PROTOTYPE TOOL OF IEEE 802.11AC WIRELESS NETWORKS PROPAGATION IN INDOOR ENVIRONMENTS

Alejandro Molina*, Pablo Corral*, Sergio Fernandez+, Jesús Vidal*

**Dpto. Ingeniería de Comunicaciones, Universidad Miguel Hernández, Elche (Espanha)*

+CCT- Universidade do Estado de Santa Catarina, Joinville (Brasil)

pcorral@umh.es

Abstract. This research pretends to be useful for the future deployment of the wireless network of the Universidad Miguel Hernández, specifically at the campus of Elche. In terms of capacity, in short term we will need more capacity in the wireless network, for this reason we are testing some aspects of the protocol IEEE 802.11ac (Wi-Fi ac). This protocol works in the 5 GHz band and provides us more channels and capacity with channel bonding and MIMO. Before the deployment of the wireless network, we need to know the propagation model of the signal in different scenarios and conditions. We analyse the results obtained by a developed software tool capable of representing different measurements of the signal strength with LOS and NLOS scenarios and comparing with indoor propagation models. For measuring the signal level we have used an emitter 3x4 MIMO and a receiver 3x3 MIMO, both compatible with Wi-Fi ac.

***Keywords:* Indoor radio propagation tool, MIMO, Channel Bonding,**

1. Introduction

The motivation of this study is the need in terms of capacity in the current deployment of the wireless network of the Universidad Miguel Hernández, specifically in the campus of Elche [1]. Nowadays, each user has more and more devices capable of connecting to the wireless network. The current implemented protocol (IEEE 802.11 b/g/n) with its number of available channels in the 2.4 GHz band, will be soon insufficient. For this reason, we started testing the protocol IEEE 802.11ac that works in the 5 GHz frequency band. It allows a higher number of channels, and allows different techniques and parameters adjustable that permit to improve the throughput and the signal level coverage. These parameters are explained later further on. On the other hand, we know that if you increase the frequency of signals, in our case up to 5 GHz, you will increase the attenuation. In this research, we were focus on the measurements and analysis of signal strength at 5 GHz band [2]. For taking samples of signal strength at different distances we have used as emitter an access point (AP) of Cisco called Aironet 2702I-E-K9 which allows us 3x4 MIMO. We have used an HP laptop as receiver with an 802.11ac D-LINK card. It is connected by USB 3.0 port with the laptop. This receiver is called AC1900 Wi-Fi USB adapter and it allows us 3x3 MIMO applications. The MIMO configuration improves the signal to noise ratio at the receiver because it receives and combines different copies of the signal by the 3 or 4 antennas at reception. We have used the “NetSpot” application for Windows 10 that has total compatibility with IEEE 802.11ac. Therefore, the end goal of this research is to analyze the results of the developed software tool. We should be able to represent the propagation model in every case, taking into consideration every parameter available in this protocol version and different scenarios. These configurations have been possible thanks to the Cisco access point that allows us many configuration parameters.

In the next parts of this article, we are going to deal with the general procedure of taking measurements and its corresponding analysis. First, we are going to introduce the point called Test Bench where we show an explanation of the procedure's steps [3]. In addition, we do an introduction of all concepts that we need for the study of each case: Wi-Fi ac parameters configurable, different scenarios and the known models of indoor propagation that we have chosen for this study and the main functions of the software tool. Secondly, in the results part, we are going to show the RSSI results obtained in one case of study with the indoor propagation models. Finally, we will conclude the research explaining how useful the developed tool is.

2. TEST BENCH

A. *Procedure to take measurements:*

The first step is configuring the transmission parameters in the AP. This step is important because we can distinguish the exact case that we are studying now. Then we have to obtain the data that it is going to be sent to be processed. To do that, NetSpot application is going to be used, capable of detecting the signal level emitted by the AP function of the distance. In this case, the study is limited exclusively to previously known indoor environments, so just take measurements at intervals of distance. After obtaining these measurements, we have to pass data to a Microsoft Office Excel format (.xlsx) in order to facilitate the next task. The next step is to send the data to the RSSI AC Studio tool for processing. Finally, with the tool we can represent the measurements of signal level as a function of distance in each case. Moreover, we can compare them with different known models of indoor propagation and we are able to choose the most similar. That chosen model can be useful for us. Then, with a little mathematician variations of those models, we can achieve a model of path loss in every single case of studio (Chosen scenario and Wi-Fi ac configuration parameters).

