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IEEE 802.11 b and g WLAN Propagation Model using Power Density Measurements at ESPOL

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***Abstract*—**This paper describes the development of a WLAN propagation model, using Spectral Analyzer measurements. The signal is generated by two Access Points (APs) on the base floor at the administrative Communication School of ESPOL building. In general, users do not have a Q&S reference about a wireless network; however, this depends on the level signal as a function of frequency, distance and other path conditions between receiver and transmitter. Then, power density of the signal decrease as it propagates through space and data transfer rate is affected. This document evaluates and implements empirical mathematical formulation for the characterization of WLAN radio wave propagation on two aisles of the building base floor.

***Keywords*—**frequency, Spectral Analyzer, transmitter, WLAN.

I. Introduction

A Wireless Local Area Network (WLAN) provides a connection through an access point to the wider internet. WLANs became popular in the home by the year 2000, due to the increasing popularity of laptop computers. Educational Institutions and Public businesses such as coffee shops and malls began to offer free wireless access to their students and customers respectively. The development of IEEE 802.11b y g wireless networks increase rapidly, that is why, it have been become a neediness to modeling the behavior of propagation, before to implements this kind of networks. In a campus environment, coverage with an acceptable infrastructure density can be provided only if a 2.4 or 5 GHz system is used. Radio propagation models typically focus on realization of the path loss with the auxiliary task of predicting the area of coverage for a transmitter or modeling the distribution of signals over different regions. Three propagation phenomena can usually be distinguished: multipath fading, shadowing and 'large-scale' path loss. Multipath propagation leads to rapid fluctuations of the phase and amplitude of the signal if the receiver moves over a distance in the order of a wave length or more. Multipath fading thus has a 'small-scale' effect.

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Shadowing is a 'medium-scale' effect: field strength variations occur if the transmitter is displaced over distances larger than a few tens or hundreds of meters.

The 'large-scale' effects of path losses cause the received power to vary gradually due to signal attenuation determined by the geometry of the path profile in its entirety. This is in contrast to the local propagation mechanisms, which are determined by building and terrain features in the immediate vicinity of the antennas.

As a result of this paper, we will have the development of Power signal received model y the coverage analyze [2]. The goal of developing a Power signal received model is to predict the way radio waves are propagated from one place to another. Coverage analyzes give relevant information to define the network quality of service due to the relation between level signal and data transfer rate.

II. Power Signal Received Model by Distant-Power Gradient Method [2]

Distance-Power gradient α is used for the determination of power decrease as a function of distance from transmitter. For example, 10α is the average attenuation per decade of increase in the distance. In general, α is equal the number two in areas such as corridors, sitting areas and free areas. Therefore, as the distance between a transmitter and a receiver increases, the received signal power will have short and long distance fluctuations, referred to as multipath fading and shadow fading, respectively.

Fluctuations of the average received signal strength over a short window of time show the effects of shadow fading. Also, we can observe the effects of multipath fading with the plot of the received signal versus the distance (fig. 1).

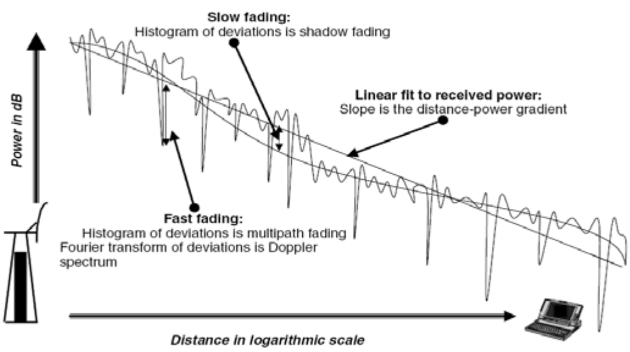

Fig.1 Received power versus distance between a mobile terminal and a base station, linear fit with a fixed slope, multipath fading, and shadow fading. [2]

To develop a model for coverage of IEEE 802.11b and g WLANs, it was measured the received signal strength (RSS) in different locations on the base floor of the administrative FIEC-ESPOL Institute (Fig 2).

