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Determination of GSM Signal Strength Level in Some Selected Location in EKPOMA

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Abstract: *In this work, the empirical method was adopted because it involves the measurement of large data, with the help of software called RF signal tracker which was installed in a mobile phone called Samsung galaxy pocket, this software gave us the distance to site (base station) and the signal strength level of the network provider at a particular distance. From my data, it was observed that the calculation of path loss with log – distance model which is deterministic is not as accurate as the empirical model (generated model), the generated model gave a better and more accurate result than the existing ones, and that the path loss exponents of the tested locations was fully known. Model was developed to calculate the power received of GSM signal in Ekpoma and the model was named "Generated model".*

I. Introduction

Many research efforts have been devoted to modeling the path loss propagation effects for narrowband communication systems by using different methods ranging from analytical models, semi-empirical models, to empirical models. An analytical model is typically based on applying electromagnetic theory to a specific environment. Detailed information about the environment needs to be available in order to formulate the model. Thus, an analytical model tends to be precise but complicated to apply. Moreover, it is site-specific. A semi-empirical model starts with a simple physics-based model with unknown parameters. The simple physical model makes it relatively easy to implement but not accurate enough to account for the more complex features of a given environment. The unknown model parameters are to be determined from measurements so as to improve the accuracy of the model. Semi-empirical models are generally site-specific. In practice, most radio propagation path-loss models are semi-empirical models. They are usually developed by fitting parameterized physical models to measurement data. An empirical model is simply a hypothesized mathematical model determined by fitting measurement data. It may not have any physical basis. However, empirical models are easy to use since they do not require any information about the environment. Numerous measurement-based, narrowband, semi-empirical path-loss models have been proposed and investigated. The path loss for macro cells with coverage areas having radii from 14km to 20 km has been proposed by Hata, and several other research groups (Sharma, P.K. 2013). Hata proposed the path-loss models for different environments such as urban areas, suburban areas, and rural areas based on measurement data. All of these models are similar with respect to the signal attenuation rate (path loss exponents). Lee also performed measurement works in different cities around the world and proposed alternate path-loss models. Several other research groups also investigated the path-loss models for narrowband communication systems based on measurement (Sharma, H.K et al, 2011). Those models are applicable not only for different environments, but also for varying carrier frequency, antenna heights, the TX-RX separation, etc. For small distances between the TX and the RX, several other research groups have also proposed the path-loss models for micro-cell areas (Thiago, 2001). It is noticed that all the semi-empirical models predict the median path losses. There are some techniques used to develop the path-loss model using computer simulation. The two-ray models are most commonly used to predict the path loss and calculate the signal strength. These models use the ray-tracing technique that is based on geometrical optics to account for the three mechanisms discussed above (Armoogum et al, 2007). This technique assumes a finite number of multipath signals from the TX to the RX. The knowledge about the physical elements of the channel is essential, including the geometry of the scattering objects in the channel. To simplify the solution and procedure, however, the ray tracing technique often makes approximations to obtain an excess path length. Typically, it is assumed that the nearest scattering objects are in the far-field regions of the TX and the RX. In addition, the scattering objects are electrically large (Saunders, S. 2000). Several research efforts reported have employed the ray-tracing technique. It shows a simple deterministic-plus-stochastic path-loss model for small outdoor areas (such as parking lots and intersections). It is found that for these areas with well defined geometries, a model (such as 2-ray, 4-ray or multipath reflection model) may be postulated initially and the corresponding measurement will be performed to verify the accuracy of the assumed models. Simulation results of path loss and delay spread are also presented in (Domazetovic et al, 2002). This research effort finds that the propagation loss depends on shaped objects and is affected by the physical elements of the media, such as the dielectric constants and the roughness factors of the objects (Arne Schmitz and Martin Wenig 2008).

