PROPAGATION MODELLING AND LINK PLANNING FOR INTELLIGENT TRAFFIC LIGHT MANAGEMENT SYSTEM AT 5.8 GHZ

ANWAR HASSAN IBRAHIM

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MODEL PERAMBATAN DAN PERANCANGAN PAUTAN UNTUK SISTEM PENGURUSAN LAMPU ISYARAT PINTAR PADA 5.8 GHZ

ANWAR HASSAN IBRAHIM

TESIS YANG DIKEMUKAKAN UNTUK MEMPEROLEH IJAZAH
DOKTOR FALSAFAH

FAKULTI KEJURUTERAAN DAN ALAM BINA
UNIVERSITI KEBANGSAAN MALAYSIA
BANGI

2013

DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged.

09 May 2013

ANWAR HASSAN IBRAHIM
P 31451

AKNWOLEDGEMENT

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ABSTRACT

Intelligent Traffic Light Management System (ITLMS) has been deployed to improve the management of traffic flow and hence reducing the long queue at the traffic light junction. In order to coordinate the traffic junctions, communication between them via point-to-point and point-to-multipoint wireless links at 5.8 GHz is established. A good link planning must consider various factors such as environmental conditions, terrain profiles and antenna location. The objectives of this research are to characterize the propagation environment and establishing an accurate propagation prediction model, to develop a software planning tool for link planning for ITLMS and to analyze the impact of propagation impairment of the queue management model. An urban area within Bandar Baru Bangi and Kajang, Selangor Malaysia has been selected as the study area. The data collected includes the quality of the received signal under various environmental conditions such as rain, temperature, and humidity. A modified propagation model derived from log-distance model was formulated based on 700 samples of data. The effect of environmental and *k*-factor that varies throughout the year also been considered when predicting the link quality. Furthermore, the prediction model was integrated with the Ray Tracing method to enhance the link planning. The link planning was implemented using a MATLAB program with a friendly user interface namely Software Planning Tool for ITLMS (SPT-ITLMS). The research finding confirmed that there was no significant statistical difference between measured and predicted received signal using modified log-distance model at 95% confidence limit. However, in certain Line-of-Sight (LOS) and Non-LOS (NLOS) cases, the error can reach up to 4 and 6 dB correspondingly due to the topographical and terrain profile. The error using the integrated Ray Tracing model was reduced to 2.21 and 4.78 dB for LOS and NLOS conditions respectively. The error was further reduced to 1.18 dB when the number of rays was increased from 5 to 12 and the primary angle of the ray was 64^0. Finally, by integrating the predicted link quality due to signal propagation impairment in the queue management model, the average queue time per cycle can be managed more efficiently.

ABSTRAK

Sistem Pengurusan Lampu Isyarat Pintar (ITLMS) telah dipasang bagi menambahbaik pengurusan aliran trafik dan seterusnya mengurangkan kesesakan di simpang lampu isyarat. Untuk mengkordinasi simpang-simpang lampu isyarat, komunikasi mestilah diwujudkan antara mereka melalui pautan tanpa wayar titik ke titik dan titik ke titik berbilang pada 5.8 GHz. Suatu perancangan pautan yang baik mestilah mengambilkira pelbagai faktor seperti keadaan persekitaran, profil rupabumi dan kedudukan antena. Objektif kajian ini adalah untuk mencirikan persekitaran perambatan dan mewujudkan model ramalan perambatan yang tepat, untuk membina alat perisian perancangan bagi perancangan pautan untuk ITLMS dan menganalisis kesan kemerosotan perambatan terhadap model pengurusan giliran. Satu kawasan perbandaran di sekitar Bandar Baru Bangi dan Kajang, Selangor Malaysia telah dipilih sebagai kawasan kajian. Data yang dikumpul termasuklah kualiti isyarat yang diterima dalam pelbagai keadaan persekitaran seperti hujan, suhu dan kelembapan. Satu model perambatan baru yang diterbitkan berdasarkan model log-jarak telah diformulasi berasaskan 700 sampel data. Kesan persekitaran dan faktor-*k* yang berubah sepanjang tahun telah turut diambilkira semasa membuat ramalan kualiti pautan. Seterusnya, model ramalan ini telah disepadukan dengan kaedah Surihan Sinar bagi menambahbaik perancangan pautan. Suatu perisian perancangan yang dinamakan sebagai perisian *Software Planning Tool for ITLMS* (SPT-ITLMS) telah dibangunkan dengan menggunakan perisian MATLAB dengan pengantaramukaan yang mesra pengguna. Penemuan kajian ini mengesahkan bahawa tiada perbezaan yang ketara antara isyarat ukuran dengan isyarat ramalan yang diterima dengan menggunakan model log-jarak yang diubahsuaikan pada had keyakinan 95%. Walau bagaimanapun, dalam kes *Line-of-Sight* (LOS) dan *Non-LOS* (NLOS) yang tertentu, ralat masing-masing boleh mencapai sehingga 4 dB dan 6 dB disebabkan oleh topografi dan profil rupa bumi. Ralat dikurangkan masing-masing kepada 2.21 dan 4.78 dB dengan menggunakan model Surihan Sinar terintegrasi, dalam keadaan LOS dan NLOS. Selanjutnya ralat tersebut boleh dikurangkan kepada 1.18 dB dengan menambah bilangan sinar dari 5 ke 12 sinar dan sudut bagi sinar primer ialah 64°. Akhirnya, dengan mengintegrasikan kualiti pautan diramalkan akibat kemerosotan perambatan isyarat dalam model pengurusan giliran, masa giliran purata pagi setiap kitaran boleh diurus dengan lebih cekap.

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LIST OF ABBREVIATIONS

AP	Atmospheric Pressure
BBB	Bandar Baru Bangi
DTM	Digital Terrain Model
ECC	Electronic Communications Committee
SSE	Error (Residual) Sum of Squares
FW	Fixed Wireless
GHZ	Giga Hertz
GPS	Global Positioning System
ISM	Industrial, Scientific And Medical
IEEE	Institute of Electrical And Electronics Engineering
ITLMS	Intelligent Traffic Light Management System
ITU	International Telecommunication Union
LOS	Line-of-Sight
LA	Link Availability
LQI	Link Quality Index
LAN	Local Area Network
LA	Location Area
MATLAB	Matrix Laboratory
MBE	Mean Bias Error
MRD	Mean Relative Deviation
MSE	Mean Sum of Squares Of Errors
NOLS	Non Line of Sight
PL	Path Loss
PI	Performance Index
PCS	Personal Communications Service
PMP	Point to Multi Point
PTP	Point to Point
PDP	Power Delay Profile
PSD	Power Spectral Density
RF	Radio Frequency
RSS	Received Signal Strength

RSSI	Received Signal Strength Indicators
RSSE	Reduced Sum Square Error
RWC	Residential Wireless Communications
RMSE	Root Mean Square Error
SA	Service Area
SS	Signal Strength
SPT	Software Planning Tool
SPWPM	Software Planning Tools for Wireless Propagation Model
SD	Standard Deviation
SEE	Standard Error of Estimate
TBW	Tango Broad Band Wireless
TAP	Terrain Analysis Package
3D	Three Dimensions
TQM	Traffic Queue Management
2D	Two Dimensional
UK-RSWG	Uk Radio System Working Group
UK	United Kingdom
UKM	Universiti Kebangsaan Malaysia
UNITEN	University Tenaga National
U-NII	Unlicensed National Information Infrastructure
UTC	Urban Traffic Control
UTMS	Urban Traffic Light Management System
WLAN	Wireless Local Area Network
ZVI	Zones of Visual Infuluence

LIST OF SYMBOLS

$P(x)$	Absolute CW Power	Wat
T	Absolute Temperature	Kelvin
AR^2	Adjusted Coefficient of Determination	
Pi	Average Power	
ζ	Coefficient	
π	Constant (=3.14)	-
x_m	Deflection Angle	-
ρ	Density	
d	Distance	m
z	Distance From Origin	-
α	Distance Power Gradient	
K	Earth Radius	
h_S	Earth's Elevation Surface	kilometer
A_e	Effective Aperture	
Φ	Elevation Angle	
Y_i	Experimental Data	
G_r	Gain of the Teceiver	
G_t	Gain of the Transmitter	
n	Index of Refraction	
θ	Initial Angle	
L_1	Initial Attenuation	mile
ϕ	Inner Angles	-
$F(r,z)$	Intensity Distribution	-
ε_r	Relative Permittivity	
k	*K*-Factor	
W_{Type}	Loss	dB
$MR_{exp,i}$	Measurement Value	
m_{type}	Number Of Partitions	
L_0	Path Loss at the Reference Distance	
γ	Path Loss Distance Exponent	

L	Path Loss Measured In Decibel	dB
S	Power Flux Density	
R	Radius	
$P_{R_{XdBm}}$	Received Power	dBm
Rx	Receiver	
h_r	Receiver Height	meter
Pr	Receiving Power	
d_0	Reference Distance	
k	Reflection Angle	-
$\theta_i = \theta_o$	Reflection Angle	
Γ	Reflection Coefficient	
(n)	Refractive Index	
$MR_{cal,i}$	Simulated Value	
N_S	Surface Refractivity	
$fEb(r)]$	The Intensity Distribution	-
E_g	Total Transmitted Electric Field	
T	Transmission Coefficient	
E_i	Transmitted Electric Field	-
$P_{T_{XdBm}}$	Transmitted Power	dBm
Tx	Transmitter Height	
Pt	Transmitting Power	-
v	Velocity in Medium	
H	Water Vapor Pressure	mbar
λ	Wavelength	

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

There are increasing demands on data transmission over wireless link using a cellular technology such as Global System for Mobile (GSM) communications, Wideband Code division Multiple Access (WCDMA), High-Speed Packet Access (HSPA), Long Term Evolution (LTE) and Wireless Local Area Network (WLAN) supporting IEEE802.11bgn standard. Moreover, fixed wireless technology such as Worldwide Interoperability for Microwave Access (WiMAX) and Wireless Broadband (WiBro) have been installed for point to point (PTP) and point to multipoint (PTMP) data transmission.

In this thesis, an Intelligent Traffic Light Management System (ITLMS) utilizing PTP and PTMP links at 5.8 GHz to manage real time urban traffic light junctions have been deployed in Bandar Baru Bangi (BBB). ITLMS uses a set of predefined parameter setting for individual traffic junction to decide the queue time over a number of cycles. Hence the traffic queue and waiting time can be reduced. The system controls the traffic flow using CCTV camera on each side of the junction by counting the number of vehicles in queue to give the priority time for attention. The high-performance data with video transmission up to 54 Mbps and management engine for advanced analysis is exchanged via wireless transmission. Figure 1.1 shows the ITLMS's system architecture. The traffic light node at the traffic junctions have been assigned with home IP address for identification and connection to control room via PTP as shown in appendix B.5.

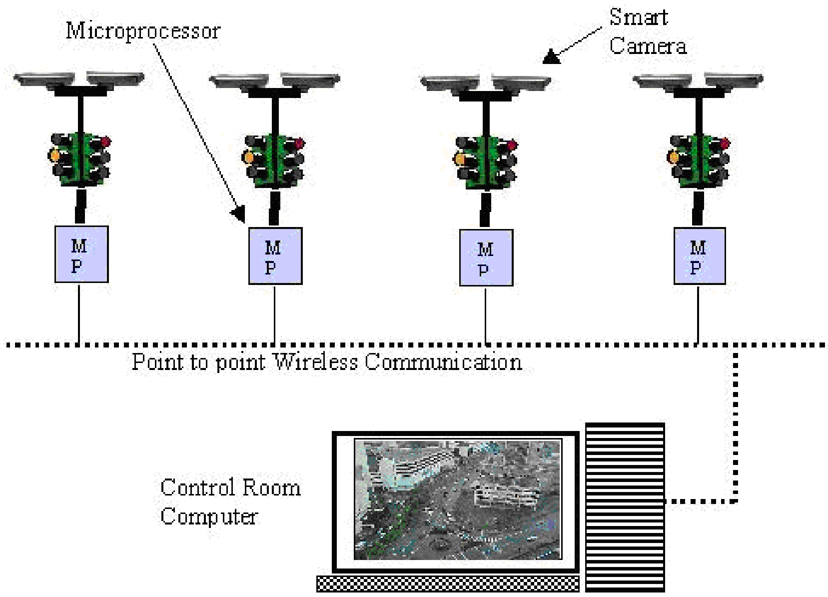


Figure 1.1 ITLMS Architecture

The ITLMS links established a clear line-of-sight (LOS) by erecting adequate pole height at each traffic light with highly directional antennas employed to support the required data rate. However, some links are prone to failure due to radio propagation impairment. Hence, site survey involving link quality measurement has to be carried out and the effect of obstruction (NLOS), rain, humidity and temperature on Link quality index (LQI) are to be predicted.

1.2 BACKGROUND

The traffic management in urban areas is controlled by traffic lights junction, which contribute to the unnecessary long waiting times for traffic if not efficiently controlled. Inefficient link coordination influenced the traffic delay since most of the traffic lights changing-time are based on a fixed cycle. One of the best model was developed to control the traffic lights using a sophisticated sensor and intelligent traffic optimization algorithms (Khalil et al. 2010). The traffic light controllers used an adaptive traffic control system; however it may fail when the sensor is out of service.

