INDOOR RADIO PROPAGATION

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This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Computer Engineering) With Honours

Faculty of Electronic and Computer Engineering

Universiti Teknikal Malaysia Melaka

April 2009

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek : **INDOOR RADIO PROPAGATION**

Sesi Pengajian : **2008/2009**

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Dedicated to my beloved father and mother

ACKNOWLEDGEMENTS

Firstly, Say prayer to the Allah S.W.T THE ALMIGHTY, the most merciful and compassion for giving the writer this sole chance to jot down and elaborate some meaningful information regarding to the activities that being done along the completion of this thesis. A bouquet of gratitude to Mr. Riduan Bin Ahmad for his limitless time and efforts in guiding and accessing my work.

A thousand of thank you to the writer's working colleagues for their invulnerable co-operations and supports along the completion of this training. The writer also wants to wish thank you for those who support the writer directly or indirectly towards the finishing episode of this training.

A great deal of appreciation also goes to the contribution of my faculty – Faculty of Electronic and Computer Engineering (FKEKK).

Last but not least, the writer wants to wish thank you to his parents for their morale support and influences along the completion of this Final Project Report. THANK YOU

ABSTRACT

Typically a wireless Mesh infrastructure is designed and installed by networking Professionals. Indoor radio communication systems gain increasing interest of cellular network operators. A prerequisite to the design of these systems is the knowledge of indoor radio propagation characteristics. This knowledge should include information, concerning the in-building structure which strongly affects the signal transmission. The results presented in this paper provide a prediction of the signal behavior in indoor corridor environment and dynamic effects of people. All the measurement was collected by using the specific software and location around building of Electronic and Computer Engineering Faculty (FKEKK). The purpose of the measurement campaign is to derive a path loss model considering site specific information. A description of the measurement environment and experimental set-up is given. Path loss exponents and absolute path loss values are estimated for each measured case. Statistical analysis of the measured data is also presented.

ABSTRAK

Lazimnya satu infrastruktur Mesh tanpa wayar adalah direkabentuk dan dipasang oleh rangkaian Professional. Sistem telekomunikasi radio tertutup mempunyai peningkatan dalam kepentingan operator-operator jaringan selular. Satu prasyarat untuk merekabentuk sistem-sistem ini adalah tentang ciri-ciri pengetahuan pembiakan radio tertutup. Pengetahuan ini harus meliputi maklumat berkenaan dengan struktur bangunan yang mana melibatkan penghantaran isyarat ke penerima isyarat. Keputusan tersebut telah dicatatkan dalam thesis ini bagi menyediakan satu ramalan dalam persekitaran koridor tertutup dan mengambil kira tentang kesan-kesan dinamik persekitaran sekeliling. Semua data telah dikumpul dengan menggunakan perisian tertentu dan lokasi untuk projek ini adalah di sekitar bangunan Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer (KFEKK). Tujuan pengukuran adalah bagi menerbitkan satu model kehilangan laluan dalam menimbangkan tapak maklumat tertentu. Satu gambaran bagi persekitaran ukuran dan struktur percubaan telah diberi. Kehilangan laluan pendukung-pendukung dan kehilangan nilai-nilai mutlak laluan telah dianggar untuk setiap kes secara berhati-hati.

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LIST OF ABBREVIATION

dB	-	Decibel
RF	-	Reflection Frequency
LOS	-	Line Of Side
NLOS	-	Non Line Of Side
GUI	-	Graphic User Interface
LAN	-	Local Area Network

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CHAPTER 1

INTRODUCTION

Chapter 1 give an overview of Indoor Radio Propagation, the objective of the project are stated clearly. There are few problem statements that explain about the existing problems which is eventually lead to this project development. The methodology explains briefly about the project flow. The scope of work which consisting of hardware and software development is being discussed in this chapter as well.

1.1 Basic Radio Propagation:

The most basic model of radio wave propagation involves so called "free space" radio wave propagation. In this model, radio waves emanate from a point source of radio energy, traveling in all directions in a straight line, filling the entire spherical volume of space with radio energy that varies in strength with a 1/(range)^2 rule (or 20 dB per decade increase in range). Real world radio propagation rarely follows this simple model. The three basic mechanisms of radio propagation are attributed to reflection, diffraction and scattering. All three

of these phenomenon cause radio signal distortions and give rise to signal fades, as well as additional signal propagation losses. Outdoors, with mobile units, movements over very small distances give rise to signal strength fluctuations, because the composite signal is made up of a number of components from the various sources of reflections (called "multipath signals") from different directions as well as scattered and / or diffracted signal components. These signal strength variations amount to as much as 30 to 40 dB in frequency ranges useful for mobile communications and account for some of the difficulty presented to the designer of reliable radio communications systems. The basic signal attenuation with range noticed in the real world gives rise to what are termed "large scale" effects, while the signal strength fluctuations with motion are termed "small scale" effects. Indoors the situation is even worse. It is very difficult to design an "RF friendly" building that is free from multipath reflections, diffraction around sharp corners or scattering from wall, ceiling, or floor surfaces (let alone operate perfectly in a randomly chosen building location). The closest one could probably get to an "RF friendly" building would be an all wooden or all fiberglass structure -- but even this must have a structurally solid floor of some kind and this more ideal RF building will still have reflections, multipath and other radio propagation disturbances (as the materials properties section below shows) which will prove to be less than ideal. Indoors then, the simple free space model fails to account for the small and large scale fading that is observed in real world radio links.