II. Materials And Methodology

The methods adopted in the realization of this work involves the following stages

I. 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 (MTN network provider)

II. This software called RF signal tracker with software version 01 was installed in a mobile phone called Samsung galaxy with the model GT – 55300, see Fign 1 for the diagram of the mobile phone and Table 1 shows the main menu screen of the software

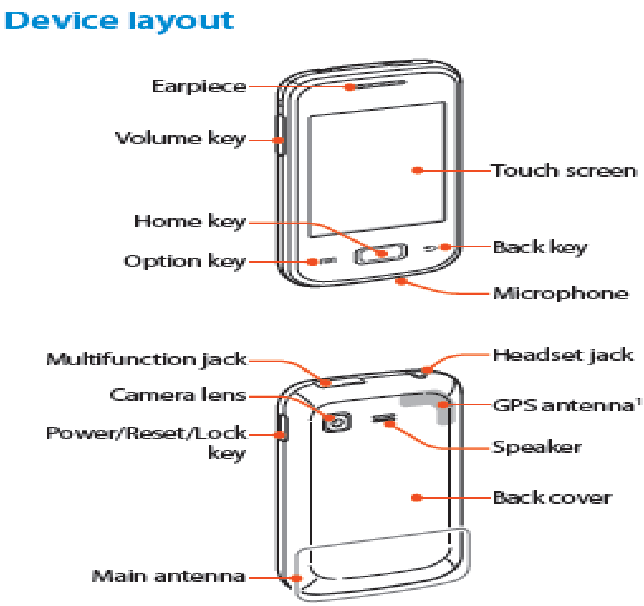

Fig 1: Samsung Galaxy Phone Picture

Table 1: RF main screen menu

Phone Parameters.	
Number	08063268446
Phone type	GSM
IMEI/ESN	353170055933935
Manufacturer	Samsung
Model	GT-S5300
SIM SN	
SIM State	STATE-READY
Software version	01
Sub ID	
Signal strength	-75dBm
Bit Error Rate	255
EVDO	-1dBm
Ec/I_o	-1
SNR	-1
Battery level	80%
Network Parameters	
Operator	MTN
Technology	EDGE
MCC	621
MNC	
LAC	30
Cell id	33061
Location Parameters	
Site database	Google
Best Provider	GPRS
Mobile latitude	$6^0$44'24.724"
Mobile longitude	6^0 6'28.675
Mobile Heading	

Mobile Altitude	263m
Site brg	
Speed	
GPS Accuracy	± 26.2ft
Distance to Site	1km

MEASUREMENT PROCEDURE

The general approach was to measure the signal strength level of MTN network signal in the chosen locations (Ambrose Alli University, college of medicine and Emando Campus, A.A.U, Ekpoma Edo State). The chosen locations attenuation was then computed.

The Samsung galaxy pocket handset and MTN SIM card were used to conduct the measurement.

Readings were taken only when there was a change in the distance to site indicated by the RF signal tracker. And this reading were been taken from the beginning of a chosen locations and the reading were been recorded and the corresponding distance to site and the signal strengths were all recorded.

The geographical locations parameters and their descriptions were all recorded. The geographical locations parameters and their descriptions were taken from the beginning of the tested locations and the parameters include: mobile latitude, mobile longitude, mobile heading, site bearing, GPS accuracy and speed. The GPS function of the Samsung galaxy pocket must be switch ON before the RF signal tracker can work otherwise, it will fail to function.

MEASUREMENT CONDITIONS

Measurements were taken five different times for each of the locations for a long period, the average of each of the month at a distance 1km, 2km, 3km, 4km and 5km were taken and recorded as shown in Table 2. This was to allow a clear picture of the variation of the weather within the period of study.

III. Data Presentation

Table2: Mean of the measured received signal strength for a given distance for the month of September, 2013. This shows the mean at each distance of the two different tested locations, College of medicine, AAU and Emaudo campus, AAU.