Sawant et al. (2004) proposed a model focused on the behavior of individual vehicles, and thereby can simulate the dynamic groups of vehicles using neural network. Although such models have carried out the realistic design, but they still have errors when the junction is heavily congested. Furthermore, Lee (2008) managed to optimize the traffic light switching by increasing road capacity and traffic flow to prevent traffic congestions using an intelligent system by applying fuzzy logic and evolutionary algorithms. This method is acceptable for traffic light control in the junction using sensors to detect the car movement, but nothing related to the queue duration time.

In this study, the traffic junctions are monitored through wireless links. However, some limitations to the link procedure of intelligent traffic control due to propagation impairment are expected, although the link is LOS connection. Avoiding traffic jams at the traffic junction is thought to be beneficial to both the environment and economy, but improved traffic-flow may also lead to an increase in demand for the technology required (Levinson 2003). The initial improvements in the traffic junction management were introduced to reduce time losses while waiting at the traffic junction.

The simplest form of traffic prediction at a junction is done by measuring the number of vehicles congested for a certain duration of time, and assuming that the conditions will be the same for the next period. The ability to predict the actual data shared in all the traffic junctions through wireless communication conditions is important for optimal control and failure incidence (Ministry of Transport Malaysia 2003). Consequently, signal reception at each traffic junction during normal and worst condition link coverage survey was done to rectify the problem before the ITLMS system is implemented.

The installation of a wireless network requires much the same basic planning as any wired network. The main difference is that the wireless signal requires some additional methods to study the signal propagation (Neskovic et al. 2011). This method includes environment path preparation study and clean LOS for outdoor conditions. It is important that the profile of the transmission path to be carefully observed and the suitable equipments (transmitter, receiver and pole) required must be properly defined for the specific application. Figure 1.2 shows the sample of the equipment installed at UKM traffic junction such as CCTV camera, antenna, and control system box used for traffic light monitoring. The antenna fixed on the top of the pole is the directional antenna operated at 5.8 GHz to transfer the data and video from UKM main gate to the control room at the faculty of engineering.

Figure 1.2 System Monitoring at UKM traffic light junction

1.3 PROBLEM STATEMENT

Wireless transmission is subjected to various propagation impairments such as rain attenuation, humidity, terrain and trees. Hence, the identification of these impairment factors and their effects for good link planning must be considered to meet signal quality and data throughput to avoid unexpected link failure due to lack of information on the deployed system. Extensive data collection and signal analysis will produce better prediction model. The development of link planning requirement also considered various propagation factors using data collected from the field, such as signal strength, terrain profile, antenna height and propagation impairment.

Recently, in the market, there are a variety of tools available for LOS surveys and analysis, such as StarNet and Nera (Christopher 2008), but all of these softwares only considered terrain profile. Some of these tools presented are simple, while others considered mathematical and statistical analysis. For an accurate LOS propagation analysis, there must be a good terrain model accumulated with environmental factor value. Some commercial applications modeled the software planning to generate LOS rays from the target of eye height consideration without full control over the target, the angle of sweep, maximum search distance and correction for earth curvature and refraction (Thomas & Peter 2004; Rappaport 1996).

Since long time, Malaysia has been officially recognized as one of the tropical countries with a very heavy rain rate (Wayan et al. 2012). Trees beside buildings serve as a vital obstacle in the urban environment and demand important to characterize the link. There are a variety of propagation models developed by researchers in the past decades to analyze wave propagation in wireless PTP and PTMP link, but none of the model is comprehensive and caters for various impairment factors. Most limitations have relationships with the topology of the region to which they are being applied, for example, the blockages along radio wave propagation paths, and the space loss caused by different land covers (Cocheril & Vauzelle 2007).

1.4 RESEARCH OBJECTIVES AND SCOPE

The main aim of this study is to manage real-time traffic light and coordinate traffic junction in ITLMS under PTP and PTMP link at 5.8 GHz. The detail research objectives are as follows:

1. To characterize the propagation and typical environment for ITLMS link planning in the study area.
2. To establish a new prediction model for point to point and point to multi point in ITLMS.
3. To develop a software planning tool for ITLMS link LOS planning under normal and worst condition.
4. To model the impact of propagation impairment on ITLMS queue management.

The scope of the research has been summarized in addition to the summary of thesis contributions, including site selection, pole height design, installation, traffic monitoring, link performance and queue management.

1.5 CONTRIBUTION

This research contributes to the propagation model development for LOS, through a contribution to correct point-to-point or point–to-multipoint plan consideration. The deliberate objectives acknowledged by the researchers to achieve the stated goals to obtain the characteristics of the propagation environment, establish an accurate prediction model based on Log-distance and build a software planning tool for link planning. The research has presented the consequences of the initial tests of a single line of sight connection based on actual environment. The measurement done has been shown to be capable of finding reasonable condition to study the link over the actual field of study, and additional careful study to check for possible link planning accuracy was carried out. The effective set of experiments carried out and a modified log-distance propagation model was formulated to demonstrate an inventive structure for the great link line of site plan consideration in the urban area of the BBB.

More specifically, the project contributed to the valued development by addressing the following broad issues:

1. Characterized the topographical area and analyzed the data transmission between a PTP and PTMP for ITLMS infrastructure for normal and worst case.
2. Development of extended log-distance propagation model at 5.8 GHz.
3. Developed a software planning tool for ITLMS.
4. The impact of propagation impairment of initial study has been done for link quality assessment and success rate.

1.6 THESIS ORGANIZATION

In this thesis, several propagation effects are studied, which are important to the intelligent traffic light link configuration. Measured data from different antenna measurement campaigns are analyzed in order to gain knowledge about the characteristics of these phenomena. The relations of these characteristics with system parameters and meteorological data are studied, as well as statistical properties. In some cases, the goal is to improve the prediction models that exist of this propagation phenomenon. Chapter 1 provides the general background on the theory and application associated with this thesis.

Chapter 2 describes the different geographic data products that are currently available in meteorological station, which could help the research for modeling the environment. The issues related to the modeling of the terrain are discussed in Chapter 3. The descriptions for study area that can be used to model the terrain are implemented, and measurement process was carried out. Chapter 4 describes the materials and experiments set up as a method to model the propagation impairment and to combine the intelligent traffic light management and control information in the area of study.

A software planning tool, computationally less intensive prediction technique for predicting the signal characteristics and other important study are introduced in Chapter 5. Chapter 6 expressed the link quality based traffic queue management.

The advantages due to these developments will require the wireless system to be well-planned and deployed efficiently. Chapter 7 closes the thesis with conclusions and recommendations for future work. Note that each chapter ends with a summary of what was presented, as well as a lead into the following chapter.

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION

The probability and degrading of wireless applications is subject to signal strength drop or fluctuations which are common causes, due to environmental factors. All these applications connectivity's and factors affecting by the network infrastructure and link performance. A literature review in this chapter is conducted to report the current stage of work about the effect of propagation impairment in wireless PTP & PTMP communication at 5.8 GHz.

The literature review initiates with a discussion on how signal strength propagates in Line-of-Sight link counting factors that affect radio transmission. This is surveyed by a discussion about the theory of propagation factors. The chapter concludes with a review of previous research related to the factor effects on fixed wireless links line-of-sight.

Ideal radio transmission occurs under conditions whereby a visually clear path exists between the receiver and transmitter. A visually or clear line of the site ensures the strongest possible signal with minimal attenuation due to environmental factors. To have a clear line of sight, there must always be no obstacles between the two locations.

Every day the great interests on utilizing a new platform as a new means of providing best link prediction between a point to point are considered due to the needs (Leena et al. 2010). One important issue that must be investigated is the propagation characteristic of the link. This chapter explained the propagation impairment and site specific variables to the propagation mechanism in an urban environment for line-of-sight link.

In this chapter, background of traffic light system and control, coordination between traffic junction, point to point and point to multipoint radio system and application, outdoor model including urban area modeling, outdoor propagation studies and path loss model at 5.8 GHz, propagation mechanism and impairments. Many propagation models and research background for wireless link planning technology will be reviewed. Link prediction tools and techniques such as ZVI and TAP analysis technique which used in many applications also will be described.

2.2 INTELLIGENT TRAFFIC LIGHT MANAGEMENT AND CONTROL

The Intelligent Urban Traffic Light Management Systems (IUTMS) and infrastructure have been designed and developed by researchers from the Faculty of Engineering of UKM (Rahamat 2006). The system has been patented under the name of the university, to increase the needs of the passengers demanding and more efficient functioning of urban areas. The system consists of a group of innovative tools created assuming information technology, wireless communication and automotive solutions. Owing to the access to information on current conditions in BBB traffic light junction in real time as well as transport services and the driver are better informed and therefore, are able to make the optimal decisions in the traffic junction. This system increases the comfort of the driver’s work and travel passengers, using wireless communication with continuous data updating as shown in Figure 2.1. Furthermore, the information on the real time of car traffic flow at the traffic light is accessible in the control room which is located in UKM.

The intelligent configuration at each traffic light junction consists of four major network elements. They are the outdoor point-to-point or multipoint 5.8 GHz radio unit, PC terminal and CCTV camera (x4 units per junction) and outdoor standard 8 port switch for wireless medium and distribution system. Outdoor radio is the devices with wireless network interfaces. The standard 8 port switch is a router or bridge that interfaces the wireless network with the wired PC terminal. The wireless medium is the physical layer standard used to move frames from a radio unit at the located traffic junction to the control room through wireless radio equipment using 5.8 GHz.

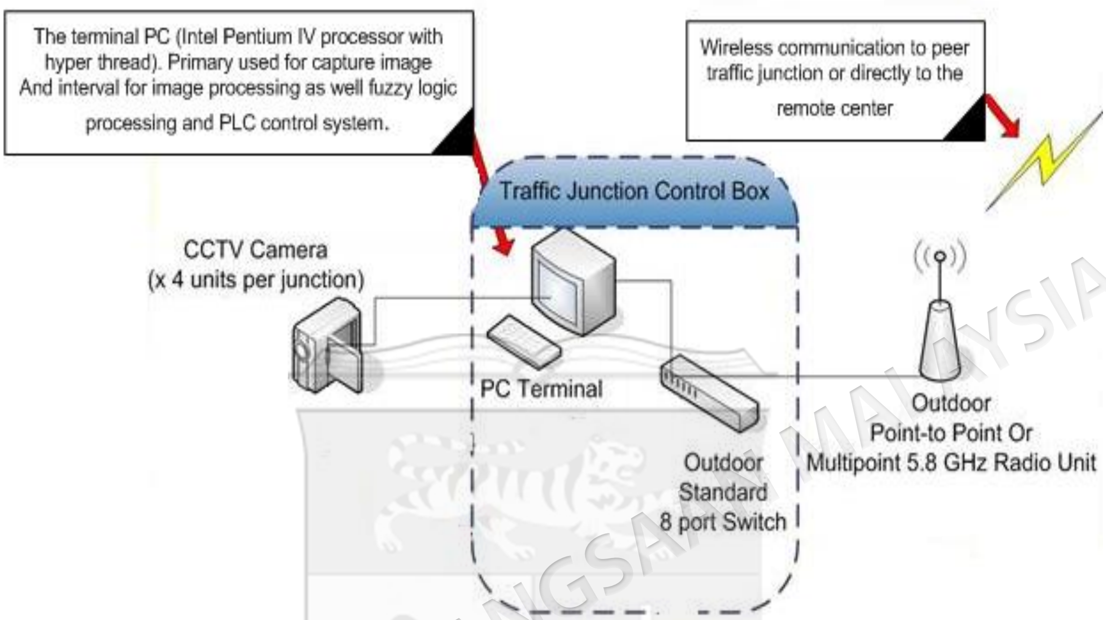


Figure 2.1 System configurations at local traffic junction

The system shown in Figure 2.1 is actually a traffic light equipped with a video sensor that coordinated intelligently to respond to traffic flow with the complete integration between the three lights (Yellow, Green and Red) at a junction as shown in Figure B.1 in the appendix. If the entire moves toward to the junction are congested with vehicles, the system would adjust accordingly, and give priority to incoming cars or outgoing traffic. As such, it is becoming very crucial to vehicle traffic efficient, adaptive and effective traffic control algorithms that enable and promise fast and smooth traffic flow that utilize new and multipurpose technologies. A vehicle queue detection system and a signal control process to control the state of the signal light at the traffic junction using the wireless control system was proposed for efficient time management that can be used to improve the traffic system and flow as well as the communication control between all traffic junctions.

2.2.1 Traffic Light System

The vehicle traffic congestion in urban areas is mainly regularized by traffic lights, which may contribute to the long queue and waiting times for vehicles if not efficiently organized. This ineffectual configuration is still the case in a lot of urban areas, where most of the traffic lights are optimized on a fixed cycle protocol (Emad & Aman 2011).

Ten's of traffic lights have observation cameras are installed in urban places in BBB in Malaysia for car surveillance. The current research carried out and upgraded the camera's observation to be able to monitor traffic flows automatically and scientifically (Rahmat et al. 2002). The cameras fixed in the traffic light are used for traffic counting, calculate speed, organizing and detect congestion.

IUTMS focus on the queue length control of vehicles and has been done with the cooperation and coordination of traffic lights in the area of the BBB. This intelligent traffic established to build a communication infrastructure committed to vehicle administration and traffic management control. The operation of the system intersections involved the coordinated structural decision of the traffic light determined by the camera for time parameters plans designed for specified traffic situations. The arrangement of the time plan is also set automatically by following a programmed time based on significant traffic require variances.

