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Received Signal Strength Estimation in Wireless Local Area Network (WLAN) Environment

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ABSTRACT

This paper is focused on indoor propagation prediction in wireless local area network. In this paper, measurements of received signal strength were carried out within fifteen meters of the three access points with a step size of one meter at a test bed environment in the Faculty of Engineering Building; Block A, Nnamdi Azikiwe University Awka, Anambra State, Nigeria. The Netstumbler software installed in a laptop (DELL. Model: Inspiron E1505) with an in-built wireless interface card was used in recording the received signal strength from each of the access points. Results obtained showed that the received signal strength decreases as the distance of the receiver increases from the transmitting point and the developed mathematical signal model can be used as a valuable tool for accurate prediction of the received signal strength in the testbed environment.

Keywords: Wireless LAN, Multipath Propagation

I. INTRODUCTION

Currently, there is an increasing need for indoor wireless application such as wireless Local Area Network (LAN) and as a result of this increasing demand, the need for measurement and sufficient signal propagation prediction for these wireless systems arises [1]. Since the Wireless Local Area Network (WLAN) systems use wideband transmission, Quality of Service (QoS) has been highly dependent not only on average signal strength in a specific location, but also on fading statistics. In such wireless application, the transmitted signals often experience channel fading and time dispersion due to user mobility and multipath propagation [1]. In multipath propagation, several waves arrive at the receiver through different paths and with different phases causing rapid variations (fading) of the received signal envelope to occur [2]. There is need for the received signal strength estimation to be carried out due to time variations of the received signal and wide bandwidth of the transmission [3].

II. METHODS AND MATERIAL

Received Signal Strength Prediction Model

In order to predict the RSS in an indoor wireless LAN, the pathloss exponent of the environment must be known. The extent to which signal degradation occurs in a communication channel can be known by determining the pathloss exponent of the environment. Therefore, pathloss exponent, n, of an environment shows the variation of signal loss in an environment. The pathloss exponent, n, and the received signal strength obtained from field measurement can be used to completely characterize a propagation environment under consideration. The mean path loss, $P_L(d_i)$ [dB] at a transmitter receiver separation, d_i , is given as [4]:

$$P_L(d_i)\,[\text{dB}] = P_L(d_0)\,[\text{dB}] + 10n\log_{10}\left(\frac{d_i}{d_0}\right) \quad (1)$$

Where n = pathloss exponent,

$P_L(d_0)$ = pathloss at known reference distance d_0.

For free space model n is regarded as 2. It is accepted on the basis of empirical evidence that it is reasonable to model the pathloss, $P_L(d_i)$ at any value of d at a particular location as a random and log-normally distributed random variable with a distance-dependent mean value [5]. That is:

$$P_L(d_i)\,[\mathrm{dB}] = P_L(d_0)\,[\mathrm{dB}] + 10n\log_{10}\left(\frac{d_i}{d_0}\right) + S \qquad (2)$$

Where S,the shadowing factor is a Gaussian random variable with values in dB. The path loss exponent, n, is an empirical constant which depends on propagation environment.

In order to determine the pathloss coefficient, n, of the test bed environment, equation (2) can be used to manually compute it as:

$$n = \frac{\{P_L(d_i) - P_L(d_0)\}}{10log_{10}\left(\frac{d_i}{d_0}\right)} \qquad (3)$$

But, using linear regression, the value of n can be determined from the measured data by minimizing total error R^2as follows:

$$R^2 = \sum_{i=1}^{M}\left[P_L(d_i) - P_L(d_0) - 10nlog_{10}\left(\frac{d_i}{d_0}\right)\right]^2 \qquad (4)$$

Differentiating equation (4) with respect to n,

$$\frac{\partial R^2(n)}{\partial n} = -20log_{10}(d)\sum_{i=1}^{M}\left[P_L(d_i) - P_L(d_0) - 10nlog_{10}\left(\frac{d_i}{d_0}\right)\right] \qquad (5)$$

