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Outdoor Propagation Prediction in Wireless Local Area Network (WLAN)

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***Abstract*— This paper presents an outdoor propagation prediction in wireless local area network (WLAN).Experiment were performed in a test bed area to determine the pathloss exponent and to develop an acceptable pathloss model for the test bed area. Results shows that with the implementation of the developed pathloss model, a network planner can determine the amount of wireless infrastructure needed and the accurate placement point for effective network coverage.**

***Index Terms*— IEEE 802.11g, Path loss, Network Stumbler, Wireless Local Area Network (WLAN)**

I. INTRODUCTION

As a result of rapid growth in wireless telecommunications, there has been an increasing need for proper network coverage predictions. This proper network coverage predictions planning requires a good understanding of the fundamental limitations caused by various environmental condition to the propagation of the signal such as interference and multipath fading[1]. As with sound waves, electromagnetic waves can be reflected, diffracted and attenuated depending on the medium between the transmitter and the receiver and the size of the obstacles that the wave faces. The reflection occurs when the wave hits a surface of an object whose dimension is much larger than its wavelength. The diffraction happens when a wave hits the edge of an object or an object whose dimension is smaller than its wavelength. The scattering waves will be generated or resulted from the diffraction. Furthermore the signal can be attenuated due absorptions from the medium .Base on the above mentioned factors; the signal will arrive from different paths which means different phases and different levels of power .The signal will be the summation of the received signals which mean constructive or destructive[2] . This is known as multi-path fading. In this paper, the measurement and investigation of these waves were carried out in an outdoor test bed environment using an hp laptop possessing a nets tumbler software in it.. Network stumbler software is used to measure the signal strength per varying distances.

II. LITERATURE REVIEW

Methods for predicting outdoor wireless signal coverage is being developed for decades. These models predict the signal power at a given point by determining the path loss, the difference between the transmit power and received power, from the transmitter to the receiver [3, 4]. The information is vital for the determination of coverage of a base-station (BS) placement and in optimizing it. Without propagation predictions, these parameter estimations can only be obtained by field measurements which are time consuming and expensive, especially in growing areas in terms of people and buildings. The propagation models can be classified into three models: empirical model, stochastic model and deterministic model. [5]. Empirical models are those models that based on the observations and measurements alone. These models are mainly used to predict the path loss, but models that predict rain-fade and multipath have also been proposed [5].

It can be described by equations derived from a statistical analysis of a large number of measurements. It is also called statistical models in some references. The models are simple (few parameters) and do not require very detailed information about the environment. The input parameters for the empirical models are usually qualitative and not very specific; one of the main drawbacks of empirical models is that they cannot be used for different environments without modification. Examples of popular empirical models are: okumura model, hata model and cost 231-hata model. Okumura's model is wholly based on measured data and does not provide any analytical explanation. It's major disadvantage include it's slow response to rapid changes in terrain which makes the model fairly good in urban and suburban area, but not as good in rural areas[6]. Hata Model is also an empirical model

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that is based on the Okumura's model where some correction factors are included. It works in the frequencies range from 150MHz to 1500MHz. The COST-HATA model is an extension of the Hata model. It was enhanced by the COST 231 project (European cooperation of scientific and Technical research). The purpose was to extend the limitations of the HATA models and apply appropriate correction factors to improve upon their degree of correctness in Europe.
Stochastic models, on the other hand, model the environment as a series of random variables. These models are the least accurate but require the least information about the environment and use much less processing power to generate predictions [6].
The deterministic models make use of the laws governing electromagnetic wave propagation to determine the received signal power at a particular location. Deterministic models often require a complete 3-D map of the propagation environment. An example of a deterministic model is a ray tracing model
Deterministic models are also known as physical models and are based on the fundamental mechanisms of radio wave propagation. They can be either site specific or not site specific [6].
Path loss exponent, *n*, is an empirical constant which depends on the propagation environment, it shows the rate at which signal fades over a range of distances. Table 1 taken from [5] gives typical values for *n*for different environment.