IUTMS builds for the assessment of traffic efficiency and performance of traffic light in urban areas. The current traffic light is affected by congestion especially in the peak hour time due to the fixed time intervals of green, orange and red signals which will cause the time loss and fuel as well. To make traffic junction controlling in more efficient, the intelligent system developed the emergence of new techniques called as "Intelligent traffic light controller". This makes the traffic junction more efficient with Embedded Technology.

a. Existing Traffic Light System

Most of the current research done in the area of intelligent traffic light management control (Balaji & Srinivasan 2010; Nieto et al. 2011) focused more on the fundamentals of link transmission techniques within systems and the advancement of procedure and compression techniques in support of the increasing bandwidth required.

Researchers have established traffic light models using several techniques. For instance, Viera et al. (2000) characterized the traffic light as a sample of an object that displays a performance set and assists as a case study for a number of motivating design issues. It was applied using traffic light internal state and consistent control information that was built using sensors.

Wu & Jiang (2005) proposed a system to control the traffic lights in a simple connection by taking into account single vehicle arrival behavior to define different kinds of vehicles, such as public vehicles and emergency transport vehicles. As mentioned in his research, the use of sensors has an amount of limitations. Because the reason of the power problem and a distance determination problem with two or more sensors. Yang et al. (2008) proposed a branch and bound approach method to control the traffic lights in a simple intersection. This method was based on new technologies for identifying vehicles and traffic lights that allow characterizing different kinds of individual vehicles such as public or emergency vehicles. These two suggested systems are relatively slow and complicated; because the additional techniques are necessary add in in order to identify several objects that appear in the act of a traffic light.

In most technology, the traffic junction function has been adapted to allow a vehicle- actuated past-end green (PEG) in fixed time coordinated systems developed by El-Shawarby et al. (2006). In Stockholm Archer (2003), developed a system based on the timing of the signals executed manually and considered the signal inputs controlling the termination of the green signal by using PEG.

Wireless communication has a possible way to improve traffic flow, safety efforts and efficiency. It can be used to provide warning information to the driver, for example, at intersections, or can be used to automate a task like lane merging or as an extension to an adaptive cruise control system. Travel information can also be sent to the drivers for route decision or entertainment to avoid the traffic congestion.

Traffic light signal management is one of the most important now days, because of the continuous increase in the congestion level in the urban area, especially at rush hours, which caused a critical problem in many countries and is becoming a major concern to transportation specialists and decision makers. In Bandar Baru Bangi, the number of traffic junction controlled by traffic flow has increased since the ITLMS is successfully used, but the efforts to study the traffic flow efficiency and failure is a diverse propagation environment yet the extensive through.

2.2.2 Traffic Light Control

Environmental influence has recently emerged as one of the most impending and effective at radio frequency (RF) signal strength certainly and service availability (Shahnaz 2007). Propagation models have repeatedly exposed the susceptibility of RF link planning disturbance by compromising a lot of vulnerable method at an extremely fast rapidity of data rate and high frequency involved (Seybold 2005). Some recent studies have shown that, good planning identification can serve as an effective outdoor performance by collecting site information in the same way as a disturbance.

The advantages due to these developments will require the wireless system to be well-planned and deployed efficiently. Any wireless link LOS system could be affected by the physical objects and the environmental factors in the selected area. Moreover this effect can play an important role in the performance prediction. The design of the wireless system will require careful planning and prediction of the coverage and interference levels.

The strategic deployment and growth of wireless systems have generated a great deal of interest in propagation prediction research (Iskander & Shigeru 2006).

Any type of cellular or personal communication system requires careful planning and prediction of signal coverage and interference levels (Kucar 1991). Unfortunately, this type of in-depth site planning requires a careful way of measured data that can often be ruled out exclusively. Therefore, a huge demand already exists in the wireless industry for the development of accurate propagation prediction techniques, a demand that will only increase as the industry turns its attention toward the door and microcellular systems (Lee 2000).

Chen & Yang (2006) have created an algorithm to simulate the operations of traffic light control in a city to find a minimum total time path. The consideration of this method is to deploy the probability of lane size, which is not logically appropriate method to use. After them, some researchers worked on these problems and eventually (Girija & Poorva 2007) developed an automatic traffic light control system based on a fuzzy logic algorithm for solving the road congestion problem.

Acarma et al. (2007) builds their strategy to control the traffic light junction by the simulation model created to evaluate the freeway lane management signing. This model showed that lane control had some influence on congestion.

Jarkko (2010) developed a traffic light controller based on fuzzy logic to optimize the control of fluctuating traffic junction such as over saturated or unusual running conditions. The length of the current green time is terminated depending upon the arrival. Therefore, the number of cars approaching at the green light time and the queue length must match to the number of queuing vehicles in red time.

An expert system uses a set of giving rules to decide upon the action in traffic light control, such an action can change some of the control parameters (Chen et al. 2011). Findler & Stapp (1992) described the network of roads connected by traffic light-based expert systems. The expert systems can communicate to allow for synchronization. Performance on the network depends on the rules that are used. For each traffic light controller, the set of rules can be optimized by analyzing how often each rule fires, and the success it has. The system could even learn new rules. Findler and Stapp showed that their system could improve performance, but they have to make some simplifying assumptions to avoid too much computation to avoid the delay.

Therefore, as the communication system structure is being built, the information from the road side control is also initialized to be exchanged for traffic management functions.

2.2.3 Coordination Between Traffic Junction

Coordination between traffic light junctions is the most important step in the design of a LOS RF link planning. In most cases, a survey must confirm the path design derived from the map study. Investigation of the possible sites is usually necessary, and information on man-made obstructions as well as confirmation of natural obstructions should be obtained (Holland 1993). Possible degradation due to reflection points may also need calculation.

The installation of IUTMS requires much the same basic planning as any wired network. The main difference is that the wireless signal requires some additional planning in BBB area, due to the urban area. This planning includes environment path preparation study and clear line-of-sight for suitable outdoor conditions (Conan 1992). Although the line-of-sight implemented to do wireless intelligent traffic light junction system, reducing the effect of obstructions in the path, and it is important that the characteristics of the path must be carefully determined. With this knowledge, components and network requirements can be correctly planned for the specific application. The site survey helps wireless planner to clearly define the impact of the environment effect on their overall wireless networking and system requirements (Pei 2001).

A basic consideration is the physical location of the sites coordinated at each end of the link (Athanasiadou et al. 2000). In RF, signals travel in a straight line. A clear line of sight between antennas is ideal, particularly for directional antenna. However, the locations of the desired links are fixed.

Possibility of future obstructions in the area, the trees grow high enough to interfere with the signal and there are plans to be vertical buildings between the sites that may obstruct the path. The researcher recommended that these conditions must be taken into the consideration early in the planning process. The planning of a wireless link involved collecting information and made decisions that the sights can use the line- of- sight connection using the software for antenna's height define.

The prediction of large-scale path loss has, to date, represented the dominant application of site-specific techniques. However, as computerized site information becomes available and as future wireless systems operate with higher bandwidths, the application of wireless link prediction techniques becomes very attractive. Lamaire et al. (1996) sites specific techniques are important to facilitate the design of wireless modems by replacing the excruciation of testing and measurement with the convenience of computer simulation.

The performance operation and growth of wireless systems in recent years have generated a great deal of interest in propagation prediction research (Bertoni 2000; Lee 2000; Cavalcante et al. 2006). The prediction of path loss has, to date, represented the dominant of site specific techniques. However, the physical area and the characteristics of the space where wireless coverage is needed must first be defined.

Wireless LAN coordination using the LOS link in urban area is among the most commonly overlooked issues covered by the site survey, which could ‘make or break’ any links line-of-sight system (Qixing et al. 2006). The focus on parameters affecting RF propagation has remained relatively since the initial conception is principles and not considered in a proper way. A visually clear line of sight guarantees the strongest possible signal strength with smallest attenuation due to environmental factors. To have a clear line of sight there should be no obstacles between the two locations in the area.

The description of the environment has to be complete and as error free as possible to obtain accurate results for the predictions. This would mean that a large number of sides for coordination would have to be modelled while describing the environment. However, the computational complexities of ray tracing software's are being used to define the site survey in recent year's increases with the total number of site coordination (Huschka 1994). Site specific selection guaranteed to facilitate the design of current wireless by measuring the factors cased problem to the system coordination using convenience computer simulation.

2.3 PTP AND PMP PROPAGATION AND APPLICATION

Propagation prediction lies at the core of the frequency spectrum engineering and management. Signal strength measurements appear to be the natural choice for accurate prediction. In reality, measurements of point-to-point (PTP) or point-to-multi-point (PTMP) analyses turn out to be a complete design (Anderson et al. 2009) by considering site survey. Furthermore, measurements are not quite enough to evaluate the link scenarios. Fortunately, with the ability of computers and the availability of high consideration for digital terrain data, it is now possible to simulate propagation phenomena within reasonable accuracies. Empirical propagation models are available for a wide range of complexity accuracy and input requirements (Pascal & Patrice 2006).

It is widely accepted that, in line-of-sight (LOS) case, directional antennas reduce the delay spread as compared to omni directional antennas (Theodore 2002). The consideration of the research involved Line-of-Sight (LOS) consideration, atmospheric conditions and terrain effects that cause path loss to differ from free space; lastly, the parameters and processes required to dimension a microwave link.

In an NLOS link, a signal reaches the receiver after being scattered/refracted or diffracted by buildings and other obstacles in its path. This signal consists of various components of the direct path, multiple reflected paths, scattered energy and diffracted propagation (Fujii 2003). Taking advantage of these different signal components have been varying delay spreads, the planning for LOS is very important, since the case is critical for providing NLOS coverage (TianChi & Liang 2011).

Several conditions within the atmosphere can have an adverse effect on line of sight link performance. A few of these are temperature inversion, barometric pressure, and humidity and water droplets (Ashraf et al. 1997). The temperature and moisture content of the atmosphere normally decreases uniformly with an increase in altitude (Elena et al. 2010). However, under certain conditions, such as humidity, the temperature may first increase with height and then begin to decrease. Such a situation is called a temperature inversion. An even more important deviation from normal may exist over the ocean.

2.3.1 Point-to-point (PTP) radio systems

Many wireless LAN systems integrated together to exchange the information, and the easiest way to connect two or more systems together is via Point-to-Point Connection linkage. A point-to-point connection makes a certain condition that only one receiver receives a particular message. For this type of connection, the transmitter must know the location of the receiver. The transmitter often must translate the message into a format that the receiver understands. Using PTP connections, each transmitter determines the address of all the other receivers that it needs to communicate with. When target addresses details change, the entire systems that communicate with the transmitter must be updated. A clear line of sight is present if an imaginary straight line can be drawn connecting the antennas on the side of the link. A clear line of sight exists when no physical objects obstruct viewing one antenna from the location of the other antenna (Yusnita et al. 2003).

Point-to-point fixed wireless systems can be used effectively to carry very high-speed access lines from public telecommunication network operators to subscribers. Higher frequencies (5GHz to 10GHz) are generally applicable only to PTP links (Rautiainen et al. 2002). This is because at these frequencies, range is a limitation. The system is also plagued by other problems (Vaidyanathan 2002).

1. The signal at higher frequencies is subject to attenuation in the atmosphere. Weather, particularly rain, leads to signal fading. The signal also suffers attenuation due to foliage.

2. The radio frequency (RF) bands selected to PTP system usage are not able to propagate easily through obstacles or diffract around them. This makes LOS necessary between the transmitter and receiver. The need for a LOS system and the skill associated with verifying LOS during installation makes the expensive system. However, once deployed, the system is capable of realizing high-bandwidth communications.

These issues lead to the popularity of PTP radio systems, which operate within the sub of 5 GHz bands. Generally, PTP refers to a connection restricted to two endpoints (A&B) as shown in Figure 2.2.

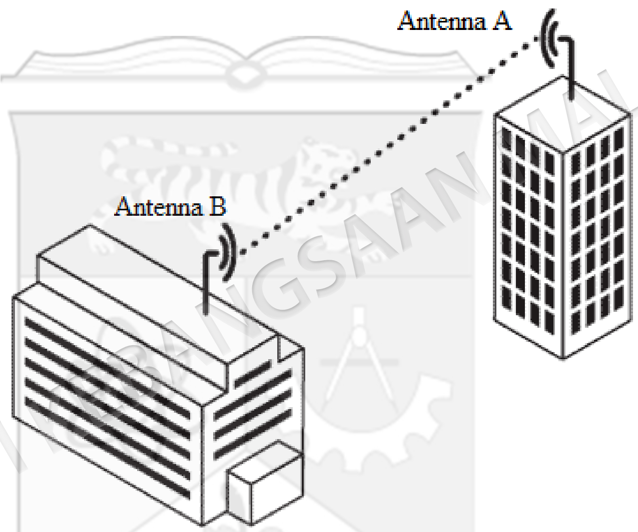


Figure 2.2 Point to point system

2.3.2 Point-To-Point (PTP) Application

The flexibility offered by WLANs has been a major factor in their widespread deployment and popularity (Eralta & Raul 2000). The advantages brought by this technology are its maturity, low cost, and the ease of deployment of WLANs. The overall performance of a specific WLAN installation is largely determined by the network layout and its configuration. Among the necessary conditions for designing an efficient WLAN are therefore careful coverage planning and optimizing such network design parameters as an access point (AP) locations, channel assignment, and AP transmit power allocation. These network planning and optimization tasks are in focus in the current part of the thesis.

In addition, LOS systems require rooftop installation of the CPE, which means a lot of lost (Toledo & Turkmani 1992). A truck roll means that a technician from the service provider must visit everyone end-user to install and precisely "point" the antenna towards the base station. With a broadband service, offering expected to generate thousands and thousands of users, this represents a great cost.