Distance (km)	1km	2km	3km	4km	5km
College of medicine,AAU	-75.7	-77.9	-81.4	-81.5	-78.8
Emaudo	-77.3	-77.6	-78.6	-80.0	-80.9

Table 3: Mean of the measured received signal strength for a given distance for the month of October, 2013. This shows the mean at each distance of the four different tested locations, College of medicine, AAU and Emaudo campus, AAU.

Distance (km)	1km	2km	3km	4km	5km
College of medicine,AAU	-80.8	-79.7	-79.6	-83.8	-79.8
Emaudo	-79.2	-77.8	-81.6	-75.7	-76.9

Table4: Mean of the measured received signal strength for a given distance for the month of November, 2013. This shows the mean at each distance of the four different tested locations, College of medicine, AAU and Emaudo campus, AAU.

Distance (km)	1km	2km	3km	4km	5km
College of medicine,AAU	-77.0	-81.4	-89.0	-76.5	-75.0
Emaudo	-80.5	-81.3	-83.2	-81.5	-85.1

Table5: Mean of the measured received signal strength for a given distance for the month of December, 2013. This shows the mean at each distance of the four different tested locations, College of medicine, AAU and Emaudo campus, AAU.

Distance (km)	1km	2km	3km	4km	5km
College of medicine,	-85.9	-79.2	-79.5	-78.2	79.1
Emaudo Campus	-80.8	-82.5	-82.5	-80.9	-82.5

Table6: Mean of the measured received signal strength for a given distance for the month of January, 2014. This shows the mean at each distance of the four different tested locations, College of medicine, AAU and Emaudo campus, AAU.

Distance (km)	1km	2km	3km	4km	5km
College of Medicine	-80.4	-82.6	-83.4	-82.9	-85.8
Emaudo Campus	-79.1	-82.8	-82.9	-83.9	-85.3

Table7: Mean of the measured received signal strength for a given distance for the month of February, 2014. This shows the mean at each distance of the four different tested locations, College of medicine, AAU and Emaudo campus, AAU.

Distance (km)	1km	2km	3km	4km	5km
College of medicine	-84.3	-80.8	-84.4	-83.4	-86.6
Emaudo Campus	-85.4	-83.2	-84.8	-84.1	-83.9

IV. Development of Model and Analysis

Calculation of Signal

This portion of this research deals with the calculation of the signal and it is based on classical theories and empirical data which was collected from measurement, 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 my outdoor calculation/computation. Empirical data gotten were used to derive the model.

These data includes;

(i) The received signal strength denoted by P_r

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

Outdoor Calculations.

By using log-distance path loss model, the path loss is given as (Thiago, 2001).

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

Operating frequency was taken as 1800MHz

Wavelength, λ =speed of light/frequency…………………………………………………………(2)

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

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

=77.5dB

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

Note that,

Path loss, PL (dBm) = PL (d_0) + 10nlog$\left(\frac{d}{d_0}\right)$ ………………………………………………….(3)

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

Note that, value of n = $\sum\frac{n}{2}$ ……………………………………………………..(4)

And n = the path loss exponent values for shadowed urban environment.

n = $\frac{3+5}{2} = 4$ (average value of n)

Calculation Of Path Loss Using Existing Equation (log-distance path loss model)

At distance d = 1km, we have 40.1dBm. At distance d = 2km, = 52.1dBm.

At distance d = 3km, = 59.2dBm. At distance d = 4km, = 64.2dBm. At distance d = 5km, = 68.0dBm.

Calculation Of Signal Using Generated Model And Generated Loss Constant.

$$PL(dBm) = PL(do) + U10n\log\frac{d_i}{d_0} \text{……………………………………………………(5)}$$

And the loss constant for each of the locations for the period tested has been calculated and is represented as Y_0 to Y_4.

Recall that, PL (d_0) = 0.0775 (which was gotten from this 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 = $\frac{3+5}{2}$ = 4 (mean of the path loss exponent of a shadow urban environment) and U = Y has been calculated which is the generated loss constant.

