Planning and Modeling of Indoor WLAN through Field Measurement at 2.437 GHz Frequency

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***Abstract*- Radio signal attenuation and path losses rely on the environment and are recognized to be tough to calculate and predict. Past studies of the signal propagation, in an indoor environment have used several models with variable degrees of success and quality. In this paper, the field measurements of signal strength taken at the frequency of 2.437 GHz in indoor environments are presented and analyzed. Based on the characterization of environment, a new path loss model is proposed, which can be used to predict the signal strength for indoor environment accurately. These parameters may be utilized in future network design.**

***Keywords:* Path loss, Propagation models, RSSI, WLAN, curve fitting**

I. INTRODUCTION

Wireless technologies are very popular for the pour of information. IEEE 802.11 technologies have started to spread quickly, enabling consumers to set up their own wireless networks [1]. Also with the rising use of mobile computing devices such as PDAs, laptops, and an expansion of Wireless Local Area Networks (WLAN), there is emergent interest in optimizing the WLAN infrastructure so as to increase productivity and efficiency in various colleges and office campuses with carrying out a cost-effective infrastructure model. So it has become essential to understand the propagation characteristics for a proposed wireless local area network before deployment [2].

Predicting how far a signal can go before installation will ensure that a connection cannot be made in areas where it is not desired. The strength, range and coverage area of an access point is strongly affected by its positioning in reference to its environment [3].

To avoid undesired connection in places where it should not be made, it is necessary to carefully predict the signal strength, range, coverage and the correct placement of base stations [4].Various mechanisms like reflection, diffraction, refraction, scattering & absorption also affects the strength of the signal [5].The strength of our existing WLAN for indoor & outdoor access points can be analyzed by statistical field measurements [6].

The complexness of the indoor situation (diversity of layouts, obstruction by wall or floors etc) ends up in an issue once investigation the propagation characteristic or predicting the trail loss and delay unfold, particularly in multi-floor buildings [7]. The multi-wall- and-floor penetration plays an important role in total signal attenuation. therefore on improve indoor coverage, and avoid the interference from completely different floors, the channel property during a multi-floor atmosphere ought to be examined for improvement of indoor base station location or network preparation designing work of a wireless network[8].

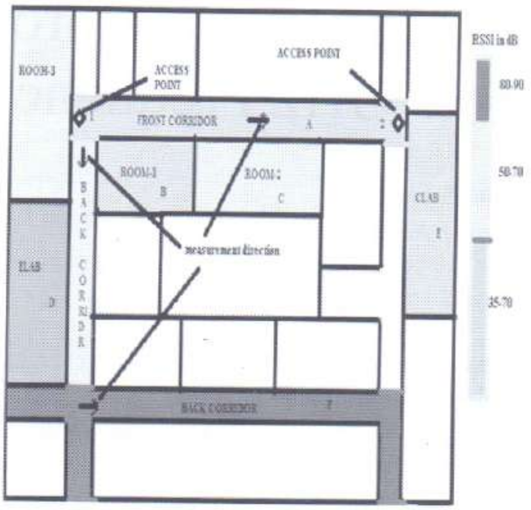
This paper demonstrates the analysis of the existing wireless network in indoor & outdoor environments by examining the field measurements of received signal strength (RSS). The data taken for the analysis is used to calculate the path loss exponent & standard deviation & a new path loss model of the location. The frequency of the radio signal analyzed is 2.437 GHz. The received signal levels were monitored from the access point (AP) or base station (BS) manually. Total coverage area chosen for the measurement campaign consisted of a mixture of significantly different propagation environments.

Section II describes the measurement procedure, measurement location layout of building and data sniffing tool used to produce the models in this Paper. Section III describes the different propagation models. Section IV shows the data processing and modeling of new model for future planning. Sections V describes the converge analysis and VI conclude with a summary of results and future work.

II. SITE SURVEY

A. Area chosen

We performed experiments using the existing indoor wireless infrastructure in the Electronics & Communication Engineering Department at Noida Institute of Engineering & technology, Greater Noida for indoor analysis using the indoor access point We considered our indoor measurements at 8 locations, three rooms and two labs at fifth floor & other three locations were the corridors at the fifth floor in which one corridor containing the access point.