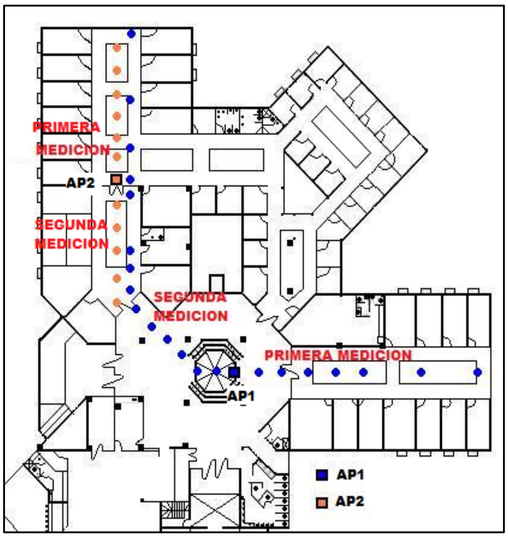

Fig. 2 Location of transmitters and locations of the receiver used for calculation of the RSS and path loss.

Spectral Analyzer SRM-NARDA 3000 was used to get the received power density measurements (100kHz to 3GHz) [3]. RSS is calculated through the power density using the equation [1]:

$$A_e = \frac{\lambda^2 * G_r}{4\pi} \quad (1)$$

$$P_r = P_d * A_e \quad (2)$$

in which Ae is the effective aperture, λ^2 is the wavelength of the transmitted signal , Gr is the receiver gain, Pr is the received power and Pd is the power density. Assume that the antenna gain (Gr) is include in Pd as a unit.

To develop a model for the coverage of the WLANs, it used the simple distance-power gradient model [2], in which, the path loss in decibels at a distance of 1 m is given by:

$$L_0 = 10 * \log_{10} P_t - 10 * \log_{10} P_0 \quad (4)$$

y it can be defined the total path loss Lp as:

$$L_P = L_0 + 10 * \alpha * \log_{10}(d) \quad (5)$$

P_t = Transmitted signal power

P_0 = Transmitted signal power at a distance of 1 m.

d = Distance between transmitter and receiver

L_P = Path loss

L_0 = Path loss at a distance of 1 m.

α = Distance-Power gradient.

On the data transmission power of the access point that is equal to 20 dBm as shown in Table I, we can calculate the Lp values for each of our measurements as follows:

$$Lp = 20 - RSS \quad (6)$$

TABLE I
TRANSMITTER TECHNICAL DATA

CENTRAL FREQUENCY	Fc = 2435000000 Hz
VELOCITY OF RADIO-WAVE PROPAGATION	C = 300000000 m/s
WAVELENGTH	λ = 0.12320329 m
EFFECTIVE APERTURE	Ae = 0.00120791
TX GAIN	Gt = 8 dBi
ATENUACION POR PARED	Mtype = 6
TX POWER	Ptx = 20 dBm
TX POWER	Ptx = 0.1 W

One way to determine Lo y α for each environment analysis is to plot the Lp values versus log10 (d) measured. The slope of the linear fit of the points is the distance-power gradient and the extrapolation of the values toward the vertical axis is the loss Lp at a distance of 1 meter (Lo).

Several measurements were made about two Access Points (APs) from the ground floor of the building, starting with a distance of 1m, 3m and increasing at each point of measurement, whose results are shown in tables II, III, IV and V.