College Of Medicine AAU, Ekpoma Location.
At college of medicine, these are the values of the loss constant (Y) at different distance for the period used.
For The Month Of September, 2013.
Y_0 = 1.89, Y_1 = 1.50, Y_2 = 1.38, Y_3 = 1.27, Y_4 = 1.16.
When d = 1km and Y_0 = 1.89,

$$PL(dBm) = PL(d_0) + Y_0 10n\log\frac{d_i}{d_0} = \quad = 75.7\text{dBm}$$

For 2km = 78.1dBm. For 3 km = 81.6dBm. For 4km = 80.5dBm. For 5km = 78.9dBm
For The Month Of October, 2013.
Y_0 = 2.01, Y_1 = 1.53, Y_2 = 1.34, Y_3 = 1.31 and Y_4 = 1.20.
When d = 1km and Y_0 = 2.01,

$$PL(dBm) = PL(d_0) + Y_0 10n\log\frac{d_i}{d_0} = 80.5\text{dBm}$$

For 2km = 79.7dBm. For 3km = 79.2dBm. For 4km = 84.0dBm. For 5km = 81.6dBm
For The Month Of November, 2013.
Y_0 = 1.92, Y_1 = 1.56, Y_2 = 1.50, Y_3 = 1.20 and Y_4 = 1.10.
When d = 1km and Y_0 = 1.92,

$$PL(dBm) = PL(d_0) + Y_0 10n\log\frac{d_i}{d_0} = 76.9\text{dBm}$$

For 2 km = 81.3dBm. For 3km = 88.7dBm. For 4km = 80.0dBm. For 5km = 74.8dBm
For The Month Of December, 2013.
Y_0 = 2.14, Y_1 = 1.52, Y_2 = 1.34, Y_3 = 1.22 and Y_4 = 1.16.
When d = 1km and Y_0 = 2.14,

$$PL(dBm) = PL(d_0) + Y_0 10n\log\frac{d_i}{d_0} = 85.7\text{dBm}$$

For 2km = 79.2dBm. For 3km = 79.3dBm. For 4km = 78.3dBm.For 5km = 79.9dBm
For The Month Of January, 2014.
Y_0 = 2.00, Y_1 = 1.59, Y_2 = 1.41, Y_3 = 1.29 and Y_4 = 1.26.
When d = 1km and Y_0 = 2.00,

$$PL(dBm) = PL(d_0) + Y_0 10n\log\frac{d_i}{d_0} = 80.1\text{dBm}$$

For 2km = 82.8dBm. For 3km = 83.4dBm. For 4km = 82.7dBm. For 5km= 85.7dBm
For The Month Of February, 2014.
Y_0 = 2.10, Y_1 = 1.54, Y_2 = 1.43, Y_3 = 1.30 and Y_4 = 1.27.
When d = 1km and Y_0 = 2.10,

$$PL(dBm) = PL(d_0) + Y_0 10n\log\frac{d_i}{d_0} = 84.1\text{dBm}$$

For 2km= 80.2dBm. For 3km = 84.6dBm. For 4km = 83.4dBm. for 5km = 86.4dBm

Emaudo Campus AAU, Ekpoma Location.
At Emaudo, these are the values of the loss constant (Y) at different distance for the period used.
For The Month Of September, 2013
Y_0 = 1.93, Y_1 = 1.49, Y_2 = 1.33, Y_3 = 1.25 and Y_4 = 1.19
When d = 1km and Y_0 = 1.93

$$PL(dBm) = 0.0775 + 1.93 \times 10 \times 4\log\frac{1000}{100}$$ = 77.3dBm

For 2km = 77.6ddBm. For 3km= 78.7dBm. For 4km= 80.2dBm. For 5km = 80.9dBm.

For The Month Of October, 2013

Y_0 = 1.98, Y_1 = 1.49, Y_2 = 1.38, Y_3 = 1.18 and Y_4 = 1.13

When d = 1km and Y_0 = 1.98

$$PL(dBm) = 0.0775 + 1.98 \times 10 \times 4\log\frac{1000}{100}$$ = 79.3dBm

For 2km = 77.6ddBm. For 3km = 81.6dBm. For 4km = 75.7dBm. For 5km = 76.9dBm.