Wireless communication growing fast and concurrent with the application since it allows users to access network services without being forced to use wired infrastructure. WLAN point to point application is based on IEEE 802.1la standard and functioned in the Unlicensed National Information infrastructure (UNII) band (5.725 to 5.875 GHz) (Rahim et al. 2006). Point to point communication brings an essential responsibility to antennas since they are predictable to supply the wireless transmission between those devices (Balanis 2005).

2.3.3 Point-To-Multipoint (PMP) Radio Systems

Point-to-multipoint systems are essentially characterized by the capability for a single radio to sustain links with multiple radio terminals. The great point to multipoint link with protection against the path failures is essential for undertaking critical applications. As well, a high level of planning is needed to support real-time applications and keep the system satisfied (Lenan & Wei 2011).

These systems are more suitable for deployment of broadband wireless access, especially in an urban setting, where most of the time finding a LOS path from a transmitter to the receiver is improbable owing to the variation in terrain, building clutter, etc. (Zhang 2010). Currently, PMP systems have broken the LOS barrier and can operate within an NLOS environment with the same fidelity as it would be in LOS environments. This has made a keen interest within the broadband wireless market to adopt such systems (Baker & Palmer 2003). Generally, PTP refers to a connection to more than endpoints (B, C, D, E, F & G) from only one point (A) as shown in Figure 2.3.

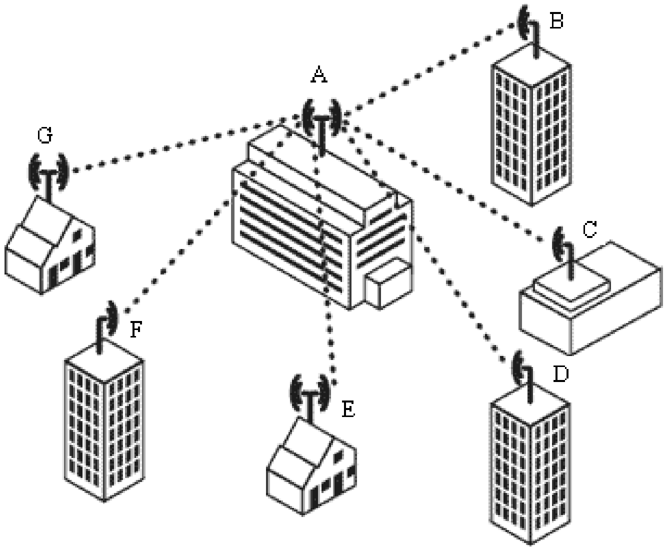


Figure 2.3 Point to Multipoint System

2.3.4 PTMP Application

This capability to maintain several radio links with only one point radio is PMP's fundamental advantage over PTP systems, which need to accept the higher cost of setting for the radios to support the same links. Further than this common characteristic, however, there are significant differences in features between varieties of PMP implementations. Some of these features provide significant operational and cost advantages between PMP systems in the perfect application. Multipoint distribution system used in broadband wireless technology to carry voice, data, video services and the Internet in the 25-GHz and higher spectrum (Kara & Yazgan 2008).

2.4 OUTDOOR MODEL

Electromagnetic fields of the system for the complicated environment as urban area containing many houses, trees on the roads, cannot be easily studied by analytical methods (Panady & Agrawal 2006).

In the literature, there are many experimental and theoretical studies of outdoor propagation model. These models tend to focus on a particular characteristic like temporal fading or inter-floor losses. In the empirical models, all environmental influences are implicitly taken into account regardless of whether they can be separately recognized. This is the main advantage of these models. Because deterministic models are based on the principles of physics they may be applied to different environments without affecting the accuracy. In practice, their implementation usually requires a huge database of environmental characteristics, which is sometimes either impractical or impossible to obtain. The algorithms used by deterministic models are usually very complex and lack computational efficiency. For that reason, the implementation of the deterministic models is commonly restricted to smaller areas of microcell or indoor environments.

An important requirement for radio plan systems is the provision of reliable services, to the increasing the significance of the system performance across the outdoor interface. To achieve this and at the same time reduce the possibility of interference, the radio network has to be carefully planned and optimized (Parsons 2000). For this reason, the radio propagation has two entirely appreciate the conditions, which can influence the accuracy of modeling predictions or even the practical measurements which are carried out for planning purposes.

The selected study area provides the planning necessary to prepare the site for the propagation model used to build a wireless system plan (Lee 1986). System development is part of the design virtually for any physical, inanimate object that we come into contact with in our everyday lives. Most often they are invisible to us. We don't know that they are there, but almost always they are essential for making things work.

Methods for predicting outdoor wireless signal coverage is the main concern in most of the current research in wireless, especially in wireless LAN as mentioned in details in the background of the study. These models predict the signal strength and power spectral density at a given point by determining the path loss, the difference between the transmit signal and received signal, from the transmitter to the receiver.

Tam & Tara (1995); Anderson & Rappaport (2004) suggested a statistical model to predict the impulse response of an outdoor multipath fading channel, which is also applicable to the indoor environments. Chen et al. (2009) also have proposed a statistical impulse response model with their measurement results in a two-story office building together with the measurement results from other researchers. This model is successful in office environments but not in industrial environments. Rappaport (1991) has developed an impulse response model, which predicts the impulse response of a mobile radio channel for factory and open plan building environments based on the statistical data such as the amplitude, phase and arrival time of the multipath waves. Several statistical models (Nakamura et al. 2002) are also proposed, which are applicable to indoor radio channel propagation modeling, but unsuccessful in factory environments.

2.4.1 Urban Area Modeling

The local terrain, buildings, and vegetation are included as the main factors in the path loss calculation. Moreover, the models for each of these must include in the analysis. Fortunately, these types of data are freely available in google earth or either can be easily extracted from the MapInfo software. Besides modeling the geophysical area, the LOS infrastructure must model in order to achieve accurate analysis of the path loss model.

Additionally, the relative height to the resident terrain and orientation of each antenna is necessary in the area of the study (Abhayawardhana et al. 2005). In this method the relative height was calculated by measuring a fixed distance from the antenna site and then using simple angle measurements and determines the height of the antenna. This technique was checked for a building of identified height and was found to be significant. In order to determine the path loss from the transmitter to the receiver, the output power of the transmitting antenna must be known (Rappaport 2005).

Visser et al. (2002) concerning continuous-wave measurements carried out in downtown Ottawa were used as the basis for comparisons between the propagation loss at frequencies near 2 GHz and 6 GHz in urban environments. The difference (dB) was found to have a Gaussian distribution over urban microcellular coverage areas. To provide physical explanations for measuring results, modeling was carried out at 2

GHz. During this process, low complexity models reported in other parts of the world were evaluated against the measurements, which were made in an urban area, which is typical of North America. Comparison of selected models with measurement data resulted in median root mean square (RMS) modeling errors that ranged between 4 dB and 7 dB.

René et al. (2011) developed a new method for propagation modeling in urban structure based on 3D vector building databases. The scenarios presented are based on the element that not altogether rays between transmitter and receiver subsidize a similar portion of the energy. Some paths are central and by defining only these dominant paths due to the computation time are reduced without affecting the accuracy. The output result of the ray tracing model is compared to measurements in different urban scenarios shown that the new propagation model based ray tracing is more accurate. In general, the structure of urban area must also be taken into justification, as it affects the visibility between communication points examined during the computation.

Multi-Ray methods, as described by Sarkar (2003), are those that determine the signal path loss based on the aggregation of the field strength for a multi-ray path from the transmitter to the receiver. Multi-Ray models generally make a direct design of path loss based on paths determined by geometric reflections, diffractions, and scattering method, relatively. The ray tracing method focused on launching a greater number of rays from the transmitter to the receiver and use geometric optics to define the subsequent paths of the rays.

2.4.2 Outdoor Propagation Studies and Path Loss Models at 5.8 GHz

As electromagnetic waves propagate through the wireless medium (air), the energy spreads out and at any given distance is inversely proportional to a power α of the distance. The simplest form of the path-loss model (in dB) is given by equation (2.1) (Pahlavan et al. 2005).

$$L_P = L_O + 10\alpha \log_{10} d \tag{2.1}$$

where $L_O = -10\alpha \log_{10} G_t G_r \left(\frac{\lambda}{4\pi}\right)^2$ (in dB) is the path-loss in the first meter, α is the distance- power gradient, G_t is the gain of the transmitter, G_r is the gain of the receiver, and d is the distance in meters. The distance-power gradient α is a propagation parameter that depends on the environment and is equal to 2 in free-space. For indoor environments, the distance power gradient varies widely, from less than 2 (waveguide effect in hallways) to 6 (when the building is constructed of metal). However, to more accurately describe outdoor environments, a more environment specific path-loss model is appropriate. The area surface dependent path-loss model describes the total path-loss as free-space path-loss with an additional path-loss component contributed by walls and floors, as given by equation (2.2).

$$L_P = L_O + 20\log_{10} d + \sum_{typet} m_{type} W_{type} \tag{2.2}$$

where m_{type} is the number of area surface of a particular type and the type W_{Type} is the loss (in dB) for the given area surface type. There are more complex models that, for example, incorporate breakpoints, where the path-loss up to a certain distance d_{bp} has a smaller distance-power gradient than after the breakpoint. The IEEE 802.11n channel modelling document uses such models for each of the six-channel models that are proposed. More information on various paths- loss models can be found in (Pahlavan et al. 2002).

Since the wireless networks technology increase, studies of signal propagation have been required to ensure an efficient system with good coverage and quality of services. Bruno et al. (2011) has made a comparative study between known propagation models throughout least squares modification algorithm for 5.8 GHz frequency band. This study considered the environmental factors on the 12 cities located in the Amazon Region, Brazil. The least squares modified algorithm has been made to adjust the models based on the measurements. The collected data have been carried out at Amazon Region. These cities are recognized by their woodland environments. The vegetation normally comes into view mixed with the residential area. Differentiation of the established measuring operation (Yang & Shi 2008; Pallardó 2008) that are made by continuous data collection using a mobile unit, this data attainment has been carried out by taking the punctual RSSI in 335 fixed clients installed in 12 cities that have been contemplated. Based on the achieved results, the authors proposed for future works can consider an adjustment of some parameters or adding some terms which is related to some new environment feature. This method is still lacking of accuracy and due different propagation factors in different cities which may criticize the result obtained.

2.4.3 Outdoor Propagation Mechanism

IUTMS planning consideration is organized with particular propagation complications compared to the channel characteristics in radio systems with fixed and carefully positioned antennas. The antenna heights at a site are usually fixed in an exact position. Hence, the antenna is expected to have small Fresnel zone 'clearance', so obstacles and reflecting surfaces in the surrounding area of the antenna have a significant influence on the characteristics of the propagation path. Moreover, the propagation characteristics change from place to place and if the condition of the environment changes, from time to time. Thus, the transmission path between the transmitter and the receiver can be different from the simple direct line of sight to one that is severely obstructed by buildings, vegetation and the terrain profile.

Many good urban models (Landstorfer 1999; El-Sallabi & Vainikainen 2003; Giampaolo & Bardati 2009) were developed for macrocellular service. However, since these models pursue the prediction in the urban cities describing the urban environment as an array of buildings on flat or smooth terrain, these have difficulty in describing the radio wave propagation in the urban cities on the hard terrain profile. For the urban cities have hard terrain profile, reflection and diffraction by hills, as well as buildings, should be considered.

Liang & Bertoni (2006) have developed a three-dimensional propagation model for communications in an urban street scene, based on the reliability theory of diffraction. To position the points of reflection and diffraction, image theory is used but on the two dimensional plane observation of the environment. Athanasiadou & McGeehan (2000) planned a high-speed image based ray tracing model for microcellular and indoor environments. To improve the speed, two dimensional building database and image generation process are used. The field strength is calculated in three dimensions for each two dimensional ray path

Li (2004); Durgin et al. (1998); Schwengler et al. (2000) performed experiments at 5.8 GHz in suburban areas and directly related to those obtainable in this thesis; however, as was the case with Gilbert et al. (2000); Durgin et al. (1998), they used a fixed transmitting node and a mobile receiving node rather than the spectrum analyzer integrated with GPS devices for various locations due to the signal strength.

Hoppe et al. (2003) have developed a propagation model using shooting and bouncing ray (SBR) techniques to predict the path loss and delay spread in microcellular environments. Seidel & Rappaport (1994) have developed geometrical optics based model to predict indoor radio wave propagation, in which SBR approach and diffraction using the uniform geometrical theory of diffraction are incorporated. Durgin & Rappaport (1997) have proposed another deterministic model with an improved shoot and bounce ray tracing technique. In this model, the reception sphere is not used; instead of that, two and three dimensional weighing of the rays in the proximity of the receiver is used to determine the total received power. This corrects the ray double counting errors in the reception sphere model; but diffraction, material properties and polarization effects are not incorporated. Li (2006) has also avoided the errors with the reception sphere in their model for indoor environment, but they have used ray tubes instead of rays.

2.4.4 Outdoor Propagation Impairment

Radio propagation critically depends on site selection and frequency operation, which is significantly depended on the terrain profile and propagation impairment (Faridah et al. 2008). The explanation of the environment has to be complete to reduce the error as much as possible to obtain accurate results for the LOS predictions. This would mean that a large number of surfaces would have to be modeled while describing the environment. However, the computational difficulties of ray tracing software increases with the total number of surface (Agelet et al. 2003). Therefore, a balance between these two requirements has to be achieved. High Altitude Platform networks for communications service delivery will require a study of design Local Multipoint Distribution Services (LMDS), compared with existing wireless technologies (Thornton et al. 2001).