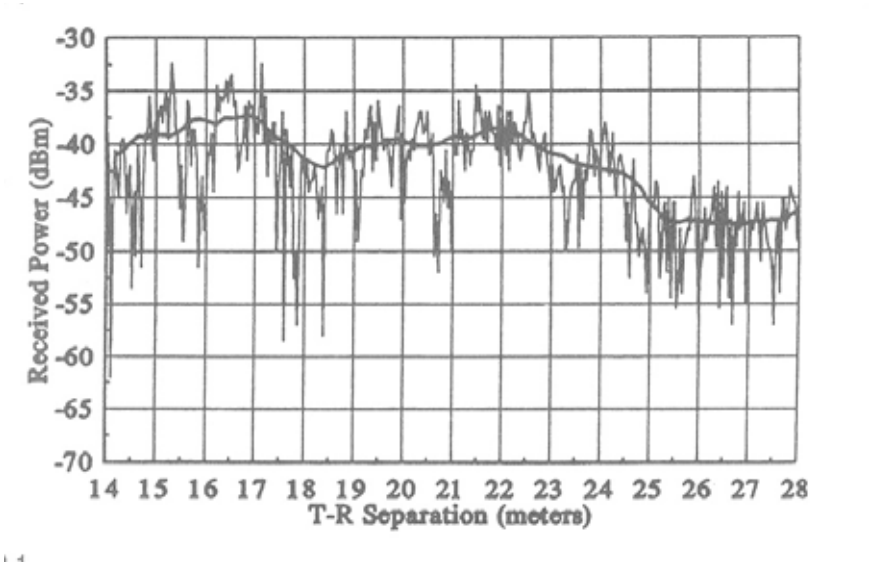

Figure 1: Received RF Power plot indoors versus range in meters

1.2 Multipath

In the real world, multipath occurs when there is more than one path available for radio signal propagation. The phenomenon of reflection, diffraction and scattering all give rise to additional radio propagation paths beyond the direct optical "line of sight" path between the radio transmitter and receiver. As Theodore S. Rappaport describes the phenomenon in Wireless Communications — Principles and Practice (ref.2):

> "Reflection occurs when a propagating electromagnetic wave impinges upon an object which has very large dimensions when compared to the wavelength of the propagating wave. Reflections occur from the surface of the earth and from buildings and walls. Diffraction occurs when the radio path between the transmitter and receiver is obstructed by a surface that has sharp irregularities (edges). The secondary waves resulting from the obstructing surface are present throughout the space and even behind the obstacle, giving rise to a bending of waves around the obstacle, even when a line-of-sight path does not exist between transmitter and receiver. At high frequencies, diffraction, like reflection, depends on the geometry of the object, as well as the amplitude, phase, and polarization of the incident wave at the point of diffraction. Scattering occurs when the medium through which the wave travels consists of objects with dimensions that are small compared to the wavelength, and where the number of obstacles per unit volume is large. Scattered waves are produced by rough surfaces, small objects, or by other irregularities in the channel. In practice, foliage, street signs, and lamp posts induce scattering in a mobile communications system."

1.3 Measurement setup

A sophisticated time-domain channel sounder whose measurement bandwidth was used the specific software in the measurement. In this measurement setup, however, the router with an Omni-directional azimuth pattern is used at both the transmitter and the receiver. The most likely applications with 60GHz channel include a high data rate point-to-point communication between equipments such

as a laptop, a monitor, a digital camera, etc. Another possible application is wireless docking system. For example, once a presenter brings a laptop into a class room, the laptop automatically finds and communicates with an overhead projector. There are tons of other possible applications with 60GHz channel. Since the process of tracking the source of signals is not easy and the reception performance at the receiver is even much worse if the angle of arrival is not correctly aligned, an Omni-directional antenna is the best choice for them. Also a certain kind of equalizers such as rake receivers can be used with the single-directional antenna to combine multipath signals using a diversity technique.

1.4 Measurement campaign

To get the meaningful measurement data for statistical analysis, measurement environments and scenarios should be correctly defined. The definition of measurement environment includes the place where measurements are taken and its distinctive characteristics such as the material used for the wall or size of the room. A lecturer room having board walls, a room in a private house full of furniture or a cubicle area with plasterboard partitions is good examples of defining measurement environments. The measurement scenario is a snapshot of the whole circumstance including the location of the transmitter and the receiver in a measurement environment. Also the separation distances, LOS or NLOS, or the material of the object blocking the direct signal path provides different scenarios. Tens of measurements are made with a fixed scenario for statistical analysis, various different scenarios are considered in a measurement environment, and several different measurement environments are also considered.