Table1: Typical path loss exponent

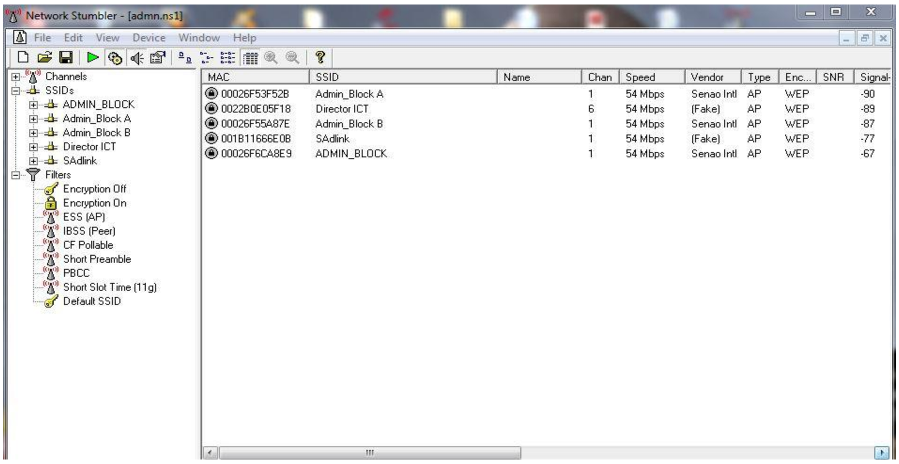
Different Environment	Path loss Exponent
Free space	2
Urban area cellular radio	2.7-3.5
Shadowed urban area cellular radio	3-5
In-building LOS	1.6-1.8
Obstructed in-building	4-6

III. TESTBED ENVIRONMENT

These experiments were carried out at the outdoor area surrounding the administrative building of Nnamdi azikiwe University Awka. The access points were placed strategically at different positions within the administrative building. A blueprint for the layout of the test bed is shown in figure 1.Positions A, B, C and D in figure 1 shows the points where the measurements where taken with respect to distances from the following access points(AP1, AP2, AP3, and AP4) located at the administrative building.

A. Measurement Tools

A software called Network stumbler was used to measure the received signal strength, it has the ability to sniff any wireless LAN within the test area. It works with aid of wireless LAN card installed in a laptop. Due the fact that the sensitivity of some wireless card of some computer is very poor, a special wireless adapter called D-Link Air Utility wireless adapter was used. In the Network stumbler interface, this wireless adapter has the ability to scans all Wi-Fi channels of interest and then makes measurements of the Received Signal Strength (RSS) for each AP it samples. Measuring tape of a longer distance calibrated in meters was used to measure the distance of received signal strength from the access point. It was also used to measure the height of the transmitter (access point).



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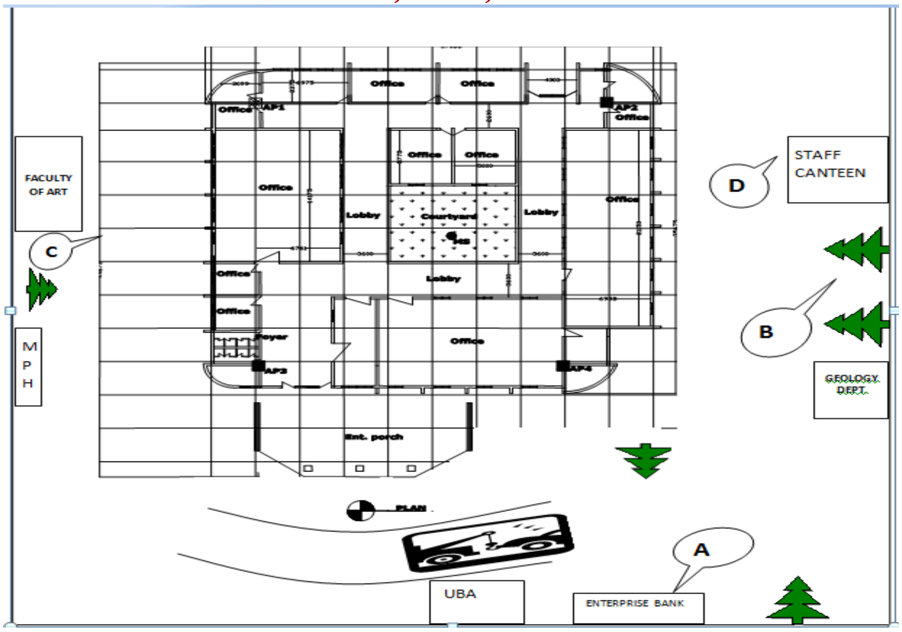