RSSI view of fifth floor ECE department, NIET greater noida

Fig.1 Access point and measurement location of ECE department NIET greater Noida

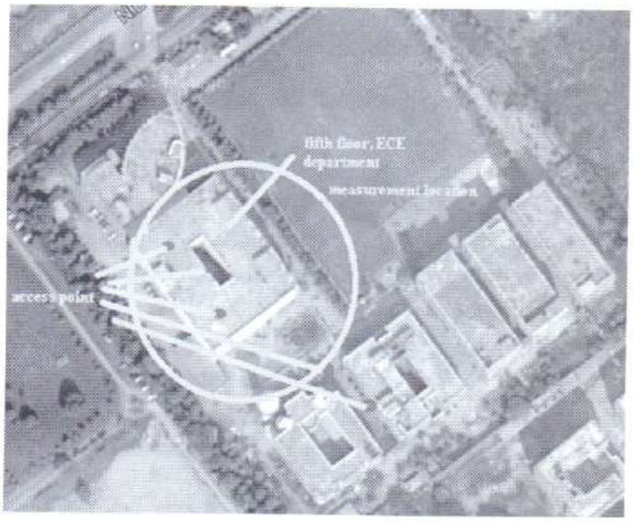


Fig. 2: G-Map view of readings taken at NIET Greater Noida inside the ECE department, fifth floor-BLOCK.

B. RSSI measurement tools

For site surveying, generally wireless sniffing tools are used to sniff wireless packets from an ad-hoc network setup using an access point. There are varieties of open source wireless sniffing tools available on the internet.

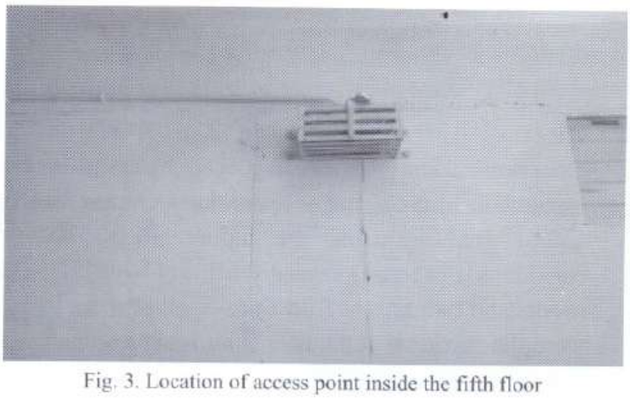


Fig. 3. Location of access point inside the fifth floor

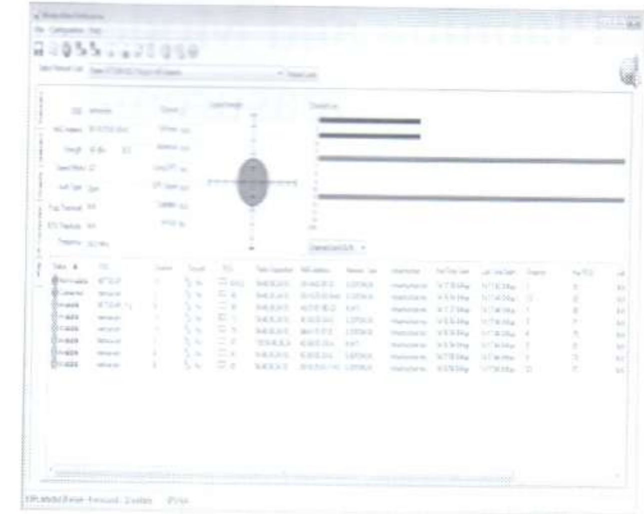


Fig. 4. Snapshot of Passmark WirelessMon Software

In our analysis, Passmark Wireless Mon Software was used to provide the values of received signal strength. It also gives the MAC (Media Access Layer) address of the access point along with the frequency value and standard of the AP. Its trial version is available on the internet. It also plots the graph between signal strength and time. The software has the sensitivity of 200 dBm [9].The figure4 shows the snapshot of the software.

Another software called as Ekahau Heatmapper was used to determine the coverage region of an access point graphically by considering a reference location of the AP on the software. If the map of the location is available then the map can be loaded in the software and with the help of that the site survey of the location can be studied and also the signal strength can be determined [10]. MATLAB 7.8.0.347(2009a) software was used for the data analysis of the readings in terms of plotting of graphs and curve fitting [11].Our client or receiver device was a laptop of HP Company of model pavilion g-6 2009tx having a wireless NIC (Network Interface Card) of Ralink RT5390 802.11b/g/n Wi-Fi adaptor .It supports WLAN protocols of type IEEE802.11 a/b/g. It was having the maximum sensitivity of -88 dBm [12].