The next flow chart shows the necessary stages in order to follow the commented procedure.

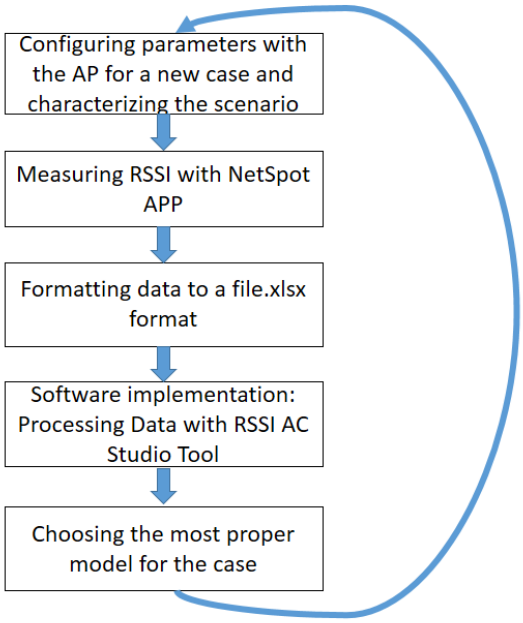

Fig. 1 Operation model

B. *IEEE 802.11ac parameters for configuring*

1) Modulation and coding schemes (MCS): We are able to configure up to 10 different combination of modulation types and code rates with the web interface of the AP (MCS0 to MCS9). Each MCS have different characteristics in terms of throughput and radio coverage.

2) Number of spatial streams: We can transmit up to 3 different spatial streams (different signals) at the same time by the same channel by different antennas. With this technique, we can improve the throughput a lot. Our receiver has 3 antennas in reception so that we can use up to 3 spatial streams, but we also can configure 2 or 1 spatial stream.

3) Channel Bonding: We can configure the channel width with 3 possible widths: 20 MHz, 40 MHz and 80 MHz. The wider the channel is, the higher data rate can be used.

4) Guard Interval: We can use 2 times for this parameter: 400 ns or 800 ns. The shorter time allows us increase the throughput because we are reducing the symbol period, but also it increases the ISI (Intersymbol interference).

C. *Scenarios Characterization*

Planning how to choose the scenarios to be studied will have repercussions on the results. Therefore, we have chosen the following six scenarios [4], each one with its own characteristics:

1) Free Space: This scenario is the reference for the study of diffraction and reflection phenomenon, and in terms of the received signal strength as well.

2) 5x2.5 meter room: It contains many obstacles such as shelves, cabinets, desks and computers. Thus, a strong diffraction is generated.

3) 6x5 meter room: It contains few obstacles and they are arranged close to the walls. Diffraction mechanism does not affect as much as the previous scenario.

4) Narrow corridor: There are some reflections between two different materials: glass and plaster. It is also interesting the fact of having equidistant columns throughout one of the corridor's walls.

5) Wide corridor: Characterized by walls made with the same material, and poor influence of obstacles.

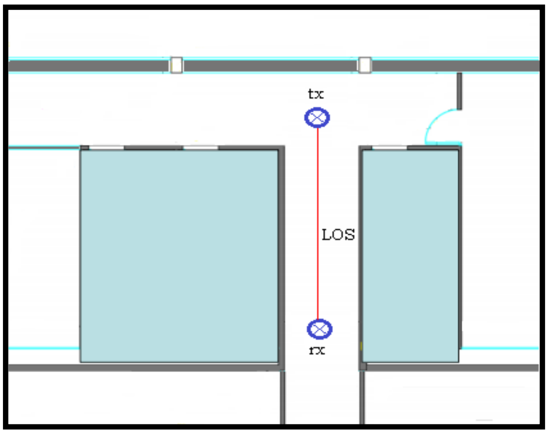

Fig. 2 Ray model for Free Space

6) Conference room: Larger than all other dimensions rooms above. The most relevant feature of this room is the repetition of the same obstacle progressively.

D. *Indoor propagation models*

Below some of the models of propagation in indoor environments are briefly described [5].