TABLE II
AP1-1: FISRT MEASUREMENT

P	*Pd [mW/m2]*	*P [dbm]*	*P [db]*	*Lp [dBm]*
01	1,6020	-27,13302	-57,13302	47,1330277
02	0,3911	-33,25677	-63,25677	53,2567747
03	0,1093	-38,79345	-68,79345	58,7934512
04	0,0657	-41,00532	-71,00532	61,0053214
05	0,0370	-43,50115	-73,50115	63,5011583
06	0,0173	-46,80924	-76,80924	66,8092449
07	0,0112	-48,68359	-78,68359	68,6835967

TABLE III
AP1-2: SECOND MEASUREMENT

P	*Pd [mW/m2]*	*P [dBm]*	*P [db]*	*Lp[dBm]*
01	0,6237	-31,22989	-61,22989	51,22989
02	0,4401	-32,74413	-62,74413	52,74413
03	0,2154	-35,84719	-65,84719	55,84719
04	0,1654	-36,99429	-66,99429	56,99429
05	0,0667	-40,94034	-70,94034	60,94034
06	0,0260	-45,03827	-75,03827	65,03827
07	0,0345	-43,79894	-73,79894	63,79894
08	0,0316	-44,18828	-74,18828	64,18828
09	0,0169	-46,89564	-76,89564	66,89564
10	0,0082	-50,02301	-80,02301	70,02301
11	0,0036	-53,62266	-83,62266	73,62266

TABLE IV
AP2-1: FIRST MEASUREMENT

P	Pd [mW/m2]	P [dB]	P [dBm]	Lp[dBm]
01	1,6020	-57,133028	-27,13302	47,133027
02	0,6584	-60,994983	-30,99498	50,994982
03	0,1975	-66,223982	-36,22398	56,223981
04	0,1554	-67,265143	-27,26514	57,265142
05	0,1231	-68,277707	-38,27707	58,277072
06	0,0923	-69,527703	-39,52770	59,527703
07	0,0394	-73,222938	-43,22293	63,222937

TABLE V
AP2-2: SECOND MEASUREMENT

P	Pd [mW/m2]	P dbm	P db	Lp [dBm]
01	1,3610	-27,84107	-57,84107	52,431041
02	1,0730	-34,09166	-64,09166	54,091663
03	0,1860	-36,48452	-66,48452	56,484523
04	0,0657	-41,00399	-71,00399	61,003999
05	0,0181	-46,59328	-76,59328	66,593280
06	0,0072	-50,62385	-80,62385	70,623855
07	0,0056	-51,69234	-81,69234	71,692347
08	0,0039	-53,21478	-83,21478	73,214781
09	0,0032	-54,17043	-84,17043	74,170430

Figures 3 and 4 shows the graphs of the power losses in function of the distance (in logarithmic scale) of experimental data obtained in the first and second measurement around the AP1, obtaining a model of loss according to Equation 5 Lp = 52.04 + 3.098 x 10logd and Lp = 51.50 + 2.091 x 10logd ,respectively as shown in Table VI, the same way we proceed with the data obtained in the area of AP2, obtaining for the first measurement the following values (α ;Lo) = (2.058, 50.37) and the second measurement (2.962, 51.64).

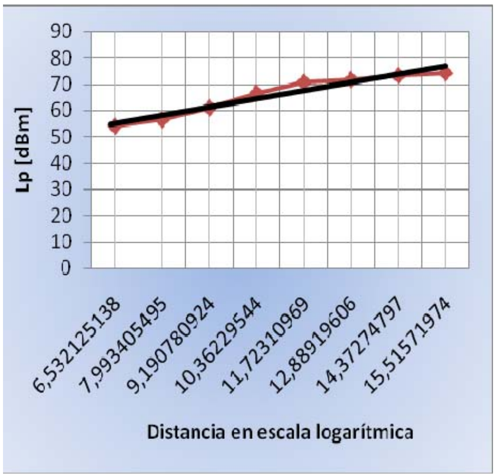

Fig. 3 Power loss vs. Distance in logarithmic scale in the first phase of AP1

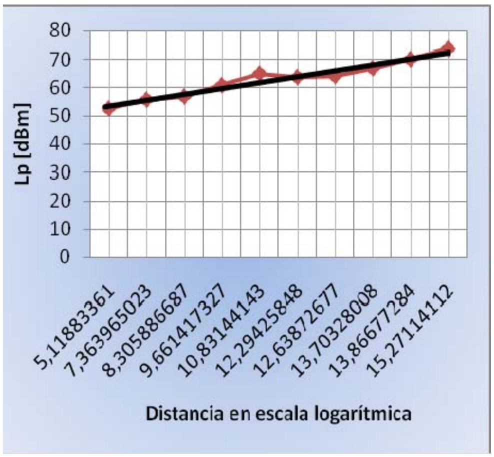

Fig. 4 Power loss vs. Distance in logarithmic scale in the second phase of AP1

TABLE VI
EQUATIONS SIGNAL MODELLING THE PROPAGATION IN THE CORRIDORS OF BUILDING.