III PROPOGATION MODEL

A. Why propagation models?

The wireless channel places fundamental limitations on the communication systems because of its dynamic nature. The transmission path between the transmitter and the receiver can vary from simple line of sight to one that is obstructed by trees, walls, floors etc. This can cause the signal strength of two points that are equidistant from the access point to be entirely different. Propagation models focus on predicting the average signal strength that may be received at a particular distance from a transmitter. Thus, it is important to determine the propagation model for the indoor wireless network by taking shadowing into account [8]. In the following sub sections we will discuss about some of these models

B. Free Space Path Loss Model (FS)

The free space path loss is an analytical model that predicts the strength of the signal received when a clear line of sight path exists between transmitter and receiver. It is the foundation for all other models. It is derived from Friis"s free space equation given by[8],

$$P_{r(d)} = \frac{G_t G_r P_t \lambda^2}{(4\pi)^2 d^2 L^2} \quad (1)$$

Where,

λ = wavelength of transmitted signal

Pt = transmitted power

Pr = Received power at a distance d from the transmitter

L = antenna dimension

The path-loss represents the attenuation the signal undergoes as it propagates through the medium. It is defined as [8]

$$PL(dB) = 10log\frac{P_t}{P_r} = -10log\left[\frac{G_t G_r \lambda^2}{(4\pi)^2 d^2}\right] \quad (2)$$

C. Log-distance path loss model

The free space propagation model is a theoretical model; not applicable to real life situations. Log distance path loss model is a practical path loss model which is based on the fact that the received power decreases logarithmically with distance. The average path loss for an arbitrary Tx-Rx separation is given by the following expressions [8],

$$\overline{PL(d)} \; \alpha \; \log\left[\frac{d}{d0}\right]^n \quad (3)$$

Or

$$\overline{PL(d)} = \overline{PL(d0)} + 10nlog\left[\frac{d}{d0}\right] \quad (4)$$

Where, d=distance of the receiver from the access point or the reference point in foot or meters, here n = path loss exponent, which indicates the rate at which path loss increases with distance. d0=close in reference distance (1 m for indoor environment).

The bar in equation (3) & (4) indicates the ensemble average of all possible path loss values foe a given value of d.

When plotted on a log-log scale the modeled path loss is a straight line with slope equal to 10 n dB per decade. The value of n depends on the environment (2 for free space, 1.6-1.8 for LOS indoor, 4-6 for NLOS indoor).

D. Log normal shadowing

It can be expressed as [8],

$$\overline{PL(d)} = \overline{PL(d0)} + 10nlog\left[\frac{d}{d0}\right] + X\sigma \quad (5)$$

Here, PL (d0) = power received at reference distanced0 & Xσ represents a normal random variable in dB having a standard deviation of σ dB. In terms of received power, the same propagation model can be re-written as [8],

$$P_r(d)[dBm] = P_t(d)[dBm] - PL[dB] \quad (6)$$

This model can also be used for outdoor propagation for small distances between transmitter and receiver [8]. On the basis of above equations, graphs were plotted between the power loss & distance on log scale. Thereafter, the table is drawn showing the path loss & deviation of each location.

IV DATA PROCESING & PROPOSED MODEL

A. Indoor location analysis

For the indoor analysis the access point or base station used was having the following specifications:

Prosafe dual band wireless N-point

Model – WNDPA350

RF Transmitting Power- (20 dBm)

Vendor– NETGEAR Wireless Limited

Support - IEEE 802.11g (OFDM)

Receiver sensitivity=-88dB

The Passmark WirelessMon software gave the received power reading at the current location of the receiver which determined the path loss on that particular point using the log-distance model [9].The following subsections illustrate the set of locations along with the figures showing the variation of path loss with respect to the distance from the access point or reference point.

On the basis of the readings obtained a linear fit of the graph was drawn to determine the approximate path loss & deviation using the MATLAB tool [11]. The height of transmitting AP was 8 feet for all locations and height of receiving point taken was 3.5 feet for different rooms & all corridor and 60 sampled were taken for each location.