Equating $\frac{\partial R^2(n)}{\partial n}$ to zero,

$$0 = -20log_{10}(d)\sum_{i=1}^{M}\left[P_L(d_i) - P_L(d_0) - 10nlog_{10}\left(\frac{d_i}{d_0}\right)\right] \qquad (6)$$

$$\sum_{i=1}^{M}[P_L(d_i) - P_L(d_0)] - 10nlog_{10}\left(\frac{d_i}{d_0}\right) = 0 \qquad (7)$$

$$\sum_{i=1}^{M}[P_L(d_i) - P_L(d_0)] - \sum_{i=1}^{M}\left[10nlog_{10}\left(\frac{d_i}{d_0}\right)\right] = 0 \qquad (8)$$

$$\sum_{i=1}^{M}[P_L(d_i) - P_L(d_0)] = \sum_{i=1}^{M}\left[10nlog_{10}\left(\frac{d_i}{d_0}\right)\right] \qquad (9)$$

Therefore, $n = \frac{\sum_{i=1}^{M}[P_L(d_i) - P_L(d_0)]}{\sum_{i=1}^{M}\left[10log_{10}\left(\frac{d_i}{d_0}\right)\right]}$ (10)

The pathloss exponent in equation (10) can be used in the RSS model as[ ]:

$$\mathrm{RSSI} = -10\mathrm{n}\,\log_{10}\mathrm{d} + \mathrm{A} \qquad (11)$$

Where RSSI = the signal power at the receiver, n= Pathloss exponent, d = Distance between the transmitter and receiver A = the received power at one meter distance

III. RESULTS AND DISCUSSION

Experimentation

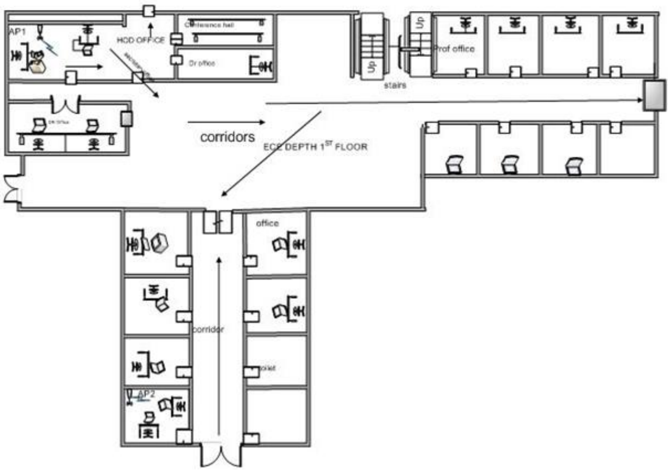

Figure 1. Testbed environment

With the network sniffer, measurement were taken on the access point locations(AP1,AP2 etc) on the test bed region which were seen to be the receive signal strength and its value were stored in the database, called the Mean RSS vector. In collecting this vector, the Netstumbler software installed in a laptop (DELL. Model: Inspiron E2105) with an in-built wireless interface card was used. The signal emanates from three APs (faculty of engineering ECE, Ifeagwu's _project and faculty of engineering deans' office.) of an IEEE 802.11b WLAN infrastructure situated in the Faculty of Engineering Building Block a NAU.

The software reports information about the signal at different points, as the MS (which in this case is referred to the laptop used) is carried around the environment. For each of the Access Points, the software displays the medium access control (MAC) address, service set identifier (SSID), wired equivalent privacy (WEP) status, signal strength, signal to noise ratio (SNR), noise, speed e.t.c. Receive Signal strength values were measured within fifteen meters of the three access points (AP1, AP2 and AP3) with a step size of one meter. These measurements were carried out within a period of three months. Note that the RSS values or measurement are in dBm as could be seen in the database. This is more convenient than using just dB, which is only a ratio of power or voltage [5].

Discussion

Receive Signal strength values were measured within fifteen meters of the three access points (AP1,AP2 and AP3) with a step size of one meter. These measurements were repeatedly taken at different times (pick and off pick periods) and dates within a period of three months. Figure1 shows the average receive signal strength values in dBm for the three different access points for the first month.

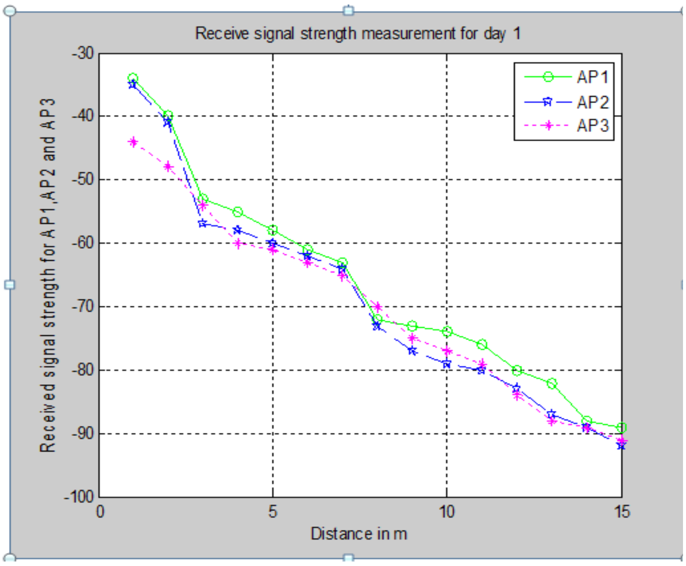

Figure 2: A graph of average received signal strength values (dBm) for the first month