The system discussed in this guide operates at 5.8 GHz. Any propagation factors that are common define in the site location which was selected for research consideration had measured. These conditions can include the amounts of rain, humidity, earth curvature and temperature ranges and used to calculate the k-factor of the integrity of the side link.

The most suitable environment database for a 3-D ray tracing software consists of many considerations that represent the surfaces of buildings and terrain. A large percentage of outside that cause any significant effect on the propagation of radio waves, such as rain, humidity, temperature and terrain profile can be modeled as a database. Data's profiles are easy to describe numerically and allow simple reflection calculations. It has clear boundaries, which make it easier to model clean line-of-sight deliberation. This profile based environment model can be constructed easily using MATLAB tools. Hence, a vector model of the terrain is most suited for 3-D ray tracing (Cavalcante et al. 2006).

If any of these obstructions high enough to block the view from the end to end, there is no visual line-of-sight (LOS). Though obstructions that are in the obvious path of the visual line- of- sight (LOS) can interfere with the radio LOS, there are considerations such as the Fresnel zone effect. If a hard object, such as a mountain ridge or a building, is too close to the signal path, it can damage the radio signal or reduces its strength (Lee 1996). This can happen even though the obstacle does not obscure the direct, visual LOS (Green 1995; Tozer et al. 2001). Most radio transmissions, especially high information capacity types, require a clear path between antennas known as a radio LOS (Green 1995). It is therefore, necessary to understand the requirements for radio LOS when designing a network. For example, satellite communication is an extension of the LOS microwave (Madza 1996). It has two drawbacks. First, of course, is limited bandwidth to send the information. The second is an excessive delay when the popular geostationary satellite systems are utilized. It also shares frequency bands with the LOS microwave (Madza 1996).

The need for an efficient way to evaluate radio propagation in buildings is increasing due to the application required (Tang & Tharek 2004). It is also important to optimize the locations of the base stations required to ensure acceptable system performances. Therefore, radio propagation prediction for indoor environments, which forms the basis of optimization for location of base stations, has become an important research topic.

Ray tracing is a technique for tracing the path between the transmitter and receiver to simulate the effects of the virtual objects. This technique is talent of producing a high degree of visual methods to produce better suited technique for applications. Ray tracing is used for simulating a wide variety of optical effects, such as refraction, reflection, scattering, and dispersion occurrences. Ray Tracing required a preprocessing of such extremely large databases of urban databases (Hoppe et al. 2003).

Several ray tracing models use multiple path loss exponents depending on the RF situation by the direct-ray path, such as LOS where there are no terrain or building between the transmitter and receiver and NLOS where there are obstructions between the transmitter and receiver (Lorne 2007). Few other models used two path loss exponents are considering the LOS path as set by geometry and determined the breakpoint distance of the power received (Aschrafi 2006; Sarkar 2003; Iskander & Yun 2002).

Comprehensive field measurements were conducted for suburban microcell channel surrounding Universiti Teknologi Malaysia by utilizing 5.8 GHz (Noor Ziela et al. 2013). These measurements covered 10 point-to-multipoint links were selected to study the influence of vegetation on propagating radio waves. This suburban location was fully characterized by terrains and tree blockage. The observation from the result shows that the external effect such as wind, trees and terrain was significantly affecting the signal performance.

2.5 LINK PERFORMANCE

The increasing demand for bandwidth in radio communication systems is anticipated to strength the communication networks for more efficient for new technology utilization. Another possibility for extending the network capacity is the allocation of higher frequency bands, such as 3.6 GHz, 5.8 GHz and 10 GHz for communication system. With respect to evaluation of the suitability of link type systems for operation in a band of 5.8 GHz (Cui et al. 2008), the review of this research estimated that models for propagation loss would provide physical explanations for the results observed from measurements. As in any radio communication system, before main wireless solutions (MWS) is designed, the radio propagation channel has to be measured. The attenuation, depolarization, multipath and other propagation effects that the radio signal can suffer on its way from the transmitter to the receiver have to be known to be able to properly design the system.

The business wireless communication has grown at a wonderful speed in the last years. In the 1980's, the word 'wireless' was matched with a cellular phone or a cordless phone. However, today the focus of wireless commerce has collaborated with wireless voice service with data (Wang et al. 2004). Wireless LANs have become popular and required continues to grow. Ongoing research is bringing multimedia content to the wireless subscriber. All of these new technologies required a much higher data rate when compared to the wireless systems used currently.

Statisticians and experiential techniques have traditionally been used to predict the coverage of a wireless system. Most of the statistical techniques use simple path loss exponent models for large-scale path loss estimation (Qin 2007). The path loss exponent was calculated based on the measurements conducted in the environment where the wireless system is deployed. Only a basic estimate of the average path loss can be obtained using this method. Moreover, the extensive measurements are prohibitively expensive, especially for high data rate applications. These models can only be used to estimate the path loss or the mean signal strength. The wideband characteristics of the channel such as the power delay profile or the delay spread cannot be estimated using these techniques. However, it has been proven that the shape of the power delay profile, and the delay spread can significantly affect the performance of a mobile communication system (Wittmann 1997).

A ray tracing based prediction technique would require a very detailed description of the physical environment (Rao 1987) as many researchers' concern. Some of the earlier ray optics based propagation prediction models used Digital Terrain Models (DTMs) with the building heights superimposed on them to do propagation prediction (Tameh et al. 1997; SoftWright 2009). The DTMs are raster databases where the elevations of a regularly spaced grid of points are stored. The raster database limits the applicability of the ray tracing software. The problems of using a raster database for a ray tracing based application are discussed in the next section. Some other ray optical models use 2-D database of the cities, which are easily available from city maps (Rizk et al. 1997) or use the street and the terrain data for modeling propagation (Giampaolo & Bardati 2009).

Table 2.1 Research limitation and probability of extension work

Author	Limitation	Probability of work extension
Nieto et al. 2011	This research focused more on the fundamental planning of LOS link transmission techniques which was produced the compression methods to increase the bandwidth required.	Need extensive data collection and the analysis will produce better prediction model
TianChi & Liang 2011	This paper has been varying delay spreads for LOS planning by taking advantage of the different signal components, since the case is critical for NLOS coverage provided.	To optimize the delay, may need to characterize the propagation impairment in the study area.
Lenan & Wei 2011	This research deal with the greatest point to multipoint link with protection against the path failures for undertaking critical applications. As well, a high level of planning was provided to support real-time applications and keep the system satisfied.	Need essential study for a single radio to sustain links with multiple radio terminals by considering the link quality factors.
Cocheril &	This paper presents a new method to model the	Need measurement to validate

Vauzelle 2007	radio wave propagation in straight tunnels with an arch-shaped cross section and in curved tunnels with rectangular cross section using 5.8 GHz.	the modeling and design concept.
Tomas & peter 2004	This paper presents commercial software for LOS planning to generate the rays from the target of eye height consideration without full control over the target.	Many users recommend this software, but need to update the database for future revenues.
Tang & Tharek 2004	This paper reviewed most commonly used ray tracing technique and applies ray tracing techniques which incorporate site specific environmental data to predict path loss in a newly constructed hotel in UTM for 5.8 GHz industrial.	Need to be generalized to apply and validate in different area.
Rappaport 1996	This study identifying the key restricted access and proposing a solution on how the antenna pole height should be designed in order to meet the challenge of providing high availabilities in a cost efficient way using 5.8 GHz.	The design for link planning need to be considered the topographical area and propagation impairment as well.

2.5.1 LINK PREDICTION TOOLS

In the 1990's, a host of new propagation models which used site-specific information to predict the propagation characteristics were introduced; an approach based on ray tracing being the most prominent of them (Tanis & Pilato 1993). A ray tracing-based approach can be used to predict the small area average receiver power, and wideband characteristics of the channel such as the root-mean square delay spread, the angle of arrival and the slow fading correlation of the different environments (Bertoni et al. 2000). However, unlike the traditional statistical models, which need very little or no information regarding the environment, a ray tracing technique must accurately model all the physical objects in the environment. Most of the researches done in the area of physical objects for propagation prediction are depending on the topology of the selected area. The first part of this thesis implements a method to model the buildings and the terrain using the geographic data available from commercial sources.

This part provides an overview of the different software and planning tools available that can be used to model the environment for site-specific propagation prediction. The part also discusses about the data format for the most suitable modeling of the environment. Figure 2.4 shows the plan view of a LOS with zones of visual influence (ZVI) analysis done for United Kingdom (UK) to Radio Systems Working Group (2005). This software only represents one layer and ignores the 3D act, so that it missed the accuracy.

For an accurate LOS analysis, there must be a good terrain model since without detailed 3D terrain data; the LOS analysis will inevitably be flawed. Some commercial applications generate LOS rays from a target with full control over the target and eye height, angle of sweep, maximum search distance and correction for earth curvature/refraction.

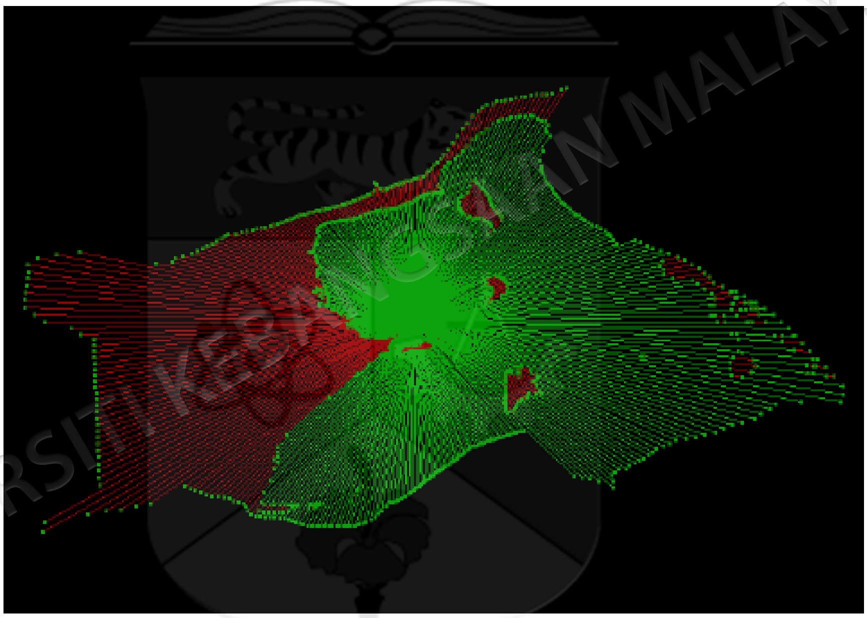


Figure 2.4 Plan view of a LOS with ZVI analysis

Source: UK RSWG 2005

The LOS analysis model can calculate zones of Visual Influence and Intrusion (ZVIs) and perform the LOS analyses and displayed on the terrain model as shown in Figure 2.4 (UK Radio Systems Working Group (UK RSWG)).

Many other profitable specialty applications use imported basic mapping modules. These kinds of the package provide an easy way to decide the visibility of a LOS to a target based upon the topography of the surrounding area via a LOS display and a profile display. A window usually allows the user to display geographic coordinates and elevations by moving the mouse over a map of the proposed coverage study. However, many users will find that these kinds of capabilities are sometimes unwarranted as they do not always present a true picture of the surroundings and are mostly seen as vendors' gimmick of getting future revenues from regular updates. On August (1998), there is featured SoftWright software used to manage the Terrain Analysis Package for Radio Propagation prediction, with a great version of TAP (Terrain Analysis Package). As shown in Figure 2.5, but still not able to handle the good terrain model for wireless propagation model. This Figure gives an idea about the Plan view of LOS areas done to analyze the terrain which is impossible to get the accurate value for LOS evaluation.

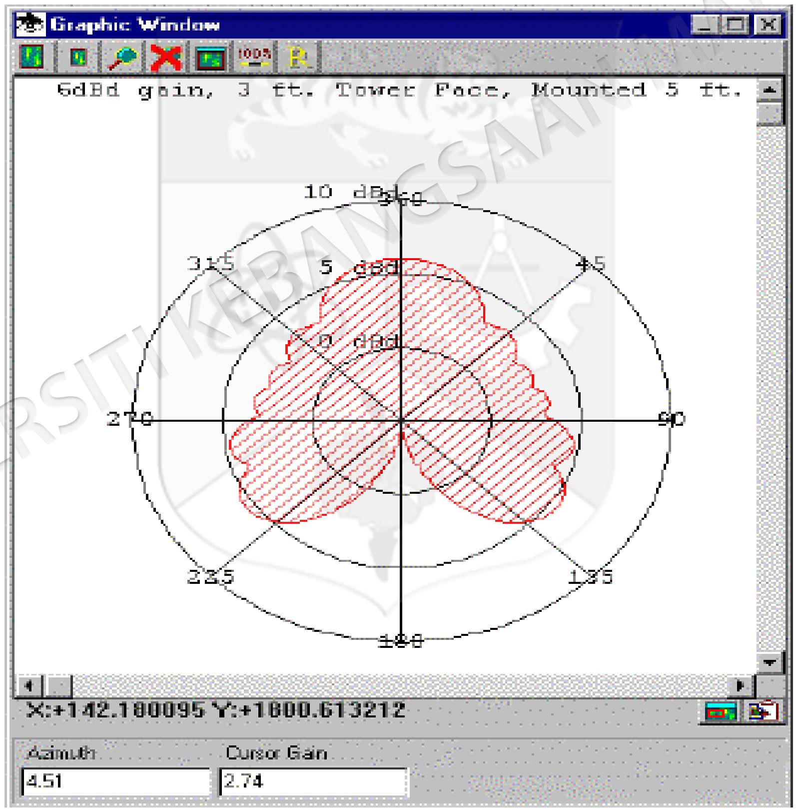


Figure 2.5 Plan views of LOS areas

Source: TAP 2003

Many authors build path loss models for line-of-sight (LOS) and non-line-of-sight NLOS) radio channels (Saunders 2001; Qixing et al. 2006, Barclay 2003); however, they seldom consider the actual probability of achieving a LOS and NLOS link in theoretical studies. It is usual for either a LOS or NLOS channels with log-Normal distance, to be affected. The previous assumption may be suitable for carrying by the radio links operating in open areas while the latter can be used for terrestrial point-to-point and microcellular radio channels.