1) The locations of transmitter: The receiver is at arbitrary locations on a table within a measurement environment. However, the transmitter is at four most likely locations:

- Lecturer room
- Tutorial room

1.5 Background

This project was developed to measure the wireless signal by using the specific software that can be provided and generated the signal strength into 4 positions (north, east, west, south) that will be affected the signal. Besides, the specification that included such as Throughput, FTPput, FTPget, HTTPtext, POP3, and SMTP. There were 3 scenarios in this project; client G-router G, client G-router N, client N-router N. This project also analyzed the strength of coverage router with and without interference.

1.6 Problem Statement

The problem of this project such coverage of the access point is unknown. That's mean we don't know how many strength or bandwidth of signal can transmit the data surrounding FKEKK building. To optimize use of access point to cover inner FKEKK building makes it some problem because doesn't know which location to specify access point. This project also, to make the signal propagation modeling for WLAN for FKEKK especially.

1.7 Objectives

The objectives of this project:

1.5.1 To learn and implement the technology of wireless local area network (WLAN).

1.5.2 To know how many rate or bandwidth of signal can be transfer in the different area and level in a building.

1.5.3 To reduce the budget for the project cost.

1.5.4 To save time and increase the service efficiency in wireless technology.

1.5.5 To model sight specific throughput matrix based on measurement collected data for wireless match network.

1.5.6 To visualize the specific graph in Mathlab software.

1.5.7 To create model in order to study for correlation.

1.8 Scope

The method of this project is preparing the important tools such as wireless router, laptop/workstation, and software that compatible with the system. Two laptops were setup with the router and act either server or client. The server system was setup the software such as IxChariot which is use to get the plot of signal for four poles (North, East, South, and West). In the FKEKK building, there were divided into two halls lecturer hall and student hall. Each hall, there were many rooms if we calculate. Let's say we take the third floor at the lecture hall, know that both of side left and right have totally 36 rooms for lecturer. So that, here we assume that each room means 36 points for our measurement. The client will be going through for each point to get the signal and know the bandwidth at that point by using the Xirrus software. There have 2 parts for this project, measurement data and model development. On the first part, we will measure the Pr (power receive) and Throughput. In theoretical, there are three steps that can help us to measure the Throughput such as Ping, Ixchariot, or FTP. Second part is model development. Here, we will create the plot the graph Throughput versus Pr (Power received). For the future work, another part will be include in this project such visualize graph in Mathlab, that's mean the GUI form will be create to show to user which location should be we locate for the access point in FKEKK building especially.

1.9Thesis Outline

1.9.1 Chapter 1 – Introduction

This chapter is about the introduction of Indoor Radio Propagation which is already state a few subtitle that we must know in this project. The basic radio propagation was already explained and clearly about specification for this project. Then, know about the multipath that occurred in the wireless transmission. The phenomenon of reflection, diffraction and scattering all give rise to additional radio propagation paths beyond the direct optical "line of sight" path between the radio transmitter and receiver.

1.9.2 Chapter 2 – Literature Review

This chapter is about the software that we use in this project. The Theoretical Study will be discussing on some related theories and explanations on each equipment used in this project. Fact and finding is the formal process to collect and capture the entire information about system, system requirements and system preferences. In addition, information source can be gathered in formal sources and informal sources. For formal sources the information can be gathered from books, journal, research papers, encyclopedias, newspapers, magazines, handbooks, thesis, bibliographies and World Wide Web (WWW).

1.9.3 Chapter 3 – Methodology

This section will describe the flow of this project. It is an important criterion for this project. This chapter discussed about procedures that will use in this project. It begins by choosing a topic of project, research and finally completing by developing the system. The purpose

in this chapter is to implement this system smoothly and follow the planning that has been decided.

1.9.4 Chapter 4 – Result and Discussion

This Chapter presents the measurement results were obtained from extensive measurement. To present this data in an orderly format, MATLAB plots are used. The MATLAB plots presented throughout this chapter are arranged with the measured signal to noise ratio for the desired link from the client to the access p on the x axis and the measured throughput on the y axis. We must know about the physical locations that will be affected to our measurement. Then, know about the measurement purpose and know how to setup or our planning to measure and collect the data measurement. The presented plots of the measurements show a definite correlation between the signal to noise ratio, and to some small degree, to the net interference power. These relationships are clearest the window averaged plots that have been presented.

1.9.5 Chapter 5 – Conclusion and Suggestion

This chapter are consists two subtopics which are the conclusion as well as the recommendation towards this project. This conclusion will present about the most important points in this project as well as the success part that has been achieved during the implementation process while recommendation presents about what are the new suggestions that can be implemented in this project for the future undertaking action. To develop this project, it must be considered to the research element as the main point. So, all about statement and proof of research element in this part are look toward the research element for