- Free Space. It is LOS between transmitter and receiver.
- Motley-Keenan. It considers intersected walls, ceilings and floors.
- COST Multi-Wall. It is an improved model. Not only does it take into account intersected walls, ceilings and floors, but also all its different materials as well. There are many empirical researches contributing with long tables where loss values are given for each material [6].
- Two Rays. It provides an estimate with piecewise linear laws based on Fresnel breakpoint.
- Log-Normal Shadowing Path Loss. It considers LOS between transmitter and receiver, adding the influence of selective fading, walls, floors, diffraction and dispersion.

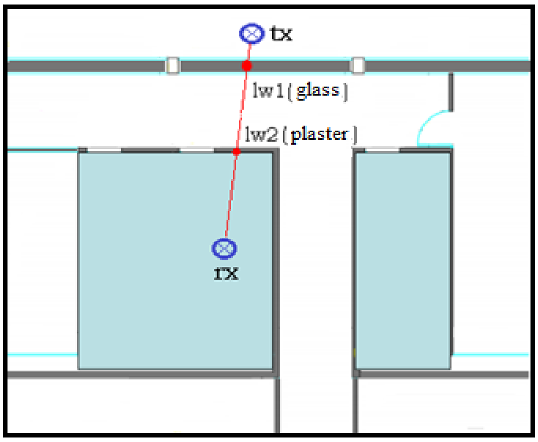

Fig. 3 Ray model for COST Multi-Wall

- Linear Path Attenuation. It estimates losses between transmitter and receiver located on the same floor. It uses a linear factor obtained experimentally [7].
- ITU-R P.1238. It may be the most sophisticated empirical model. It represents the power loss across multiple floors.

III. RESULTS

This section presents the different results obtained from the data processing. We are going to choose one case study for showing all results that we obtain in each case. The configuration of the AP is done by the web interface.

The idea is to display on the same graph the result set on the curves representing the prediction models (Fig. 4). The purpose is to resemble the experimentally obtained behaviour with the different propagation models.

Through the parameter values governing the equation that describes the model, the corresponding curves are obtained.

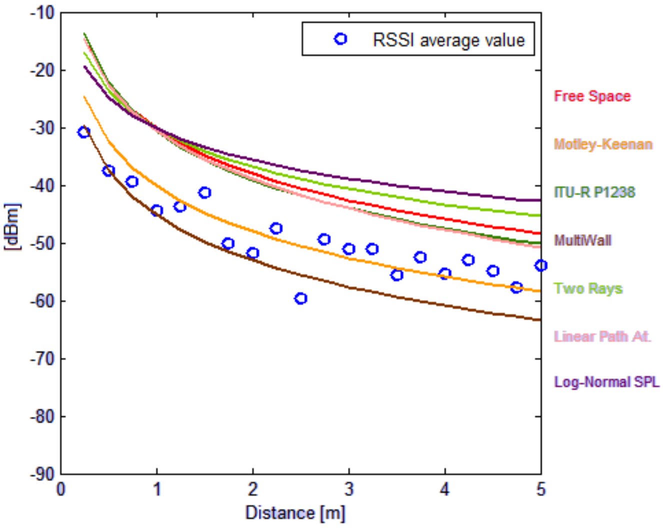

Fig. 4. Comparison of the measurements obtained and processed with the different indoor propagation models

Above the curves obtained for all samples of the conference room scenario are shown.

In all models there is a nonlinear decrease in the signal function distance. It is more accentuated for close distances.

I. CONCLUSIONS

Throughout the study, the type of room and the IEEE ac parameters that have been treated have had a big influence in the propagation of the signal. For analyzing this study from different perspectives, it has been necessary to create a mathematical tool capable of performing the necessary estimates to extract results.

A software tool has been developed exclusively for the study of wireless networks in indoor environments, capable to perform various operations on the measured signal. The chosen language was Matlab considering that one of the objectives of the project is to serve for teaching.

This tool, based on iterative algorithms to extract trends, different representations of the signal intensity level, and comparison and estimation functions, has been the basis of all this research. It can be quite useful for planning and designing wireless systems, allowing the user to obtain a first approximation of the coverage ranges and power levels in a specific area, with good computation time, and what is more, considering that this will reduce the cost and time spent on tedious measurement campaigns; which reiterates the use of RSSI Studio.

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