PROPAGATION COVERAGE FOR COMMERCIAL BUILDINGS SCENARIOS USING RAY TRACING TECHNIQUES

NURUL HASLIN BT NURYA’YA

This report is submitted in partial fulfillment of the requirement for the awards of Bachelor of Electronic Engineering (Wireless communications) with honors.

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka
BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek : PROPAGATION COVERAGE FOR INDOOR SCENARIOS AT COMMERCIAL BUILDINGS BY USING A RAY TRACING TECHNIQUES

Sesi Pengajian : 2010/2011

Saya NURUL HASLIN BT NURYA’YA mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hak milik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (√) :

☐ SULIT* *(Mengandungi maklumat yang berdaerah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

☐ TERHAD** **(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

☐ TIDAK TERHAD

Disahkan oleh:

__________________________
(TANDATANGAN PENULIS)

__________________________
(COP DAN TANDATANGAN PENYELIA)

ALAMAT TETAP: J-8399 TAMAN KESANG INDAH
UTAMA,77000 JASIN, MELAKA

TARIKH : TARIKH:
"I hereby declare this report is the results of my own work except for quotes as cited in the references."

Signature : ........................................
Author : NURUL HASLIN BT. NURYA’YA
Date : ........................................
“I hereby declare that I have read these reports and in my opinion this report is sufficient in terms of the scope and quality for the award of Bachelor of Electronics Engineering (Wireless Communication) with honors.”

Signature : .................................

Supervisor Name : PN JUWITA BT MOHD SULTAN

Date : .................................
ACKNOWLEDGEMENT

I gratefully acknowledge for assistance, support and encouragement of those individuals who have contributed either directly or indirectly in my final year project. First of all, I want to express my sincere gratitude and appreciation to my project supervisor, Madam Juwita Bt. Mohd Sultan for all her wisdom, support, and critics and advise during my final year projects.

I also want to give my special thanks to UTeM for having me as a part of family for a couple of years. I will always cherish the experienced I gained throughout this course and project. Not forget my special thank to my friend that have been provided an idea and support whether in direct or indirect ways.

Lastly, my outmost thanks to my beloved mother and families who gave me support throughout my academic years. Thanks you very much.
ABSTRACT

This project is to do the prediction coverage for commercial building scenarios using a ray tracing techniques. In order to estimate the signal parameter accurately for mobile system’s, it is necessary to estimate a system’s propagation characteristics through a medium. Propagation analysis provides a good initial estimate of the signal characteristics. The ability to accurately predict radio propagation behavior for wireless personal communication systems, such as cellular mobile radio, is becoming crucial to system design. Since sit measurement are costly, propagation model have been developed as a suitable, low cost and convenient alternative.

My report will include information available on the various propagation models for indoor area only. The ray tracing technique is use for modeling a wireless channel. The image ray tracing algorithm is used to calculate the entire possible propagation path between a radio transmitter and a receiver. MATHLAB software will use the built a coding where the coding are consider a several propagation mechanism such as a free space loss, refraction, reflection and a diffraction.
ABSTRAK


## CONTENT

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TITLE</td>
<td>i</td>
</tr>
<tr>
<td></td>
<td>PROJECT APPROVE FORM</td>
<td>ii</td>
</tr>
<tr>
<td></td>
<td>DELARATION</td>
<td>iii</td>
</tr>
<tr>
<td></td>
<td>SUPERVISOR APPROVE</td>
<td>iv</td>
</tr>
<tr>
<td></td>
<td>ACKNOWLEDGEMENT</td>
<td>v</td>
</tr>
<tr>
<td></td>
<td>ABSTRACT</td>
<td>vi</td>
</tr>
<tr>
<td></td>
<td>ABSTRAK</td>
<td>vii</td>
</tr>
<tr>
<td></td>
<td>CONTENTS</td>
<td>viii</td>
</tr>
<tr>
<td></td>
<td>LIST OF TABLE</td>
<td>xiii</td>
</tr>
<tr>
<td></td>
<td>LIST OF FIGURE</td>
<td>xiv</td>
</tr>
</tbody>
</table>
2.2.6 Tube Shooting 18
2.2.7 Ray Shooting 19

