wavelength, λ = speed of light/frequency

$\lambda = \frac{c}{f} = \frac{3\times10^8}{1800\times10^6} = 0.167m$ And d_0 = 100m (which is the fixed distance)

$$PL(dB) = -10\log\left[\frac{0.167^2}{(4\times3.142)^2\times100^2}\right]$$

$$= 77.5 \text{ dB}$$

$PL(d_0) = \frac{77.5}{1000} = 0.0775$ dBm.

Note that,

Path loss, PL (dBm) = PL (d_0) - 10nlog$\left(\frac{d}{d_0}\right)$ (2)

This equation is based on theoretical calculation for outdoor (Longley, 1978).

Note that, value of n = $\sum\frac{n}{2}$ (3) And n = 4 (the path loss exponent values for shadowed urban environment).

B. **Calculation of Path Loss Using Existing Equation (log-distance path loss model)**

At distance d = 1km,

PL(dBm) = -40.02dBm.

At distance d = 2km,

PL(dBm) = -52.02dBm.

At distance d = 3km,

PL(dBm) = -59.12dBm.

At distance d = 4km,

PL(dBm) = -64.12dBm.

At distance d = 5km,

PL(dBm) = -67.92dBm.

C. Generation of Mathematical Model

This generated model was named Uzairue's modified log-distance model, which is written mathematically as;

$$PL(dBm) = PL(d_0) - U10n\log\left(\frac{d_i}{d_0}\right) \qquad (4)$$

Where $U_{(i-1)}$ for i = distance to site, 1km,2km,3km,4km,5km…..nkm.

$$U = \text{modelled loss constant} = \frac{measure \quad received\ power}{calculated \quad power}$$

PL (dBm) = model or signal generated reception level for outdoor environment.

PL (d_0) = path loss within the antenna distance i.e 100 square meters around the transmitters (base station).

U = the loss constant, which is also known as the path loss exponent, which varies with the distance and mathematically represented as;

$$U = \frac{p_m}{p_c} \qquad (5)$$

P_m = mean of the measured signal strength

P_c = mean of the calculated signal strength

Calculation of U (modeled loss constant) For Each of the Locations for the Research Period

V. Ujoelen, Ekpoma Location

Table 2: For The Month Of October, 2016

d (km)	p_c (dBm)	p_m (dBm)	$u = p_m/p_c$
1.00	-40.02	-73.80	1.84
2.00	-52.02	-73.40	1.41
3.00	-59.12	-76.40	1.30
4.00	-64.12	-75.00	1.17
5.00	-67.92	-77.70	1.14

Table 3: For The Month Of November, 2016

d (km)	p_c (dBm)	p_m (dBm)	$u = p_m/p_c$
1.00	-40.02	-71.20	1.78
2.00	-52.02	-69.00	1.33
3.00	-59.12	-67.00	1.13
4.00	-64.12	-71.70	1.12
5.00	-67.92	-71.00	1.05

Table 4: For The Month Of December, 2016

d (km)	p_c (dBm)	p_m (dBm)	$u = p_m/p_c$
1.00	-40.02	-74.20	1.85
2.00	-52.02	-75.60	1.45
3.00	-59.12	-75.80	1.28
4.00	-64.12	-76.50	1.19
5.00	-67.92	-74.80	1.10

Table 5: For The Month Of January, 2017

d (km)	p_c (dBm)	p_m (dBm)	$u = p_m/p_c$
1.00	-40.02	-75.60	1.88
2.00	-52.02	-72.20	1.39
3.00	-59.12	-73.90	1.25
4.00	-64.12	-69.60	1.09
5.00	-67.92	-78.50	1.16

Table 6: For The Month Of February, 2017

d (km)	p_c (dBm)	p_m (dBm)	$u = p_m/p_c$
1.00	-40.02	-72.40	1.82
2.00	-52.02	-75.90	1.46
3.00	-59.12	-71.90	1.22
4.00	-64.12	-74.30	1.16
5.00	-67.92	-76.40	1.12

Table 7: For The Month Of March, 2017

d (km)	p_c (dBm)	p_m (dBm)	$u = p_m/p_c$
1.00	-40.02	-73.30	1.41
2.00	-52.02	-69.50	1.34
3.00	-59.12	-73.10	1.24
4.00	-64.12	-73.30	1.14
5.00	-67.92	-75.00	1.10

VI. Calculation of Signal Using Uzairue's log-distance Generated Model and Generated Loss Constant

$$PL(dBm) = PL(do) - U10n\log\frac{d_i}{d_0}$$

And the loss constant for each of the locations for the period tested has been calculated from Table 2-7.