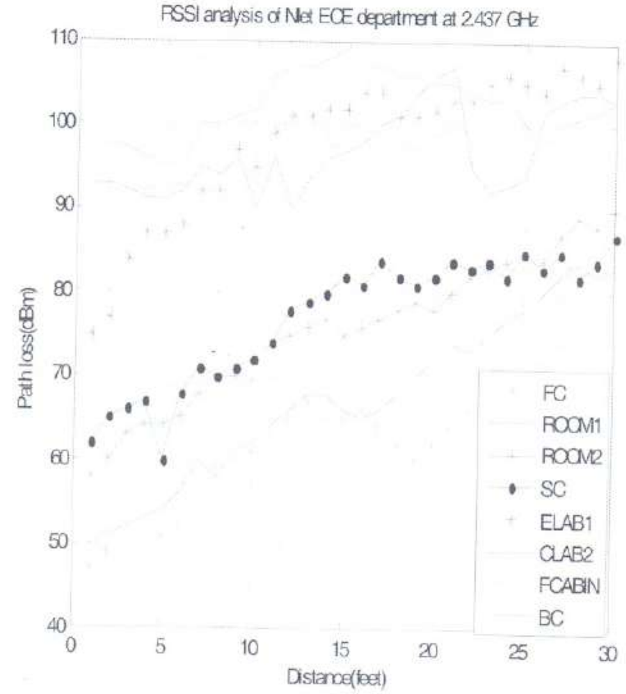


Fig. 5: Path loss vs. distance for different location of indoor environment

From sampled reading (Fig. 5) and curve fitting for all location we have obtained the path loss exponent & standard deviation of each location which are listed below in Table 1.

TABLE1
Path loss exponent & standard deviation of each location

Location	Path Loss Exponent	Standard Deviation
EC Lab	3.02	13.17
Side Corridor	2.64	12.50
Room1	2.09	9.516
Room2	1.96	8.183
Front Corridor	1.80	7.717
Commn Lab	1.35	6.047
Faculty Cabin	1.08	4.698
Back Corridor	1.01	3.469

After analysing all these variation in signal strength at different location, we will proposed a new path loss model using curve fitting and regression [11].

$$PL(d)=42.6+30.2\log(d) \quad n=3.02 \qquad (7)$$

Equation (7) gives the proposed path loss model for LOS condition when path loss exponent n is 3.02. This equation is obtained using curve fitting of measured data. By the help of this equation, we can find the path loss of indoor environment.

V. COVERAGE ANALYSIS

With the help of Ekahau Heatmapper software we can calculate the coverage area of a particular access point. Fig. 6 shows the coverage region of the outdoor access point by considering the access point at the origin [24].Based on the coverage region figure we have divided the coverage area into three regions with each region having its effective signal strength. Table 2 accounts for the range & signal strength of each region.

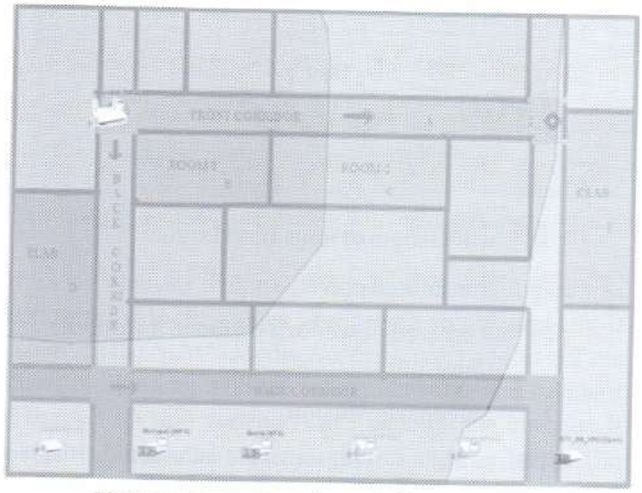


Fig 6: coverage region of a particular access point

TABLE 2
Coverage region of an access point

Reign	Effective range	RSSI in dB
Dark green(A)	2-10 m	-56 to -48
Green(B)	10-25m	-65 to -58
Yellow(C)	More than 25	-90 to -72

From these readings we can say that the strength of the signal varies as we go away from access point. Also the signal strength is Strong in region A. It is fair in region B & Very Low in region C. So to get the high speed in using internet the user must choose region A or B. To download high memory applications, these two regions are optimum.. Region C has very low strength and speed will be very low.

VI. CONCLUSION

The network operating between two walls of building posses hugs attenuation and therefore variation of signals were maximum up to 13.17.the corridor where signals are recorded estimate huge path loss and therefore large variation of signal are seen in few places. The maximum is observed in front of EC lab as the system is installed on same walls. The two devices are installed in same corridor and both are facing to each other. The area covered since to be 100% but due to large path loss only 70-80% region are covered by this devices as shown in Fig. 6. In the same time, signal strength in particular region varies according to Table 2.

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