2.3 Basic Propagation Mechanisms 19
2.3.1 Diffraction 21
2.3.2 Reflection 22
2.3.3 Scattering 23
2.3.4 Refraction 25
2.4.1 Fresnel Zone 26

CHAPTER III RESEARCH METHODOLOGY 27

3.1 Researches and Data Collecting 29
3.2 Free Space Loss 30
3.3 Free Space Path Loss 31
3.3.1 Free-Space Path Loss in Decibels 32
3.4 Received Power from Direct, Reflected, Transmitted And Diffracted Rays
3.4.1 Received Ray Power 34 (Direct Rays)
3.4.2 Reflection Coefficient 35
CHAPTER IV RESULTS AND DISCUSSION

4.1 Simulation Methodology 40

4.2 Simulation Using Mathlab 7.0 41

4.3 Plotting Data 41

4.4 Simulation Results 42

4.4.1 Free Space Loss 42

4.4.2 Transmission And Reflection 44

4.4.3 Diffraction 46

4.5 The Comparison Value Of A Power 48

Receive In (dbm)
CHAPTER V  CONCLUSION AND FUTURE WORK  51

5.1 Conclusion  51
5.2 Suggestion/ Future Work  52

REFERENCES  55
<table>
<thead>
<tr>
<th>NO</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5</td>
<td>Comparison Of Power Receive</td>
<td>48</td>
</tr>
</tbody>
</table>
### LIST OF FIGURES

<table>
<thead>
<tr>
<th>NO</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1.1</td>
<td>Wireless Topologies</td>
<td>10</td>
</tr>
<tr>
<td>2.2.2</td>
<td>The ray tracing algorithm builds an image by Extending rays into a scene</td>
<td>14</td>
</tr>
<tr>
<td>2.2.3</td>
<td>Ray Tracing Techniques</td>
<td>16</td>
</tr>
<tr>
<td>2.2.4</td>
<td>Method of Image</td>
<td>17</td>
</tr>
<tr>
<td>2.2.5</td>
<td>Brute Force Ray Tracing</td>
<td>18</td>
</tr>
<tr>
<td>2.2.6</td>
<td>Tube Shooting</td>
<td>19</td>
</tr>
<tr>
<td>2.3a</td>
<td>Basic Propagation Mechanism</td>
<td>20</td>
</tr>
<tr>
<td>2.3b</td>
<td>Types of Rays in an indoor environment</td>
<td>20</td>
</tr>
<tr>
<td>Section</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>2.3.1</td>
<td>Diffraction Process</td>
<td>22</td>
</tr>
<tr>
<td>3.0</td>
<td>Flow Chart of Research Methodology</td>
<td>28</td>
</tr>
<tr>
<td>3.2</td>
<td>Free Space Loss</td>
<td>29</td>
</tr>
<tr>
<td>4.4.1</td>
<td>Power Receive for Free Space Loss</td>
<td>42</td>
</tr>
<tr>
<td>4.4.2</td>
<td>Power Receive for Transmission and Reflection</td>
<td>44</td>
</tr>
<tr>
<td>4.4.3</td>
<td>Power receive for Diffraction</td>
<td>46</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

This project goal was to model the indoor radio channel propagation. In addition to channel measurement, 3D tracing software was developed for accurate radio propagation predictions. The ray tracing software computes the electromagnetic radio propagation characteristics between transmitter and receiver. First, the geometric engine defines the geometric path taken by the radio wave to reach the receiver. Secondly, the electromagnetic engines compute the electromagnetic propagation along each path.