For The Month Of November, 2013

Y_0 = 2.01, Y_1 = 1.56, Y_2 = 1.41, Y_3 = 1.27 and Y_4 = 1.25

When d = 1km and Y_0 = 2.01

$$PL(dBm) = 0.0775 + 2.01 \times 10 \times 4\log\frac{1000}{100}$$ = 80.5dBm

For 2km = 81.3ddBm. For 3km = 83.4dBm. For 4km = 81.5dBm. For 5km = 85.0dBm.

For The Month Of December, 2013

Y_0 = 2.01, Y_1 = 1.59, Y_2 = 1.39, Y_3 = 1.26 and Y_4 = 1.21

When d = 1km and Y_0 = 2.01

$$PL(dBm) = 0.0775 + 2.01 \times 10 \times 4\log\frac{1000}{100}$$ = 80.5dBm

For 2km = 82.8ddBm. For 3km = 82.2dBm. For 4km = 80.8dBm. For 5km = 82.3dBm

For The Month Of January, 2014

Y_0 = 1.97, Y_1 = 1.59, Y_2 = 1.40, Y_3 = 1.31 and Y_4 = 1.25

When d = 1km and Y_0 = 1.97

$$PL(dBm) = 0.0775 + 1.97 \times 10 \times 4\log\frac{1000}{100}$$ = 78.9dBm

For 2km = 82.8ddBm. For 3km = 82.8dBm. For 4km = 84.0dBm. For 5km = 85.0dBm.

For The Month Of February, 2014

Y_0 = 2.13, Y_1 = 1.50, Y_2 = 1.43, Y_3 = 1.31 and Y_4 = 1.23

When d = 1km and Y_0 = 2.13

$$PL(dBm) = 0.0775 + 2.13 \times 10 \times 4\log\frac{1000}{100}$$ = 85.3dBm

For 2km = 78.1ddBm. For 3km = 84.6dBm. For 4km = 80.2dBm. For 5km = 83.7dBm

Comparison Between The Path Loss Values From Measurement, Using Deterministic/Theoretical Model (log-distance path loss model) And The Generated Empirical Model For The Period Used For College Of Medicine, AAU Ekpoma.

Table8: College Of Medicine For The Month Of September, 2013.

Distance km	PL(dBm) From Measurement	PL(dBm) From Equation	PL(dBm) From Generated Model
1	-75.7	-40.1	-75.7
2	-77.9	-52.1	-78.1
3	-81.4	-59.2	-81.6
4	-81.5	-64.2	-81.5
5	-78.8	-68.0	-78.9

Table9: College Of Medicine For The Month Of October, 2013.

Distance km	PL(dBm) From Measurement	PL(dBm) From Equation	PL(dBm) From Generated Model
1	-80.8	-40.1	-80.5
2	-79.7	-52.1	-79.7
3	-79.6	-59.2	-79.2
4	-83.8	-64.2	-84.0
5	-79.8	-68.0	-81.6

Table10: College Of Medicine For The Month Of November, 2013.

Distance km	PL(dBm) From Measurement	PL(dBm) From Equation	PL(dBm) From Generated Model
1	-77.0	-40.1	-76.9
2	-81.4	-52.1	-81.3
3	-89.0	-59.2	-88.7
4	-76.5	-64.2	-80.0
5	-75.0	-68.0	-74.8

Table11: College Of Medicine For The Month Of December, 2013.

Distance km	PL(dBm) From Measurement	PL(dBm) From Equation	PL(dBm) From Generated Model
1	-85.9	-40.1	-85.7
2	-79.2	-52.1	-79.2
3	-79.5	-59.2	-79.3
4	-78.2	-64.2	-78.3
5	-79.1	-68.0	-79.9

Table12: College Of Medicine For The Month Of January, 2014.