2.6 SUMMARY

This chapter provided a description of the background theory and previous research related to this study. Adequate theory and a literature review are important as the basis to support the investigation of the results and the expansion of the most current methodology to response the research questions. The current researches have concentrated on these issues notified that wireless communication has a strong potential to improve traffic light flow control. Although, the issues arrangement to propagation impairment during the traffic light's assessment through wireless communication must take place in the performance due to the signal attenuation factor. Some specific propagation mechanisms were presented in varying models for possible responses, with an indication to the researcher to be efficient. In addition to the usual requirements such as wireless link planning constraints and the propagation impairments need to be studied for accurate model. This chapter presented a brief overview of some of the established models for outdoor propagation. Since the different models have some limitations, it is important to investigate under which circumstances the models can be used to plan for LOS communication. The weaknesses and strengths of the different models were clarified and show which parts that are useful and which parts that have to be improved. The critical concern of LOS link planning at 5.8 GHz for ITLMS has discussed and identified the traffic light control through point to point and point to multi-point connection with a great deal to propagation modeling based on impairment factors. Therefore, the findings of this investigation will contribute to more studies on the effect of propagation impairment for ITLMS wireless LAN networks using 5.8 GHz. In the next chapter, the research methodology will be describing the method adopted by this study to achieve the objectives stated in section 1.4.

CHAPTER III

METHODOLOGY

3.1 INTRODUCTION

This chapter describes the method adopted by this study to achieve the objectives stated in Section 1.4. Propagation impairment refers to the risk of incurring losses due to unexpected changes in the link quality of ITLMS using LOS. This research considered the empirical models based signal strength measurements in the area of BBB, where the transmitter and receiver has a main influence on the link quality of the transferred signal. Trees are the main cause of attenuation for electromagnetic wave which are interacting with the leaves during rain and humidity. Most of the models as mentioned in the literature review have the advantage of unquestionable accuracy of the environments and locations in which measurements were taken. However, from the propagation model, the data must be generalized for different environments and antenna configurations for more accuracy.

The requirements for an accurate propagation models for outdoor communication systems is more important due to the risk of the link failure. For the site-specific in BBB area, the environmental factors of the propagation impairment were taken into account. Several techniques are available for the link planning and propagation model based on measurement prediction of the wireless LOS network as discussed in the literature review. The main issue of this thesis is to predict an accurate packet receive by strongest signal strength that reflects the actual throughput that a traffic light control can expect to manage during peak time operation.

This chapter is divided into three main parts. The first part details the description of the ITLMS study area. The second part details the measurement procedure and instrument used in the study. The third part outlines the details of the methodology used in the study, including the propagation development and software planning tools. The three sections discuss the considerations of the research and its potential problems to solve.

3.2 DESCRIPTION OF ITLMS STUDY AREA

Bandar Baru Bangi is considered as an urban area which is characterized by higher tree density and human features created and further developed building by the process of urbanization. The ITLMS technique is the controlled isolated traffic signal strategy in the area of Bandar Baru Bangi. It is initially developed in order to increase safety and to reduce lost time and the number of stopping vehicles at the traffic junctions. The ITLMS incorporated with the intention of reducing the number of vehicles in the queue zone and thereby reducing the number of red-light signal time for waiting delay and take care of collisions happened.

By definition, all of today's wireless communication systems contain one key element of antenna for some form (Andrea 2005) in the certain area to serve wireless LAN system. An Intelligent Traffic light management system used directional antenna to serve as the transceiver between the traffic lights located in urban areas. To design this wireless LAN system, a consideration of an accurate propagation model that meets the system's requirements is needed to firmly secure the link between the remote points of the communications system. The suitable antennas also must be taken to meet these system requirements for communications systems to handle well performance deliberation.

Since first-generation, line-of-sight (LOS) used for fixed broadband wireless access techniques (Constantine 2005). However, services based on this technology have been limited in scope to service areas where transceivers can communicate with their base stations, unimpeded by trees, buildings and other obstructions. This limitation has serious consequences in that the system can deliver only 50% to 70% coverage within a given cell radius, thus affecting received signal (Vaidyanathan

2002). Next generation broadband fixed wireless access techniques are aimed at achieving a link optimization greater than 90%. To achieve this target, these techniques must be based on a point to point (PTP) and point-to-multipoint (PMP) link architecture with perfect antenna's height, thus accurate the ability to operate in true line-of-sight (LOS) conditions. A possible limiting factor for these systems is links performance due to the topographical area.

3.2.1 Site Selection and Consideration

Site selections and path profiling is the most important step in the design of a LOS RF link planning. In most cases, a survey must confirm the path design derived from the map study. Investigation of the possible sites is usually necessary, and information on man-made obstructions as well as confirmation of natural obstructions should be obtained (Taga 1990). Potential reflection points may also be determined.

The installation of ITLMS requires much the same basic planning as any wired network. The main difference is that the wireless signal requires some additional planning in Bandar Baru Bangi (BBB) area, due to the sensitive issue. This planning includes environment path preparation study and clean line-of-sight for suitable outdoor conditions. Although the line-of-sight implemented to do wireless intelligent traffic light junction system, reducing the effect of obstructions in the path, and it is important that the characteristics of the path must be carefully determined. With this knowledge, components and network requirements can be correctly planned for the specific application. If the RF path designed and installed without the benefit of a field survey is a high risk except for the types of paths where the path characteristics are obvious, and the path is short.

A basic consideration of the wireless link planning using radio frequency is the physical location of the sites at each end of the link (Zhang 2007). When a clear line of sight cannot be achieved, the project must plan accordingly used non line-of-sight antenna (Haipeng et al. 2010). Figure 3.1 shows the site selection; include latitude, longitude and altitude for each junction in Bandar Baru Bangi, Selangor, Malaysia

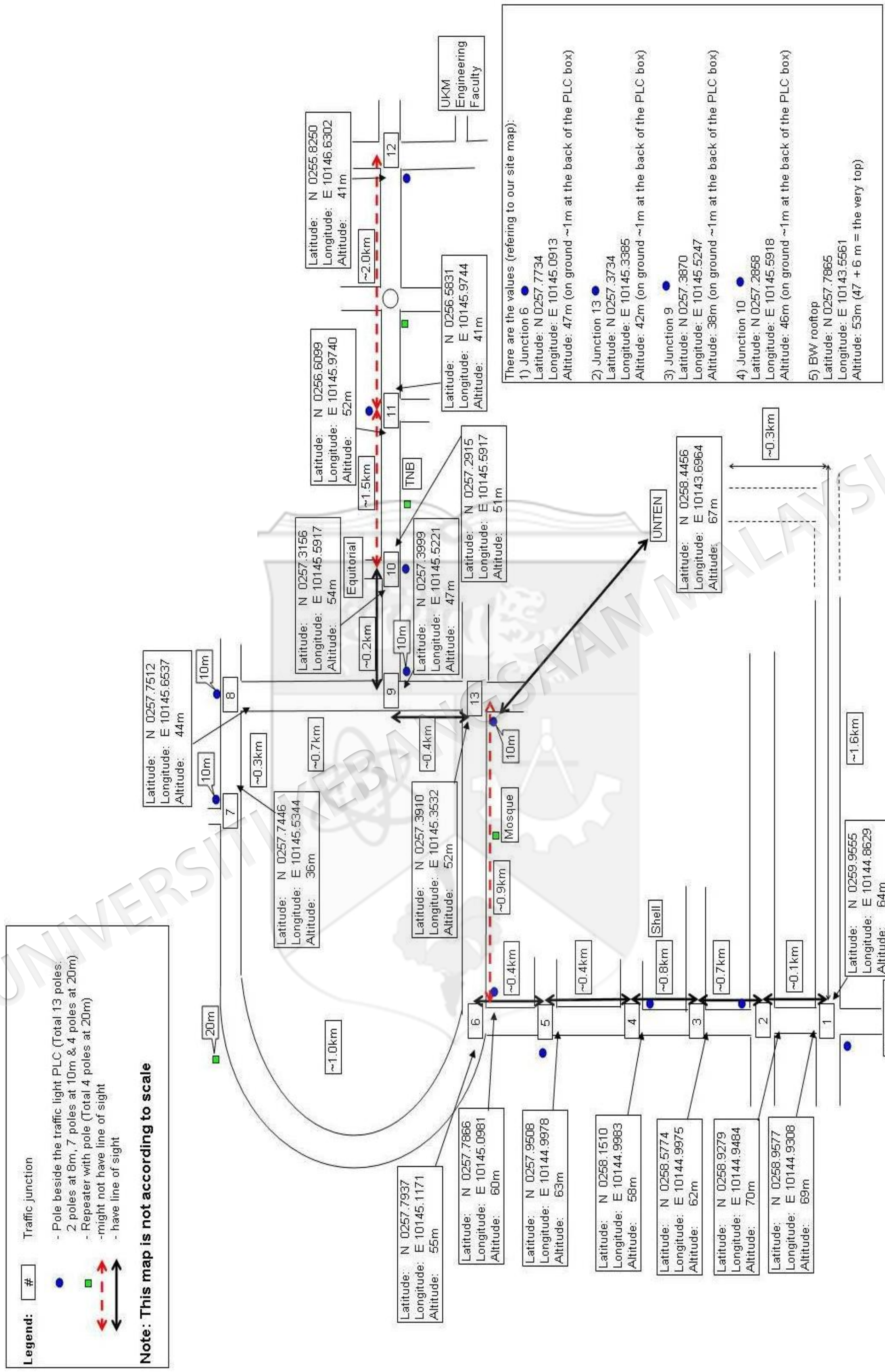


Figure 3.1 Site selections with latitude and longitude

The prediction of large-scale path loss has, to date, represented the dominant application of site-specific techniques. However, as computerized site information becomes available and as future wireless systems operate with higher bandwidths, the application of wireless link prediction techniques becomes very attractive.

The performance operation and growth of wireless systems in recent years have generated a great deal of interest in propagation prediction research (Hope et al. 2003). The prediction of path loss has, to date, represented the dominant of site specific techniques. However, as computerized site information becomes available and as future wireless systems operate with higher frequency.

3.2.2 Terrain Profile and Area Topology

The description of the environment has to be complete and as error free as possible to obtain accurate results for the predictions. This would mean that a large number of surfaces would have to be modelled while describing the environment. However, the computational complexity of ray tracing software increases with the total number of surface as claimed by (Jeffry & Fordham 2008) in their research. Figure 3.2 shows the view of the topographical map of Bandar Baru Bangi (site specific of the measurement area).

Figure 3.2 A topographical map of Bandar Baru Bangi

The research has attributed the main problem by conducting experimental measurements in outdoor environments in the area cited in Figure 3.2. The idea is to simulate a condition of a wireless link LOS network system communicating in the presence of buildings, terrain profile and vegetation. This area provides the necessary planning to prepare the site for the propagation model to build a wireless system plan (Lee 1986).

In order to plan for any single or multi-link wireless PTP, a number of factors such as wireless propagation impairment (rain, humidity, trees, terrain and temperature) must be carefully measured in the area. The purpose of the topographic map shown in Figure 3.2 is to plan and converse the factors that have impact to affect the link LOS implementation.

To take full advantage of receiver strength needs to reduce the effect of the signal disturbance by removing or avoid obstacles from the radio frequency line of sight. If the link is free, the radio waves will travel in a straight line from the transmitter to the receiver. But if there are obstacles near the path, the radio waves reflecting off those objects may arrive out of phase with the signals that travel directly and reduce the power of the received signal.

A difficult process followed in the area whereby the clear line of sight distance from the original site is plotted on a Line-of-Sight (LOS) ranging diagram based on the fixed reference point to a variable point. To generate a fixed point, encompassing all the possible elevation values, is impossible, as the plotting of the line- of- sight (LOS) distance has to take the physical distance of the obstruction’s peak into consideration. The plotted diagram is then filed for record and other reference purposes as well.

Furthermore, in this thesis the link planning in the topographical area which is reached by crowded trees, buildings and terrain profile as shown in Figure 3.2 are obtained by the MapInfo software planning approach provided a good estimation for the performance of simple and low-cost devices. Therefore, The first planning approach for ITLMS planning in BBB done by the vendor of Nera Company, it was taken as a very complicated system, where intelligent Traffic-Light Management System schemes are very sensitive and an advanced system design eliminates most of the performance losses that are caused by the problem of an optimal links competing for the available resources due to the wrong planning. Although the system is very sensitive and expensive to be built, that needs to provide a useful performance between traffic lights. By comparing the performance results of both approaches (Nera Software and ITLMS software) for link planning can demonstrate the performance compromise in LOS wireless system.

The main motivation for using the ITLMS method in the topographical area of BBB, which starts from an expected unachievable performance while using Nera software and proceeds towards a more realistic system plan to be able to identify the key block in a wireless LAN planning consideration. The goal of the planning is to identify which impairment is affecting the LOS link and required the most attention, where simplifications of a good link planning can be made without causing less performance and losses.