The number of users in mobile radio is growing rapidly setting tighter requirements for frequency. In order to estimate the signal parameters accurately for mobile systems, it is necessary to estimate a system's propagation characteristics through a medium. Propagation analysis provides a good initial estimate of the signal characteristics.
The ability to accurately predict radio-propagation behavior for wireless personal communication systems, such as cellular mobile radio, is becoming crucial to system design. Since site measurements are costly, propagation models have been developed as a suitable, low-cost, and convenient alternative. Channel modeling is required to predict path loss and to characterize the impulse response of the propagating channel.

The path loss is associated with the design of base stations, as this tells on how much a transmitter needs to radiate to service a given region. Channel characterization, on the other hand, deals with the fidelity of the received signals, and has to do with the nature of the waveform received at a receiver. When two-way communication ports can be defined for a mobile system, it is possible to use reciprocity to focus the energy along the direction of an intended user without any explicit knowledge of the electromagnetic environment in which the system is operating, or knowledge of the spatial locations of the transmitter and the receiver. [3]

There are several basic mechanisms considered in ray tracing are transmission, reflection, diffraction. In indoor area, diffraction around the corners of building can not be neglected since the power from transmitted signals through buildings o numerous reflection in the street is small

1.1 Objectives

1. This projects main target is to predict the coverage for commercial buildings scenario in terms of the maximum distance and obstacle by using a ray tracing techniques.
2. To model the indoor radio channel propagation by using a MATHLAB 7.0 software. The ray tracing software computes the electromagnetic radio propagation characteristics between transmitter and receiver. To updating the ray tracing program currently developed in MATHLAB.

3. To evaluate and improve the accuracy of the software, by checking against actual measurements of the radio channel. The results that presented from the simulation will be analyzed and the comparison between several situations will be studied and analyzed based in the characteristics in the performance.

1.2 Problem Statements

In a typical wireless communication environment, there is a lot of propagation is exists from a transmitter to the receiver due to scattering by a different objects. The problem that we always face nowadays by using a wireless communication technology is the signal coverage will not cover the entire area. This problem happen because there is a propagation mechanism that have to considered in a free space loss, transmission, reflection and a diffraction. For a commercial buildings situation, the relative permittivity of a glass, floor and ceiling also consider. The reason why the propagation mechanism and relative permittivity of a commercial buildings consider is to make the best prediction where is the receive signal is better and where the receive signal starting drop.
To carry out these projects, the knowledge requirements are basic knowledge of ray tracing techniques and usage of MATHLAB simulation 7.0. In this projects, a comparison between a several propagation mechanisms include a transmission, reflection and diffraction is presented and considered.

1.3 Scope Of The Project

In order to ensure that the projects can be implemented successfully, the following scopes are listed. The first scope of this projects is meaning and characteristics for a ray tracing technique where include a several basic propagation mechanism such as transmission, reflection, diffraction, scattering and refraction. All the propagation mechanism is finding out by doing a research on a literature review.

All the information carried out from journal, internet, books and technical reports. This project is to make a prediction coverage at commercial buildings using a ray tracing techniques and make analysis comparison between a propagation involve in a commercial buildings and consider a relative permittivity consider in the environment.

The ideal of general equation which are used to calculate the signal in a free space loss situation, diffraction situation, reflection situation with consider a relative permittivity of a glass, floor and ceiling of each situation. Then combining all the formula of simulation through simulation program and analyze the results of power receives in an every situation.
1.4 Methodology

This project is carried out by step by step, firstly, the literature reviews is studied. All the information and a suitable input related to a ray tracing techniques. All the information is researched from book, journal, technical report and internet online. The relationship between received power from direct, reflected, transmitted and diffracted rays will be studied and analyze the effect of the signal when propagate at a commercial buildings area. Next, the results of power receive in a free space loss situation, reflection, transmission and diffraction will analyzes when the power receive is increase or decrease using a simulation in MATHLAB 7.0.