Fig 1: Design showing locations of Access points (AP's) and features within the environment

B. *Signal Model*

A possible method of predicting the receive signal strength within the test bed environment is by using of a mathematical model proposed by Chipcon [7].

$$RSSI = -10n \log_{10} d + A \qquad (1)$$

Where

RSSI = the signal power at the receiver

n = Path loss exponent

d = Distance between the transmitter and Receiver

A = the received power at one meter distance

Note, in this case the transmitter is the access points while the receiver is the laptop.

The path loss exponent, *n* is an empirical constant which depends on the propagation environment. To determine the path loss exponent *n* of the test bed area measurement were done to see how the signal strength decreases with increase in distance. It can be manually computed using this equation:

$$n = \frac{\{P_L(d_i) - P_L(d_0)\}}{10\log_{10}\left(\frac{d_i}{d_0}\right)} \qquad (2)$$

A matlab programme was used to estimate the value for the path loss exponent.

IV. DATA PRESENTATION AND ANALYSIS

Receive signal strength values were measured within 100meters of the four access points (AP1, AP2, AP3 and AP4) with a step size of 10 meters. These measurements were repeatedly taken at different times (morning, afternoon and evening hours), within a period of two months. Table 2 shows the average receives signal strength values for the four access points for the first month.

Table 2: Average Receive Signal Strength values (dbm) for the first month

Distance in meters	RSS for AP1(dbm)	RSS for AP2(dbm)	RSS for AP3(dbm)	RSS for AP4(dbm)
10	-19	-14	-12	-17
20	-30	-18	-28	-24
30	-58	-42	-45	-43
40	-72	-60	-63	-58
50	-75	-73	-66	-67
60	-79	-81	-72	-76
70	-82	-83	-80	-83
80	-85	-88	-86	-87
90	-87	-89	-88	-89

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100	-89	-91	-90	-91

Table 3 shows the averages receive signal strength values for the four access points for the second month, while table 4 shows the total average received signal strength measurement for the first and second month for each distance.

Table 3: Average Receive Signal Strength values (dbm) for the second month

Distance in meters	RSS for AP1(dbm)	RSS for AP2(dbm)	RSS for AP3(dbm)	RSS for AP4(dbm)
10	-20	-16	-12	-17
20	-30	-20	-26	-28
30	-48	-52	-45	-48
40	-68	-60	-63	-58
50	-70	-75	-70	-67
60	-74	-81	-76	-80
70	-82	-84	-80	-83
80	-86	-88	-84	-89
90	-89	-90	-88	-92
100	-94	-95	-90	-94

Table 4:Total Average Receive Signal Strength Measurement for first and second month

Distance in meters	Receive Signal Strength values for Ap1,Ap2,Ap3,Ap4 in (dbm)
10	-15.9
20	-25.5
30	-48.9
40	-63.3
50	-70.4
60	-77.4
70	-82.2
80	-86.7
90	-89.1
100	-91.8

Tables 2- 4 present the various receive signal strength values with respect to the access points. From table 4 ,the data collected were used to develop a matlab script for computing the pathloss exponent *n* for the test bed area. From the computation *n* was computed to be 3.3.Hence *n=3.3* will be used as the pathloss exponent in this research work.The results of the measurements for the first and second month are depicted in figure 2 and figure 3 respectively. While figure 4 shows the result of the total average measurement for first and second month combined.