Measurements	Equations (ec.5)
AP1-1	Lp= 52,04+3,098 x 10logd
AP1-2	Lp= 51,50+2,091 x 10logd
AP2-1	Lp= 50,37+2,058 x 10logd
AP2-2	Lp= 51,64+2,962 x 10logd

As seen in Table VII the average of the measured values of loss at a distance of 1 meter (Lo) compared with data obtained using the model distance-power gradient differ by a 4.48%, error was expected since the models propagation are approximations of actual values, and considering that we have developed a model that includes other factors that may cause greater loss.

TABLE VII
Lo DATA AVERAGE (dBm)

Measurements	Lo[dBm] measured	Lo[dBm] estimated
AP1-1	51,23	52,04
AP1-2	51,23	51,50
AP2-1	47,13	50,37
AP2-2	47,13	51,64
AVERAGE	49,18	51,38

In ideal conditions in free space for INDOOR areas as corridors, the value of distance-power gradient is 2. In our measurements, on average, the distance-power gradient corridors on the base floor of the building is 20% higher, α = 2.5525, which was expected as a result of the impact of environmental characteristics and the different obstacles in the way in spreading the signal.

III. COVERAGE STUDY

IEEE 802.11b y g WLANs supports multiple data rates. As the distance between the transmitter and receiver increases, the WLAN reduces its data rates to expand its coverage.

The IEEE 802.11b y g standards recommend a set of data rates for the WLAN. Table 08 shows the data rates and RSS for IEEE 802.11 g.

TABLE VIII
DATA RATES AND RSS FOR IEEE 802.11G [4]

DATA RATES [Mbps]	RSS [dBm]
54	-72
48	-72
36	-73
24	-77
18	-80
12	-82
9	-84
6	-90

Tables II, III, IV and V shows the data rates and the RSS in dBm, where the minimum value is -54 dBm, which when compared in table VII can be seen that the rate of transmission in corridors of the ground floor is a maximum 54 Mbps, which indicates that users to be part of this wireless network may transmit data efficiently.

IV. CONCLUSIONS

The three radio propagation mechanisms are attributed to reflection, diffraction and dispersion. These three effects cause distortions in the radio signal attenuation occurs because of losses in its propagation [7].

Using experimental data we evaluate the distance-power gradient method in an office area, although there was a margin of error, we can consider that the model adequately fits the results. The gradient α was obtained to model the spread in the corridors of the building was 2.5525, which model mathematically the signal attenuation in the area of analysis due to different factors, such as loss of line of sight from the transmitter to the receiver in some measurement points can be seen as an fig.2 , as well as diffraction losses caused by the corners, walls and ceilings, and considering that the two corridors of the building do not have the same design environment.

It was proved that the received power in the area if the corridors of the building is the maximum, so you can have a maximum transmission rate of 54 Mbps, this is because in the corridors of the building there is not enough loss power to the transmission rate to decline according to table VII, however, this dos not indicate that the location of the Aps in the building is ideal as it can be wasting APs in an office area as discussed in the article.

V. RECOMENDATIONS

Propagation models are recommended in order to understand the effects of attenuation and reflection of materials before making a wireless network design [5], so it can be possible to make better use of resources efficiently and establish network coverage.

As a future project will study and redesign of the network WIFI INDOOR AND AOUTDOOR b and g IEEE at the Faculty of Electrical Engineering and Computer ESPOL applying criteria and network optimization algorithms. (under development)

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