Distance km	PL(dBm) From Measurement	PL(dBm) From Equation	PL(dBm) From Generated Model
1	-80.4	-40.1	-80.1
2	-82.6	-52.1	-82.8
3	-83.4	-59.2	-83.4
4	-82.9	-64.2	-82.7
5	-85.8	-68.0	-85.9

Table13: College Of Medicine For The Month Of February, 2014.

Distance km	PL(dBm) From Measurement	PL(dBm) From Equation	PL(dBm) From Uzairue's Model
1	-84.3	-40.1	-84.1
2	-80.8	-52.1	-80.2
3	-84.4	-59.2	-84.6
4	-83.4	-64.2	-83.4
5	-86.6	-68.0	-86.4

Comparison Between The Path Loss Values From Measurement, Using Deterministic/Theoretical Model (log-distance path loss model) And The Generated Empirical Model For The Period Used ''Emaudo Ekpoma''.

Table14: Emaudo Campus, AAU Location For The Month Of September, 2013

Distance km	PL(dBm) From Measurement	PL(dBm) From Equation	PL(dBm) From Uzairue's Model
1	-77.3	-40.1	-77.3
2	-77.6	-52.1	-77.6
3	-78.6	-59.2	-78.7
4	-80.0	-64.2	-80.2
5	-80.9	-68.0	-80.9

Table15: Emaudo Campus, AAU Location For The Month Of October, 2013

Distance km	PL(dBm) From Measurement	PL(dBm) From Equation	PL(dBm) From Generated Model
1	-79.2	-40.1	-79.3
2	-77.8	-52.1	-77.6
3	-81.6	-59.2	-81.6
4	-75.7	-64.2	-75.7
5	-76.9	-68.0	-76.9

Table16: Emaudo Campus, AAU Location For The Month Of November, 2013

Distance km	PL(dBm) From Measurement	PL(dBm) From Equation	PL(dBm) From Generated Model
1	-80.5	-40.1	-80.5
2	-81.3	-52.1	-81.3
3	-83.2	-59.2	-83.4
4	-81.5	-64.2	-81.5
5	-85.1	-68.0	-85.0

Table17: Emaudo Campus, AAU Location For The Month Of December, 2013

Distance km	PL(dBm) From Measurement	PL(dBm) From Equation	PL(dBm) From Generated Model
1	-80.8	-40.1	-80.5
2	-82.9	-52.1	-82.8
3	-82.5	-59.2	-82.2
4	-80.9	-64.2	-80.8
5	-82.5	-68.0	-82.3

Table18: Emaudo Campus, AAU Location For The Month Of January, 2014.

Distance km	PL(dBm) From Measurement	PL(dBm) From Equation	PL(dBm) From Generated Model
1	-79.1	-40.1	-78.9
2	-82.8	-52.1	-82.8
3	-82.9	-59.2	-82.8
4	-83.9	-64.2	-84.0
5	-85.3	-68.0	-85.0

Table19: Emaudo Campus, AAU Location For The Month Of February, 2014

Distance km	PL(dBm) From Measurement	PL(dBm) From Equation	PL(dBm) From Generated Model
1	-85.4	-40.1	-85.3
2	-83.2	-52.1	-78.1
3	-84.8	-59.2	-84.6
4	-84.1	-64.2	-91.7
5	-83.9	-68.0	-83.7

V. Conclusion

The signal strength in the outdoor that was calculated from two different locations namely; College of medicine, AAU, Ekpoma, Emaudo campus, AAU were measured at the frequency range of 1800MHZ. Comparing the signal strength obtained from the "Generated model" and the measured signal strength obtained from RF signal tracker, it was observed that they are almost of the same values.

From my data, it was observed that the calculation of path loss with log–distance model which is deterministic is not as accurate as the empirical model (generated model), the generated model gave a better and more accurate result than the existing ones

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