Recall that, PL (d_0) = 0.0775 (which was gotten from this equation

Table 2 -7: Shows the Summary of the Comparison between Path Loss Values from Measurement and Using Model Equation

$$PL(dB) = -10\log\frac{\lambda^2}{(4\pi)^2 d^2}.$$

d_i = variable distance of the base station

d_0 = fixed or reference distance

n = 4 (mean of the path loss exponent of a shadow urban environment) and U has been calculated which is the generated loss constant. Table 8-13 shows the comparison of the Results Obtained between the Path Loss Values from Measurement, Using Deterministic/Theoretical Model (log-distance path loss model) and The Generated Empirical Model (Uzairue's modified log-distance model) For the Period Used ''Ujoelen Ekpoma'

VII. Results Presentation

Table 8: Ujoelen, Ekpoma Location For The Month Of October, 2016

Distance km	PL(dBm) From Measurement	PL(dBm) From Existing Model Equation	PL(dBm) From Uzairue's log-distance model
1	-73.8	-40.0	-73.6
2	-73.4	-52.0	-73.4
3	-76.9	-59.1	-76.8
4	-75.0	-64.1	-75.0
5	-77.7	-67.9	-77.5

Table 9: Ujoelen, Ekpoma Location For The Month Of November, 2016

Distance km	PL(dBm) From Measurement	PL(dBm) From Existing Model Equation	PL(dBm) From Uzairue's modified log-distance model
1	-71.4	-40.0	-72.0
2	-69.0	-52.0	-67.6
3	-67.0	-59.1	-66.7
4	-71.7	-64.1	-71.7
5	-71.0	-67.9	-70.7

Table 10: Ujoelen, Ekpoma Location For The Month Of December, 2016

Distance km	PL(dBm) From Measurement	PL(dBm) From Existing Model Equation	PL(dBm) From Uzairue's modified log-distance model
1	-74.2	-40.0	-74.0
2	-75.6	-52.0	-75.4
3	-75.8	-59.1	-76.8
4	-76.5	-64.1	-76.2
5	-74.8	-67.9	-74.7

Table 11: Ujoelen, Ekpoma Location For The Month Of January, 2017

Distance km	PL(dBm) From Measurement	PL(dBm) From Existing Model Equation	PL(dBm) From Uzairue's modified log-distance model
1	-75.6	-40.0	-75.6
2	-72.2	-52.0	-72.3
3	-73.9	-59.1	-73.8
4	-69.6	-64.1	-69.2
5	-78.5	-67.9	-78.1

Table 12: Ujoelen, Ekpoma Location For The Month Of February, 2017

Distance km	PL(dBm) From Measurement	PL(dBm) From Existing Model Equation	PL(dBm) From Uzairue's modified log-distance model
1	-72.4	-40.0	-72.4
2	-75.9	-52.0	-76.0
3	-71.9	-59.1	-71.5
4	-74.3	-64.1	-74.3
5	-76.4	-67.9	-76.1

Table 13: Ujoelen, Ekpoma Location For The Month Of March, 2017

Distance km	PL(dBm) From Measurement	PL(dBm) From Existing Model Equation	PL(dBm) From Uzairue's modified log-distance model
1	-73.3	-40.0	-73.2
2	-69.5	-52.0	-69.2
3	-73.1	-59.1	-73.8
4	-73.3	-64.1	-73.0
5	-75.0	-67.9	-74.7

Graphical Results Presentation

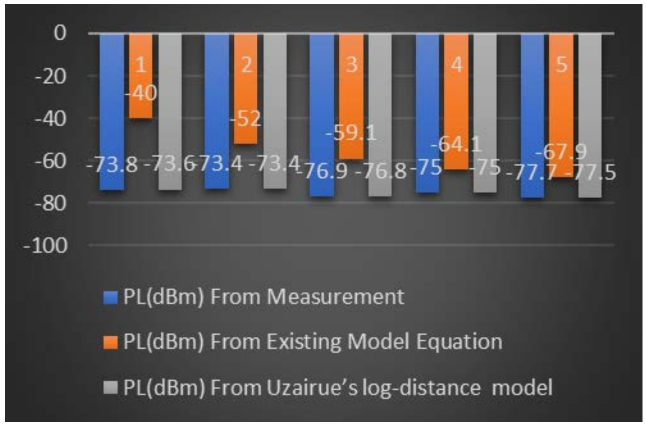

Fig 2: Graphical Representation of Ujoelen, Ekpoma Location For The Month Of October, 2016

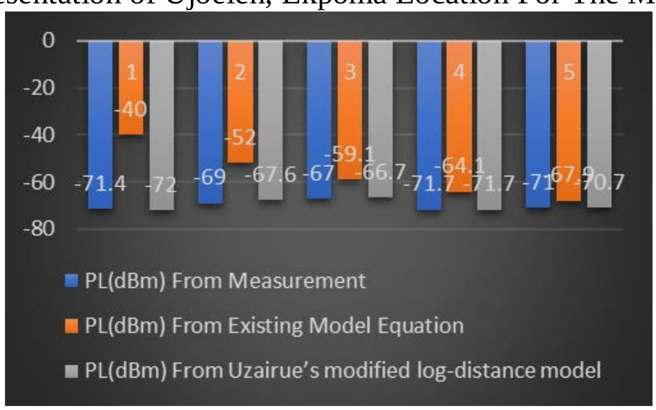

Fig 3: Graphical Representation of Ujoelen, Ekpoma Location For The Month Of November, 2016