Seconds, all the parameter consists of the free space loss, transmission, reflection and diffraction is calculated by using a required equation. Then, all the parameter is simulated in a MATHLAB 7.0 by using a simulation programming interface.

Next, the results of the simulation are analyzes and studied the relationship of power receive in a free space loss, transmission perpendicular and parallel, reflection perpendicular and parallel, and a diffraction. The best techniques to make an analysis are based on the graph in simulation.
1.5 Overview of the Projects

These theses have been written in a five main chapters. The five chapters in this thesis cover what is typically considered to be the core material to study the prediction coverage for commercial building using a ray tracing techniques.

Chapter one is an introductory chapter, of the whole projects. The topics covered in this chapter include a objectives of this projects and list of the projects scopes. In addition the first chapter also includes the projects problem statements. The overviews of the project were covered in this chapter.

Chapter two of this thesis consists of detailed discussion on background studies, literature review and the basic concepts of the projects. All the information is a suitable input that describes a ray tracing techniques, propagation mechanism. The syntheses are researched from books, journals, articles, technical reports and internet online. All the mathematical expression is presented along with a full explanation.

Chapter three discussed the research methodology in order to complete a project. Every stage in research methodology is portrayed in a flow chart. It also explained the mathematical and simulation tools that used to realize the projects.

Chapter four is dedicated to simulation results by using a MATHLAB 7.0. These include the setup for the undertaken experiments. The results of the simulation and findings are tabulated and shown in this chapter. The relationship with a several propagation mechanism will be studied and analyzed the prediction coverage for
commercial building environment. The best power receive will get and comparison will make based on the graph in simulation of every situation.

Finally, the final chapter summarizes the material presented in this thesis and draws the significant findings together in a series of conclusions. Besides that this chapter will give a full discussion on the problem encountered and solution taken. The chapter also conclude the realistic extensions to the projects where more challenging problems that require some creativity in a solution for future development. It will also propose some recommendation and enhancements that can made on this projects in the future.
2.1 Wireless Mesh Network

A Wireless Mesh Network Also Known As a (WMN’s). It Is a Communication Network Made up of radio nodes organize in a mesh topology. Wireless mesh network consists of mesh clients, mesh routers, and gateways where the mesh clients are often laptop, cell phone and others wireless device while the mesh routers forward traffic to and from the gateways which may but need to connect to the internet. When one node can no longer operate, the rest of the node can still communicate with each other, directly or through one or more intermediate nodes. The animations below illustrate how wireless mesh networks can self form and self heal.
Wireless mesh network can be implemented with various wireless technology including 802.11, 802.16, cellular technologies or combination of more than one type. The coverage area of the radio nodes working as single network is sometimes called a mesh cloud. Access to this mesh cloud is dependent on the radio nodes working harmony with each other to create a radio network. A mesh network is a reliable and offers redundancy. [16]

Wireless mesh network can be seen as a special type of wireless ad-hoc network. It is often assumed that all nodes in a wireless mesh network are immobile but this need to be so. The mesh routers may be highly mobile. Often the mesh routers are not limit in terms of resources compared to others nodes in the network and thus can be exploited to perform more resource intensive functions. Here the wireless mesh network differs from an ad-hoc network since all of these nodes are often constrained by resources. [5]

2.1.1 How Wireless Mesh Network Work

Wireless mesh network is an emerging technology they may bring the dream of a seamlessly connected world into reality. Wireless mesh network can easily, effectively and wirelessly connect entire cities using inexpensive, existing technology. Traditional networks rely on a small number of wired access point or wireless hotspot to connect user. In a wireless mesh network, the network connection is spreads out among dozens or even hundreds of wireless mesh nodes that ‘talk’ to each other to share the network connection a cress a large area. Mesh nodes are small radio transmitter that functions in the same way as a wireless router. Nodes use the common Wi-Fi standards known as 802.11 a, b, g to communicate wirelessly with users and more importantly with each other. [12]