Particularly, the measurements provide an easy way to determine the visibility of a LOS to target the traffic light link connection based on the topographical area of BBB via data measurement characterization, including the terrain heights and trees affect, based on given topographical area as shown in Figure 3.2.

3.2.3 Network Topology and Data Transmission

A basic consideration is the physical location of the topographical area at each end of the link and the locations of the desired connection. All of the data shared is transmitted between nodes in the WLAN, except in the case of a break or failure in one of the links.

The planning of the wireless link involved collecting information and made decisions that the sites proposed to use the line- of- sight connection in all the communication between the traffic lights. Figure 3.3 shows the traffic light proposed in the area of study. The topographical area of fully meshed network connection between the traffic lights is relative to the exponent of the number of traffic lights, considering that corresponding group of any two endpoints, up to and including all the endpoints. The region under consideration in this study consisted of 14 traffic light's junctions from UKM at (Kajang) Bandar Baru Bangi to Kajang tool in the same area. For each of two traffic lights, a set of the digital terrain model (DTM) was produced, using site survey measurement such as obstacle heights.

The measurements in the topographical area were digitized based on altitude, and the height's information was then converted to a DTM in which terrain heights were stored as the mean height as shown in Figure 3.1. A long straight-line paths between any two given points in the study region were recorded, using MapInfo. In order to calculate the height of the antenna at a fixed point in the profile the system automatically calculates the antenna received, depend on the antenna transmit location, which could be point-to-point or point-to-multipoint based on the obstacle height in selected location.

A real data and video streaming over PTP or PMP communication channel was considered to present the traffic light cycle time, which mainly obtain to activate the conventional traffic light control.

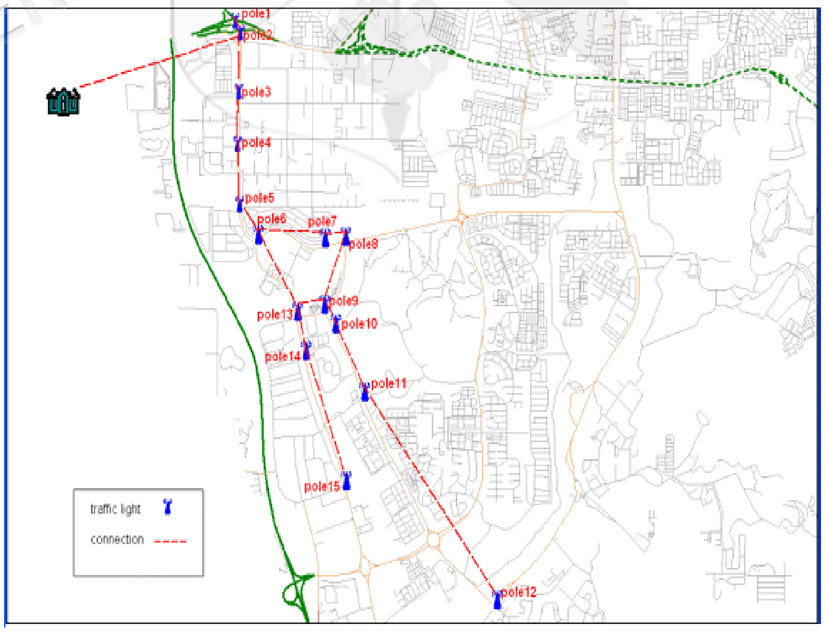


Figure 3.3 Site selection and connection topology

This research, show a simplified user-friendly model for Wireless LAN intelligent Traffic Light Management System to develop and predict the propagation in an urban environment in the area of Bandar Baru Bangi (Selangor Darul Ehsan - Malaysia) as a sample of the study based on radio link line-of-sight measurements, which was operated in 5.8 GHz unlicensed frequency bands by following IEEE 802.11 a, to provide up to 54 Mbps.

3.3 Proposed Method

This research is interested in LOS wireless communications, implicated with various propagation impairments; consequently fixed WLAN are considered. Tests were conducted to measure the terrain, trees effect, antenna height, link quality in different environmental conditions, such as trees attenuation, humidity, humidity accumulated with trees and rain attenuation cumulated with trees.

The transmitted signal for all packets sent from the fixed radio where specified by the index value and the received signal strength of all the packets received by the spectrum analyzer are measured in terms of the received signal strength indicator (RSSI). Consecutively for these index values have index factors in measuring signal strength attenuation.

Figure 3.4 represents the operation carried out on the element of data collection and measurements. It contains a series of process in brief descriptive label describing the process being carried out on the data to generate the model.

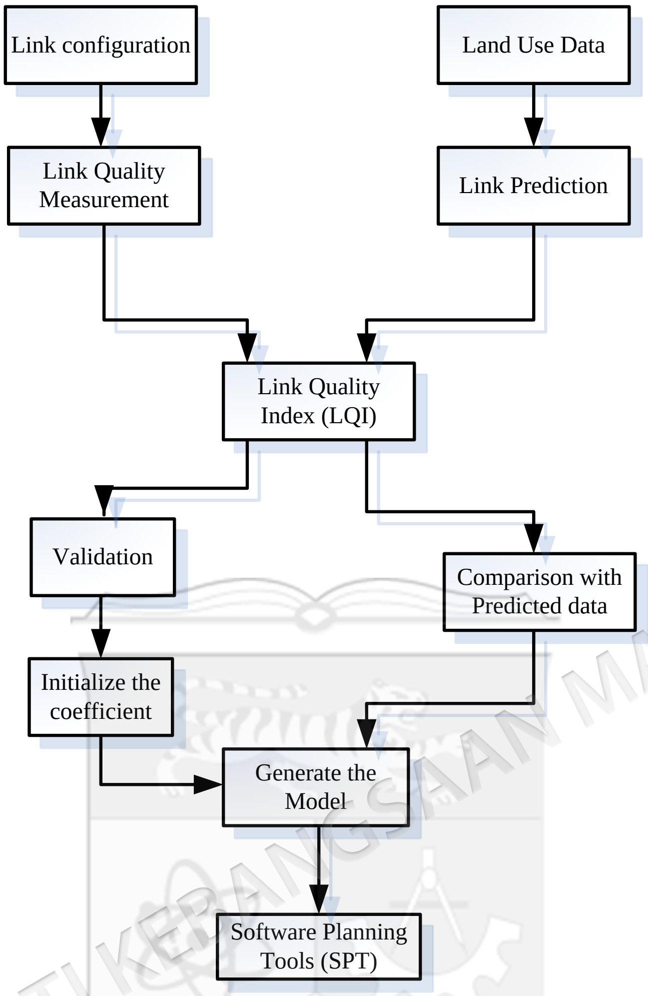


Figure 3.4 Schematic flow chart diagrams representing the proposed solution

The main aim of link quality Measurement training parameters (Tree attenuation, Humidity attenuation accumulated with trees, rain attenuation accumulated with trees) in conjunction with ITLMS is to attain higher accuracy of prediction values of ITLMS. The best production values were attained when the link was configured with traffic junction nodes.

The main aim of link use parameters is the prediction of LQI using the link with parameters only (Tree attenuation, Humidity attenuation accumulated with trees, rain attenuation accumulated with trees).

3.3.1 Link Quality Index (LQI)

In order to define the relationship between link quality factor response and information use attributes, the study introduced the link quality index based on curve fitting as shown in the equation 3.1. This model was introduced for the case study in the area of Bandar Baru Bangi (BBB). (Faris & Alias 2009).

$$LQI = 100 - [0.17HT_{SI} + 0.031H_{SI} + 0.26T_{SI} + 0.17RT_{SI}] \tag{3.1}$$

LQI: Link Quality Index

HT: Humidity attenuation accumulated with trees

T: Tree attenuation

RT: Rain attenuation accumulated with trees

SI: Sub-index

This model was developed by associating the appropriate loading factors to a set of sub-indexes. The loading factors were obtained based on a peak factor theorem by assigning weights to different categories of propagation prediction use sub-indexes initiated by Saturation Growth-Rate Model (Faris & Alias 2009; Bhargava and Setia 2008) as shown in the equation 3.2.

$$y = \frac{ax}{(b + x)} \tag{3.2}$$

The link quality constraints can be made as many factors as needed; however, link use and the area involved with propagation impairments can change gradually upon the factors change. To overcome this challenge, it was considered necessary to develop a method for data measurement that can predict the concrete LOS link use. The proposed method motivates to predict the actual link. The generation of the factors used Polynomial Fit is essential for the Lagarange Model (Mircea 2005; Aberg & Lindgren 2009) for as shown in equation 3.3 based on data collection used sub-indexes for building the model that predicts and estimates the LQI of the LOS in the area of BBB.

$$y = a + bx + cx^2 + dx^2 + \cdots \tag{3.3}$$

In order to produce descending values for all factors involved in the method, the growth observations were obtained by optimizing the relation in table 3.1.

Table 3.1 Saturation Growth rate for boundary condition and sub-index factors

Parameter (%)		Boundary Condition	Sub-index (Si) Equation		Index value
Trees Attenuation	If	$X \leq 6.6\,ft$	$R_{SI} = 0$		
	If	$6.6 \leq X \geq 100$	$R_{SI} = \dfrac{a}{1+be^{-CX}}$	Where	$a = 108.41$ $b = 14.255$ $c = 0.23004$
	If	$X \geq 100$	$R_{SI} = 100\%$		
Humidity	If	$X \leq 40\%$	$H_{SI} = 0$		
	If	$40 \leq X \geq 100$	$H_{SI} = \dfrac{a}{1+be^{-CX}}$	Where	$a = 110.34$ $b = 11.305$ $c = 0.099$
	If	$X \geq 100\%$	$H_{SI} = 100\%$		
Humidity Attenuation accumulated with trees	If	$X \leq 30\%$	$T_{SI} = 0$		
	If	$30 \leq X \geq 100$	$T_{SI} = \dfrac{a}{1+be^{-CX}}$	Where	$a = 109.34$ $b = 10.16$ $c = 0.0084$
	If	$X \geq 100\%$	$T_{SI} = 100\%$		
Rain Attenuation accumulated with trees	If	$X \leq 3mm$	$RT_{SI} = 0$		
	If	$3mm \leq x \geq 14mm$	$RT_{SI} = \dfrac{a}{1+be^{-CX}}$	Where	$a = 107.344$ $b = 14.155$ $c = 0.80904$
	If	$X \geq 14mm$	$RT_{SI} = 100\%$		

3.4 RESEARCH METHOD FLOW

The ultimate of wireless communication planning offers the desired services and covers reliably of the intended service for an Intelligent Traffic Light Management System (ITLMS) in the area of Bandar Baru Bangi. It further uses as a tool for accurate planning of the line- of- sight link planning under difficult propagation conditions, such as rain, humidity, temperature and terrain profile. The data offered in this research were collected in urban environments, characterized by congested trees. The measurement test-bed was set up based on different condition at which the GPS receiver unit updates location.

Hence, appropriate design methods are necessary we divided the research situation into three parts:

1- Measurements condition
2- Propagation Modeling
3- Software planning tools

3.4.1 Measurement Campaign

Schwengler & Gilbert (2000) conducted experiments, at 5.8 GHz in residential area, very comparable to those presented in this research; however, (Zhao et al. 2002), they used a fixed transmitting antenna and a mobile receiving signal strength.

The received power spectral density and signal strength corresponding to each RSSI value was determined by associate the values measured by the receiving test kids with known received signal strengths in verified distance. Identified received signal strengths were twisted by attenuating the transmitted signal of the fixed radio transmitter. All of the received signal strength values corresponded to each measured RSSI value was analyzed based on the regression criteria and index factor.

3.4.2 Experiment Setup

The measurements along the paths are used to compute an estimate the signal strength (SS) and Power Spectral Density (PSD) of the spatial field of the transmission in the area of BBB throughout the link medium traffic lights. The general layout of the measurement includes Spectrum Analyzer, GPS and Laptop. There is one transmitter located on the top of the pool during the entire measurements, including both lines-of- sight (LOS) and NLOS cases due to the equipment provided. However, all the results reported in this thesis are mainly considered the LOS case, where NLOS only considers for a few comparisons. Figure 3.5 shows a flowchart for measurement processes describing the sequence of steps passed by PC and hardware before measurement.