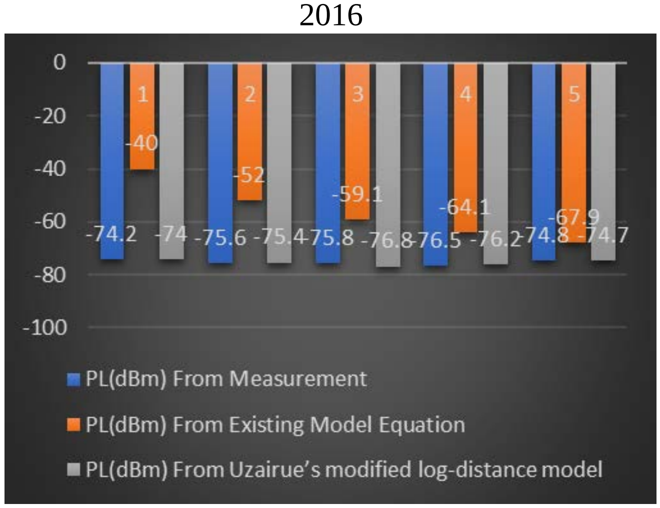

Fig 4: Graphical Representation of Ujoelen, Ekpoma Location For The Month Of December, 2016

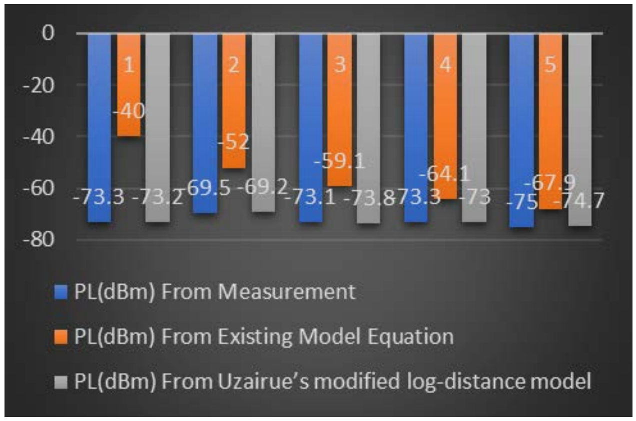

Fig 5: Graphical Representation of Ujoelen, Ekpoma Location For The Month Of January, 2017

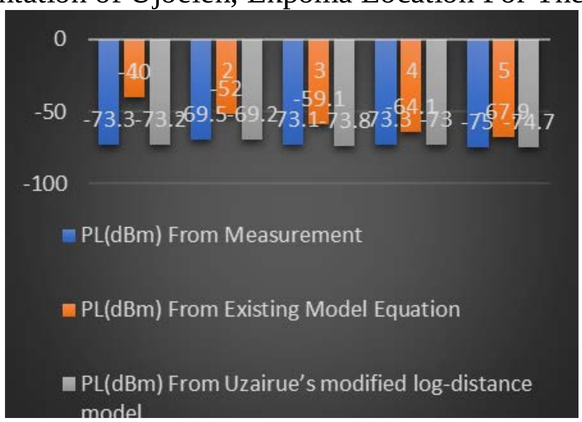

Fig 6: Graphical Representation of Ujoelen, Ekpoma Location For The Month Of February, 2017

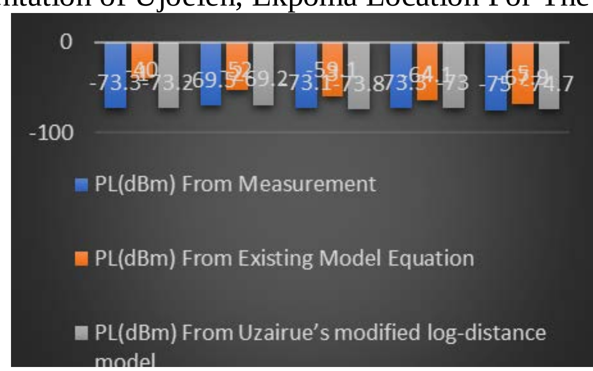

Fig 7: Graphical Representation of Ujoelen, Ekpoma Location For The Month Of March, 2017

VIII. Conclusion

From the results obtained above from table 8 to 13, it was observed that the path loss values obtained using the existing model (which is the log-distance model) is deterministic and was totally far from the measured data from the network provider using RF signal tracker (the raw data from the telecommunication company). Now comparing the measured data (RF signal tracker) with the value from the generated model (uzairue's modified log-distance model), we can see from fig 2 to 7 that the values are almost the same with little or no variation.

Hence, the generated model (Uzairue's modified log-distance model) is more reliable and gives a better result than existing model (Log-Distance model) and that the generated model can be used in the calculation of path loss values for a particular location by inputting the necessary parameters.

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