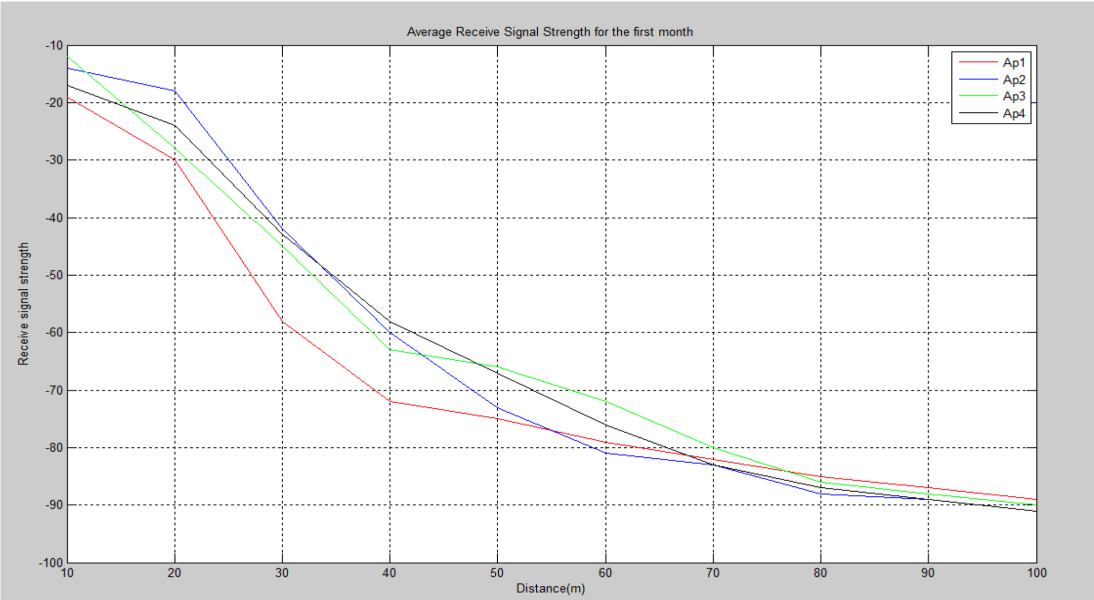

Fig 2: Average Receive Signal Strength for the first month

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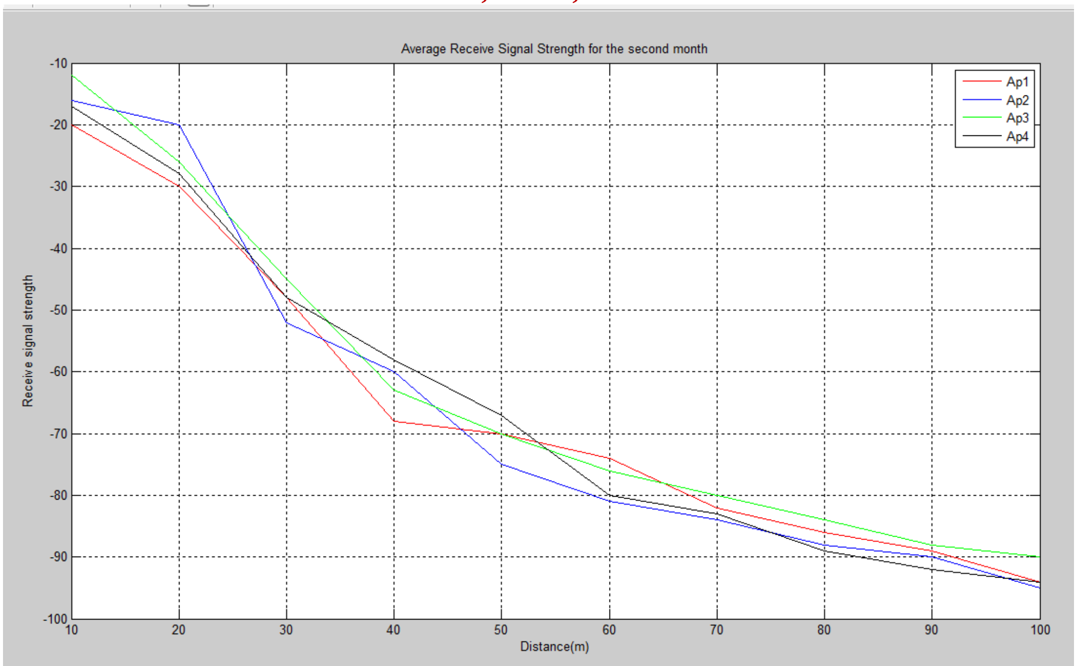

