



# Estimating Signal Strengths in Indoor Wireless Systems in Order to Deliver a Cost-Effective Solution Optimizing the Performance of the Network

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## ABSTRACT

Proper AP placement is necessary to provide adequate signal coverage and also to minimize co-channel coverage overlap. In this document, we present the test-bed used in our lab and the procedure and methodology we have created (modified) to achieve accurate measurements. We describe a procedure for carrying out the estimation of AP coverage patterns in order to eliminate the need to re-measure coverage patterns for every candidate combination of AP locations. It is expected to obtain a difference no bigger than the 3 dB between the estimated signal strength and measured signal strength.

## I. INTRODUCTION

Nowdays, indoor networks are getting more popular and its use is widely spread, growing its share into the international market. At the beginning, this solution was not popular and therefore suitable, because of its low rate speeds. Thereby, important institutes as IEEE and Wi-Fi Alliance worked together to develop a standard: IEEE 802.11x. The purpose of this paper is to show different methods for reducing the infrastructure deployment costs of wireless networks, specifically for systems that are willing to transmit very high data rates.

One important issue in the design and implementation of a wireless local area network is the selection of the Access Point (AP) locations. Proper AP placement is necessary to provide adequate signal coverage and also to minimize cochannel coverage overlap. Importance of suitable placement of APs is then very significant. Placing APs too far apart could seem to be economical but usually not such effective due to this solution could lead to gaps in coverage and thereby, reducing the effective coverage and degrading the total performance of the wireless system. On the other hand, placing APs so closely leads to excessive co-channel coverage overlap, degrading system performance even to the point on which the link goes totally off. This is our main concern. Currently, AP placement involves a trial and error technique. There is not established neither a procedure nor a methodology to solve this issue. This study pretends to reach an approach to this situation and delivers a methodology and measure the reliability of itself.

The state-of-the-art in this field is very interesting. Even though there are a lot of papers that mention and discuss this issue, most of them establish empirical measurements and techniques [1, 2] that still are falling into the trial and error technique. Obviously this technique will be used at the beginning of the research but the main idea is to simulate and be able to estimate the coverage of each AP optimizing the resources without degrading the system.

Wireless Local Area Networks are not completely deployed in Ecuador. For example, Hot-Spots are still not installed as it is supposed to be and they are not working either on that way.

We certainly believe that delivering a procedure and methodology will promote the use of WLAN's and will save a lot of money to clients and at technology delivering a cost-effective solution to the market.

In section II, the measurement setup will be presented and discussed. The algorithm design and its advantages over its drawbacks will be covered in section III. An example will be provided in Section IV showing the way the algorithm can be implemented. Finally, section VI concludes the paper highlighting the main points addressed during the entire document and also referring to the current and future work.

## II. MEASUREMENT SETUP

### A. Data Collection Methods and Tools used

Wireless network data was collected using NetStumbler. This program was selected because of its ease of use and installation; the program runs on the Windows platform. This program observes reasonable privacy guidelines in the sense that:

- Access Points are detected only if they are publicly broadcasting their SSID, or the client card is configured to look for that specific SSID.
- No attempt is made by the software to gain access to the network.
- Other traffic on the network is not intercepted or analyzed in any way

For the driving scans, a Compaq Armada 1575DM Pentium MMX processor laptop running the Microsoft Windows 98 operating system and NetStumbler 0.4.0 software for data collection was utilized. Wireless signal strength data was collected with a D-Link DWL-122 USB Adapter connected to the Laptop USB port and to move the AP (D-Link DWL-700AP) inside the coverage area we will use a test cart with mast in which we have placed a directional antenna of 80 degrees (DWL-M60AT) connected to the AP (Figure 1 shows a close up of the antenna, laptop and test cart)

Another important aspect on the design of wireless networks is to use attenuation factors obtained by the experimentation "in situ". This assured that the results are close to the reality. For this reason and according to previously measurements, we have elaborated a chart with the attenuation values for the most common materials, which are shown in the table 1.

## III. ALGORITHM DESIGN

Our work will try to reduce the difference between the estimated value and the measured value, using the algorithm of the neighbor's discovery

Figure 1. Test Cart SETUP (A) Test cart( B) Close view of the laptop with NetSlumber (C) Close view of the antenna



Table 1. Attenuation values for the most common materials founded in the Testing Area

Material Attenuation @ 2.4 GHz	
Glass 0.25" (6mm)	0.8 dB
Glass 0.5" (13mm)	2 dB
Plywood 3" (76mm)	2.8 dB
Concrete 4" (120mm)	12 dB
Brick faced concrete 7.5 " (192mm)	14dB
Concrete 8" (203mm)	23dB
Concrete 12" (305mm)	35dB

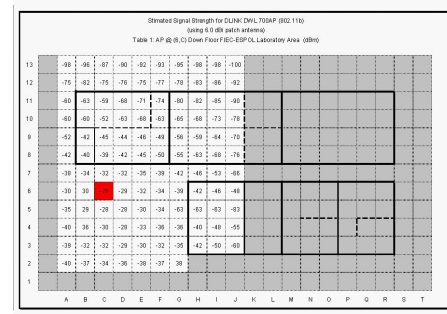
together with the empiric model of the Wall Attenuation Factor (WAF). In [1] the propagation model used is the free space path loss model, which is adjusted for outdoor environments without obstacles, or points so close to the access point. However, for the area in which we will carry out the study, we found multiple concrete walls with a thickness of 12 cm, aluminum divisions and plywood with a thickness of 8 cm, which leads us to use a model that is adjusted better to the conditions of the study.

