Empirical Analysis of Signal Strength-Distance Variations in IEEE 802.11b in WLAN

1Nnebe S. U., 2Onoh G.N., and 3Ohaneme C.O., 4Nwankwo V.I.

Abstract—The variation of signal strength in Wireless Local Area Network (WLAN) has attracted the attention of network users in recent times for the purpose of finding lasting solution to its effect on signal degradation. This paper presents an experimental evaluation of the Signal Strength-Distance variations in IEEE 802.11b WLAN. Afrihub, an established network provider at Nnamdi Azikiwe University, Awka, Nigeria was studied using a network sniffer called Network Stumbler (NetStumbler). The network has three functional access points at the time of the study. The mean of the measured signal strength of the access points was calculated. Matlab was used to simulate the experimental result to show graphically the variations of signal strengths with distances and Euclidean distances with distances. It was therefore observed that the signal strengths from the access points are inversely proportional to distance. Hence, the signal strength fades as the distance increases.

Index Terms—Access Points, Distance, IEEE 802.11b, Netstumbler and Signal Strength.

I. INTRODUCTION

Wireless mobile system has been one of the most interesting phenomena in communication industry in recent times. This must not be unconnected with it flexibility in ensuring seamless communication links between mobile users within indoor and outdoor environments. Moreso, the analysis of indoor wireless communication environment provides the platform for the review of the level of signal strength of transmitted signals of mobile users through access points or base stations. The system gives vivid explanation of the quality of service provided as a result of some impairments experienced in the transmission medium such as path loss, shadowing effects e.t.c. These channels through which the signals are transmitted constitute certain impairments which contribute essentially to the poor performance of wireless system by showing the deterioration of signal quality between one geographical position to another. Therefore, this paper looked into the performance of WLAN network and the nature of signal transmission as mobile users move from one point to another. The analysis is based on the variation of the transmitted signal with respect to distance.

The great popularity and use of IEEE 802.11 along with channel scarcity may lead to a degraded overall performance of IEEE 802.11 systems. IEEE 802.11b standard defines the extensions to the Medium Access Control (MAC) mechanism as well as, the physical layer (PHY) that operates in 2.4GHz band [1]. The foundation of mainstream WLAN products began with the original 802.11 standard developed in 1997 by the Institute of Electrical and Electronic Engineers (IEEE). The frequency spectrum available for wireless local area network operations is limited to 14 frequency channels in 2.4 GHz band, out of which three are non-overlapping and are allocated for IEEE 802.11b and IEEE 802.11g operations. IEEE 802.11b has extended the generic IEEE 802.11 standard by adding physical layer support of two speeds; 5.5 Mbps and 11Mbps respectively [2]. IEEE 802.11b specifies Complementary Code Keying (CKK), which consists of a set of 64 eight-chip code words for the 5.5 Mbps and 11Mbps data rates. The 5.5 Mbps rate uses complementary code keying to encode four bits per symbol, while the 11 Mbps rate encodes eight bits per symbol. Both 5.5 and 11Mbps rates use Quadrature Phase Shift Keying (QPSK) as the modulation technique and signals at 1.375 MSp. The work measures signal strength of Afrihub network at Nnamdi Azikiwe University, Awka which has three functional access points (IEEE 802.11b) at the time of the research. The detection of signal strength and its measurement by the network sniffer was used to estimate the mean, median and standard deviation of the signal strength. Also the signal-Euclidean distance of the signal was found. Graphs obtained during simulation were used to analyze the relationships between the signal strength and distance, and the Euclidean distance versus ordinary distance.

The study of quality of service in WLAN had been a recurring decimal in the estimation of signal strength by various authors. In their works, [3] studied the developed standard which provided for three physical layer (PHY) specifications including infrared, 1-2 Mbps frequency hopping spread spectrum (DSSS) in the 2.4GHZ ISM band [4]. The basic standard continues to be enhanced through document additions that are designated by a letter following the IEEE 802.11 name such as IEEE 802.11b, IEEE 802.11a, or IEEE 802.11g. The letter suffix represents the task group that defines the extension to the standard. These enhancements bring increases in data rate and functionality leading to rapid progression of the wireless local area network market.

The IEEE 802.11 medium access control defines two basic methods to access the medium, the Distributed Co-ordination Function (DCF) and the Point Co-ordination Function (PCF), as described in chapter 9 of IEEE standard, 802.11-1999 [5]. The DCF defines a randomized access mechanism, which is based on the carrier sense Multiple Access/ Collision Avoidance...
(CSMA/CA) scheme, where each mobile node has a fair chance to access the wireless medium.

The point coordination function is an optional access method that can be implemented in an infrastructure network (not in an adhoc network). It is implemented on top of the distributed coordination function and is used mostly for time-sensitive transmission.

II. EXPERIMENTAL TESTBED AND MEASUREMENTS

Signal strength of Afrihub Network was measured using a network sniffer and it was observed that it has three functional Access Points at the time of the study. A testbed located at the Electronics and Communication laboratory of the department of Electronic and Computer Engineering of the University having dimensions of 16m by 7m and an area of 12sqm was used as shown in the Figure 1.

The test bed is segmented by a square of 1m x 1m as shown in Figure 1. Each square in the test bed represents a user/client and each user is assigned to a particular channel/frequency. Measurements were taken to see how distance correlates to signal strength.

The graph of figure 2 shows the relationship between distance and the mean of the signal strength values. The graph shows the variation of the average signal strength with respect to the distance between the access points. From Figure 3, it was deduced that signal strength decreases with increase in distance due to attenuation and multipath effects but there are some exceptions due to line of sight reception. Hence where there is no clear LoS, signals tend to deteriorate because of multipath and shadowing. In this case, the distance covered does not translate into the strength of the received signal but the degree and nature of obstructions between the access points.

However, the Signal distance between mean measured Signal Strength vectors $X_i$ [$X_{11}$, $X_{12}$, $X_{13}$, ..., $X_{1n}$] and the mean Signal Strength vector in the data base $R_i$ [$R_{i1}$, $R_{i2}$, $R_{i3}$, ..., $R_{in}$] is computed. The Euclidean distance between the two vectors was used and is given by

$$d_i = \left( \sum_{i=1}^{n} |X_{1i} - R_{1i}|^2 \right)^{\frac{1}{2}} \quad (1)$$

The Matlab was extended to plot a graph of Euclidean distance against mean Signal Strength values as shown in Figure 4.

III. EXPERIMENTAL RESULTS AND ANALYSIS

Table 1 shows the values of the signal strength measurement taken using NetStumbler. The measurements were taken at various distances. The signal strength decreases with increase in the distance, although there are some exceptions which may be due to Line of Sight (LoS) reception. The mean, median and standard deviation of the measured Signal Strength values of the access points are computed.

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>AP1 (dBm)</th>
<th>AP2 (dBm)</th>
<th>AP3 (dBm)</th>
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**Fig 1:** Electronics and Computer laboratory (The experimental testbed)

**Fig 2:** A graph of mean Signal strength Versus Distance profile

**Table 1: Measured Signal Strengths**
Fig 3: A graph of average signal strength Versus Distance

Fig 4: A graph of Distance in meters distance in dBm Versus Euclidean distance in dBm

IV. CONCLUSION

Measuring the signal strength of access points and finding the mean of the received signal strength, helped in estimating the level of variations of signal strength with respect to distance. It actually shows that as the distance increases, the received signal strength decreases.

REFERENCES

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