Fig 3: Average Receive Signal Strength for the second month

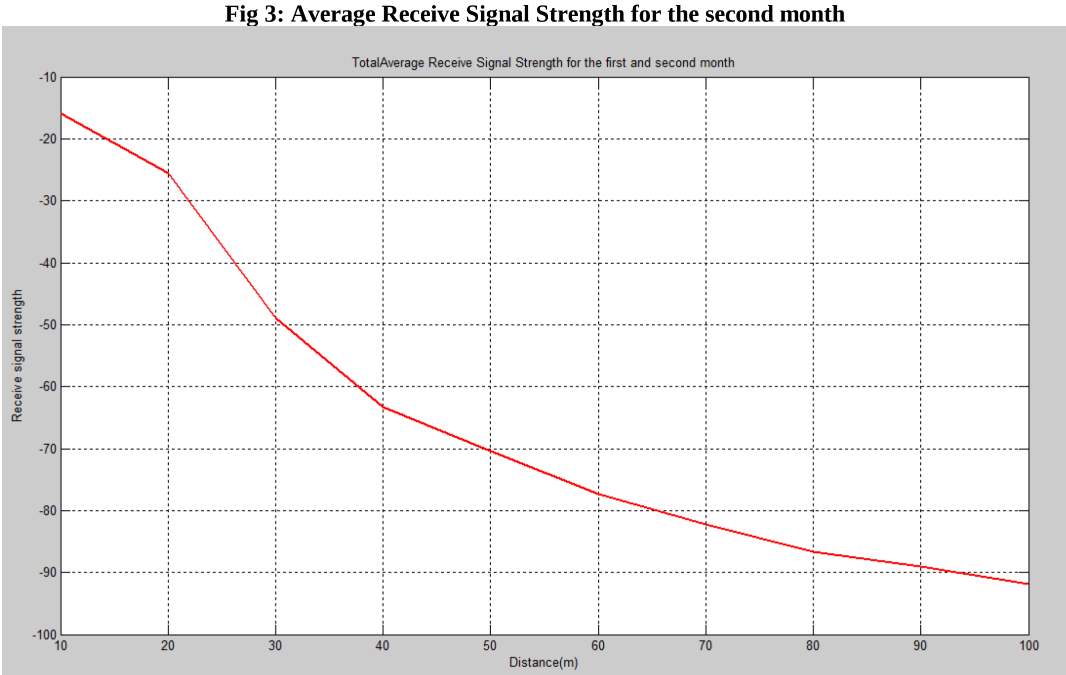

Fig 4: Total Average Receive Signal Strength measurements for first and second month

Summarily, from the figues 2 - 4 ; it was observed that generally in all the access points used for this research work, the receive signal strength decreases as distance increases.

V. RESULTS AND CONCLUSION

Based on the data collected, one can express distance as x (m) and the measured receive signal strength as y (dbm) for the test bed area. One can now model the relationship between distances and receive signal strength as:
$y = -33\log 10x - 7$ (modified from equation 1)
In this research work, a propagation model was proposed for the receive signal strength estimation in test bed area in Nnamdi Azikiwe university Awka. Several of the signal strength measurements carried out was based on true

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results. The propagation behavior of the WLAN for the outdoor environment was studied, from this studies, a conclusion was arrived at; stating that the closer the access point is to the laptop (mobile station) the higher the receive signal strength and vice versa

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