The result implies that the further the distance of the receiver from the transmitter which in this case refers to the distance from Mobile Station (MS) to the access points, the lower the receive signal strength seen by the mobile station

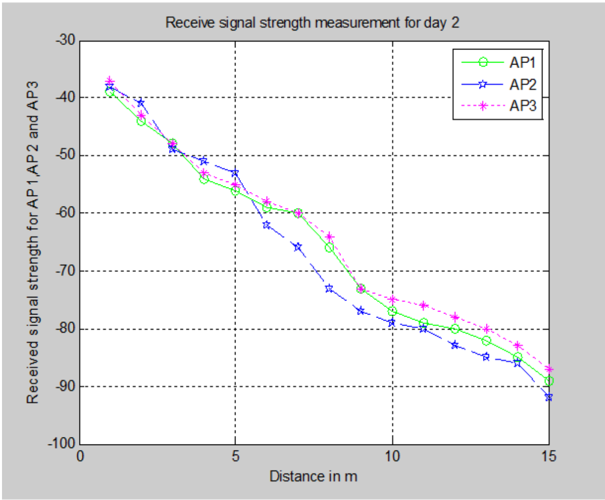

Figure 3. A graph of Average Received Signal Strength values (dBm) for the second month

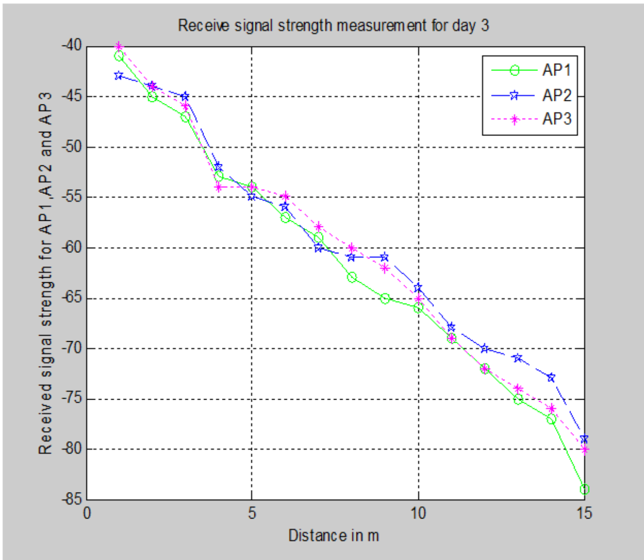

Figure 4: A graph of Average Received Signal Strength values (dBm) for the third month

Firstly, form the graphs in Figures 2, 3 and 4. It was observed that generally in all the access points used for this project, the received signal strength decreases as the distance increases. But a clearer observation from the graphs shows that at some point wireless local area network (WLAN) performed better for some period of time which were seen to be the off peak periods as their measurement was carried out in the early hours of the day(10:30 am).

The value for the pathloss exponent was computed to be 3.63. This was done with the help of a Matlab program. Other parameters gotten empirically is the value for *A;* which is the received signal power at one meter from the transmitter, and is found to be -40dBm.Putting this values back to the model represented by equation 1. We will have our proposed model as:

$$\mathrm{RSSI} = -36.3 \log_{10} \mathrm{d} - 40 \quad (12)$$

Finally we can boldly say that a model has been proposed, which can be used as a reference model for a nearly accurate prediction of the Receive Signal Strength in Wireless Local Area Network (WLAN) within the test bed environment

IV. CONCLUSION

This paper presents that a model was proposed for the Receive Signal Strength estimation in a given location on the test bed environment in Wireless Local Area Network (WLAN). Several of the signal strength measurements carried out were based on true results. The propagation behaviour of the WLAN for the indoor environment was studied. From the studies, a conclusion was arrived at, stating that the closer the access point is to the mobile station, the higher the receive signal strength.

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