We have modified a design procedure adding the steps 2 and 3, reported in detail in [2], which includes five steps, enlarging it to 7 steps:

- 1) Initial selection of AP locations;
- 2) Obtaining of the attenuation factors characteristic of the study area
- 3) Application of the WAF model with the factors obtained in 2 to estimate the signal strength
- 4) Test and redesign which is adjusting the AP locations based on signal strength measurements;
- 5) Creation of a coverage map;
- 6) Assignment of frequencies to APs;
- 7) Audit, which is documenting the AP locations and a final set of signal strength measurement at the frequencies selected.

After the initial selection of AP locations (the first step) is complete, APs are temporarily installed at the locations selected. The coverage areas of these APs are measured (see figure 2). Typically, coverage gaps and/or excessive overlaps are found. Based on the measurement results, the AP locations are adjusted as needed, more measurements are done, more adjustments are made, etc., until an acceptable design is found. The process is in principle iterative. It may be necessary to repeat this design– test–redesign cycle several times to find an acceptable solution.

Figure 2. The Measurement Grid



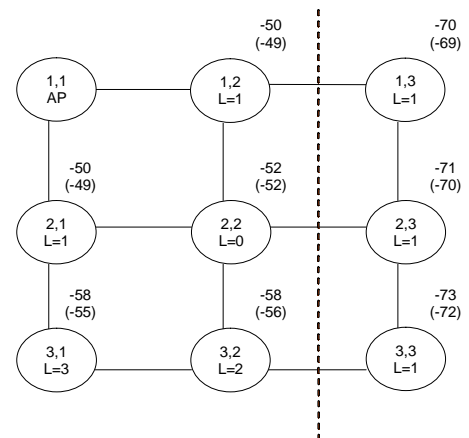
The second step of the design process can be made much faster and more efficient if the signal coverage patterns of relocated APs can be quickly estimated. This reduces the need to move APs and re-measure their coverage patterns. With this approach, APs are moved “virtually,” rather than physically, and their new coverage patterns are estimated rather than measured.

In this way, we describe a procedure for carrying out the estimation of AP coverage patterns in order to eliminate the need to re-measure coverage patterns for every candidate combination of AP locations.

#### IV. APPLICATION EXAMPLE

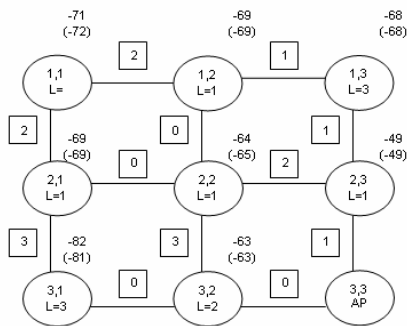
In the following example we will illustrate the procedure to use the proposed algorithm:

The first step is to locate the AP in the covering area. For this purpose, we have selected a near location to the backbone of the Faculty of Electrical and Computer Engineering (FIEC) and we will take initial measures in 8 points next to the AP. It is necessary to highlight that in the measurement area is located a wall of concrete of 12 cm. of thickness and that will allow us to apply the variant proposed to the model considering the Wall attenuation factor (WAF)



1. For each point we calculate the signal strength using  $s = s^* - 10n \log(d) - kWAF$  where  $k$  is the number of walls and WAF it is the attenuation factor, which was encountered through the experimentation like  $WAF=14dBm$  for a concrete's wall of 12 cm of thickness.
2. The measured signal strength in each node is shown in the figure 4 and the calculated measured signal strength is shown in parenthesis. The excess of lost  $L$  of each measured is calculated using these two values the value of  $L$  it is shown inside each node.

3. We assign a weight  $W$  to each edge which are shown inside the squares, these weights can be positive or negative, if they are negative they are normalized according to the procedure settled down in [1]
4. The AP is moved to a new location (see figure 5)
5. Using the algorithm of the neighbour's discovery we finds the neighbouring nodes
6. We calculate signal strength for each one the 2 nearest nodes (2,3) and (3,2) to the new location of the AP with  $s_{est} = s^* - 10n \log(d) - kWAF$ .
7. The signal strength for all the other nodes is calculated. The smallest sum possible of the weights of the edges that connect a node with a nearer neighbour it is used. The reference values of the estimated signal strength before being adjusted based on  $W_{min}$  it is shown in parenthesis. The estimated signal strength which has been adjusted considering  $W_{min}$  is shown without parenthesis.



## V. CURRENT WORK

At the moment of writing the present document we are in the phase of comparison of the results obtained with the estimated values and measured values and we hope to obtain a difference no bigger than the 3 dB between the estimated signal strength and measured signal strength.

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