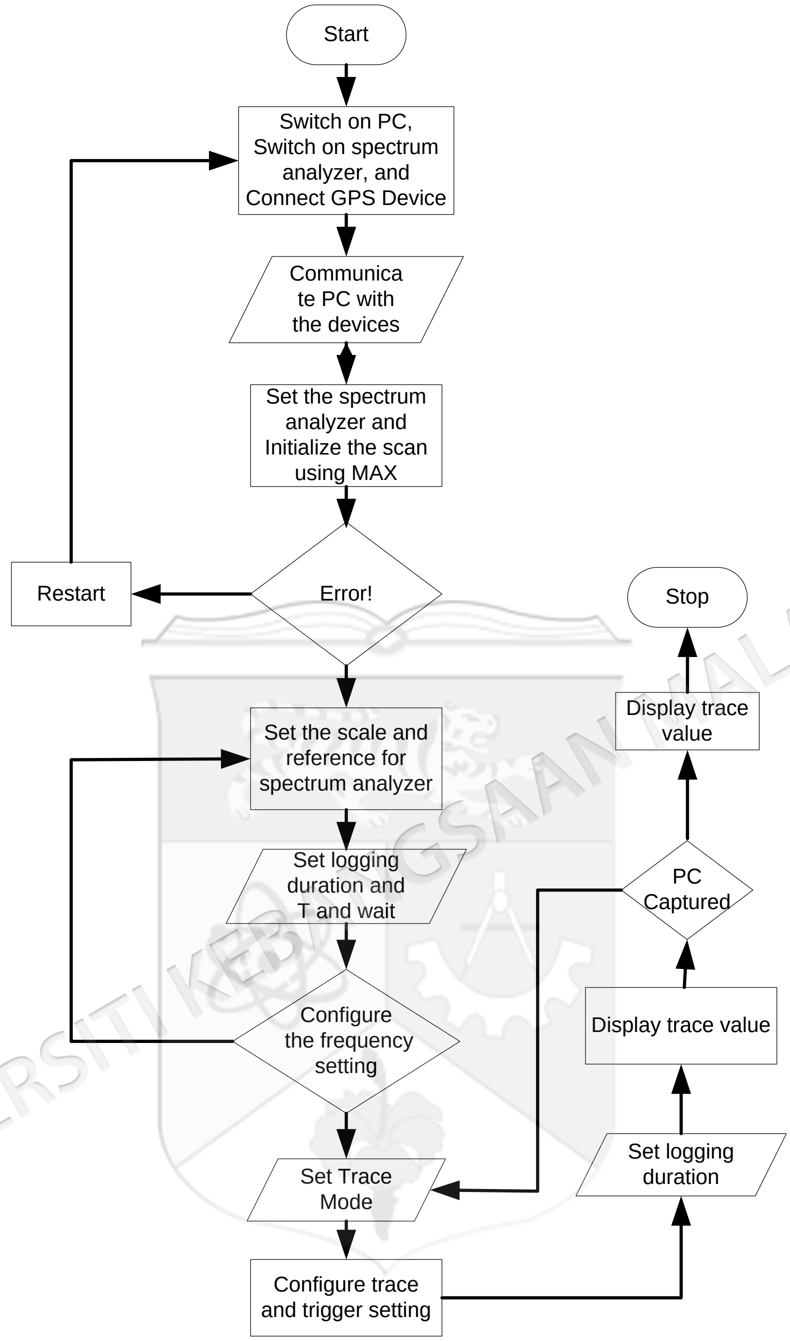


Figure 3.5 Measurement setup

The measurement equipment consists of the transmitter. Antenna received signal monitored in the spectrum analyzer, GPS receiver and Laptop as shown in Figure 3.6. The test-bed used to accumulate the data presented in this thesis was created using commercially available communications equipment.

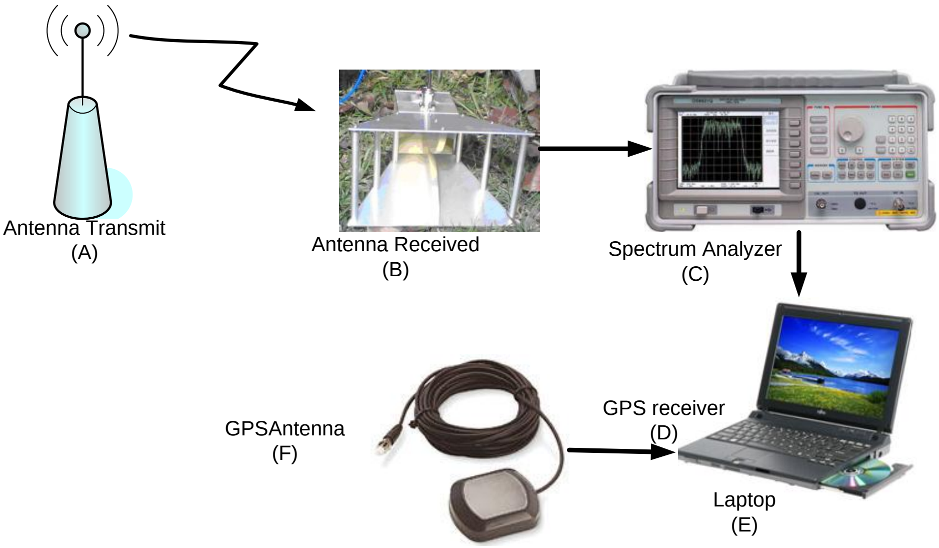


Figure 3.6 Radio Test Kit - 5.8 GHz Antenna Transmitter (A), 5.8 GHz Receiver (B) Spectrum Analyzer (C), GPS Receiver (D), Laptop Computer (E) GPS Antenna (F)

3.4.3 Communication Link Test

The communication link test describes the methodology for measuring path loss and environmental effect. Definitions of path loss and environmental effect as well as descriptions of measurement procedures, sites, and hardware are included.

Each of the three areas measured were located in the area of Bandar Baru Bangi, and represented typical area condition as urban or rural residences. For each area, we recorded a variety of construction and site information that could affect the propagation of radio waves. The link test list the area studied and contain brief descriptions of their construction, location, and layout.

3.4.4 Antenna Specification

Since antennas play a critical role in communications, they will be considered as well. There are several shapes of antenna available for transmitting microwaves. Telecommunication systems almost always use the parabolic type and sometimes the horn type (Gibilisco et al. 2001).

The Atlas Series antenna used in the system provides excellent performance and value as a high-capacity solution for Initiative and urban connect through point-to-point OFDM Wireless. This antenna is accomplished of sustained throughput of 45 Mbps with outstanding features including Dynamic Frequency Selection (DFS) and Adaptable Rate Modulation (ARM). The characteristics of the antenna afford the standard installation conditions as given in Table 3.1.

Table 3.1 RX and TX atlas series specification

No.	Parameter	Specification
1	Frequency of operation	5250-5350 MHz and 5470-5725 MHz (U-NII Bands), and 5725-5875 MHz (ISM Band)
2	Radio Dimensions	15" × 15" (ATLAS5010-INT with integrated Patch Panel Antenna). 7" × 7" (ATLAS5010-EXT stand-alone radio)
3	Channels	23 non-overlapping, user changeable
4	Channel Spacing	20 MHz
5	RF Power Output (ISM Band)	+21 dBm Max Setting (6 Mbps mode) +17 dBm Max Setting (54 Mbps mode)
6	Modulation Format	OFDM
7	Temperature Range	-40 °to 60 °C (-40 °to 140 °F); Temperature measurement via Telnet, SNMP, HTTP
8	Polarization	Integrated 23 dBi 9 °X 9 °patch dual-polarized (HPOL/VPOL), Electrically selectable polarization.

These antennas are highly directional. The microwave energy is focused into a very narrow beam of the transmitting antenna and aimed at the receiving antenna. It concentrates the received power by a mechanism analogous to the telescope, by placing the microwave guide opening at the focus of the parabola (Javier 2010).

Figure 3.7 Transmitter assembly

The measurements, simply placing a transmitter onto the fixed point as shown in Figure 3.7 and detecting the transmitted signal at some distance away via a spectrum analyzer connecting to GPS device to allow useful measurement of the signal strength and power spectral density of the antenna properties. The radio frequency of the transmitter was set to 5.8 GHz (unlicensed band) due to the proposal defined by the project members to be accumulated in BBB. Field signal strength and power spectral density measurement were recorded for one antenna site during consecutive days during all conditions, such as rain, humidity and normal time without propagation impairment.

The signal collected means that an amount can be sampled in certain distance and the geography between the transmitter and receiver (Yusnita et al. 2003). The power law affects it due to the power loss of an electromagnetic wave traveling through free space in a line of the sight path from the transmitter to the receiver (Hansen et al. 1996). Figure 3.8(a) and 3.8(b) shown the antenna connected to Spectrum analyzer. Figure 3.8 (C) shows the spectrum analyzer device.

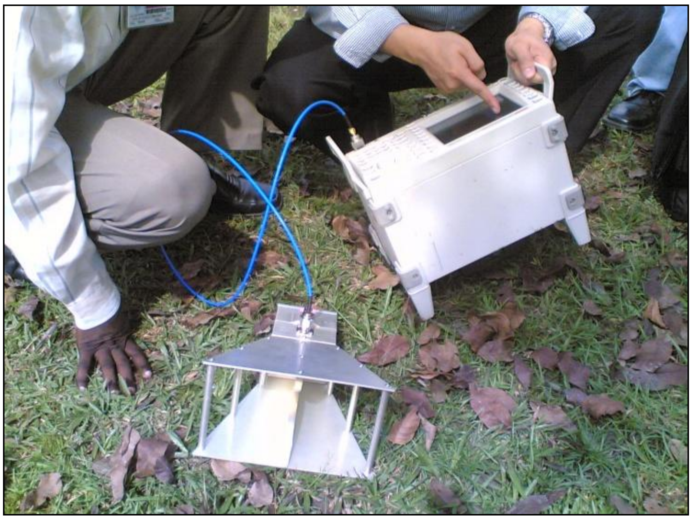


Figure 3.8(a) Antenna kit and spectrum analyzer collaboration

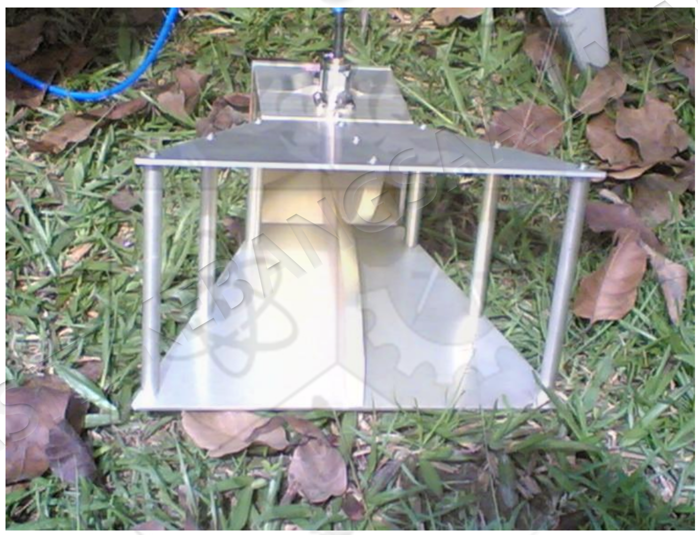


Figure 3.8(b) Antenna associated with the spectrum analyzer

Figure 3.8(C) Spectrum analyzer

3.4.5 GPS Receiver

MMCX GPS Antenna Aerial for Receiver Garmin Holux/Magnetic mount GPS antenna used to define the exact location in the area, which has a magnetic base and water resistant, allows the outside paint work on the top of the car without any screw or glue. GPS antenna MMCX does not need any extra power, which uses power from the antenna socket on the GPS device. Figure 3.9 shows the GPS MMCX antenna, used to measure the location of the signal strength.

Figure 3.9 MMCX GPS Antenna

3.5 FREQUENCY SELECTION

Governments as a rule regulate the use of the radio spectrum through distribution for different applications. Although the frequency bands which are licensed to particular parties, some bands are unlicensed so that anybody can use it, on the condition that users monitor with any required regulations (such as those restricting the transmitter power). Examples include the ISM (industrial, scientific and medical) bands, for which standards such as IEEE 802.11b/a/g (O'Hara et al. 2005) have been established.

It is highly attractive to have a direct link in an unlicensed band, removing the need for spectrum license cost. 5.8 GHz is the lowest frequency that fulfills the requirements of bandwidth availability and yet is not overused by other services in Bandar Baru Bangi. 5.8 GHz regulations also agree to sufficient link budget to diffract around large obstacles (Cheffena & Ekman 2009). However, due to the growing number of requirements, it is predictable that the unlicensed ISM bands will soon be crowded, particularly in high user-density areas. Finally, interfering challenging for spectrum will become the preventive factor to growth. In order to convince the requirement of high performance wireless systems, approach for the effective frequency function to be integrated into the planning procedure.

3.6 DATA TRANSMISSION AND LOGED

The traffic light data transmissions are most often achieved from the fixed antenna installed at major traffic junctions through WLAN. Therefore, typical parameters are traffic flow and accident detection. Additional data such as occupancy rate and waiting times can also be collected.

Data's transmission identifies some relevant sources providing real-time traffic data (daily, hourly or even per minute data) which are generally made available in the control room traffic center. Most of the data predictable are available, and most of the time provided to access.

The data collected in this thesis were characterized in urban environments (BBB), each data set represents approximately 3 hours of holding time. The means of communication test-kits were set of connections for broadcast transmission and a single transmission can be received by N-I receivers, where N was the number of transmitters involved in the test lope. The packet transmission rate was five times per second and it was equal to the rate at which the GPS receiver can update the location and heading data.

The computer in the test kit logs the GPS and transmitted data contained in the header of the received packets. The logged value assessment the transmitted signal strength field for each received packet is replaced by the measured received signal strength indicator (RSSI). Moreover, the packet received and the distance from the transmitting antenna to the receiver at which the data is logged is integrated in the data record. The uniqueness of the transmitting antenna are specified by the transmitter (IP address) identity field. The location and heading data of all packets represented by signal strength is that, the transmitter from which the packets were transmitted therefore, when the data is processed, the location and heading data of the received packets must be interpolated from the nearest antenna transmitted packet data entries in the record of that particular transmitter.

3.6.1 Data Collection and Analysis

Radio communication contains two or more devices adjusted to the same frequency to operate at 5.8 GHz. The first device acts as the transmitter while the second act as the receiver. Radio frequency began with an oscillating signal of a constant frequency transmitted from the traffic junction to the receiver mounted in the control room.

Each antenna fixed on the pole is connected with the traffic light as shown in Figure 3.10. Before any data is collected from the site, the equipment is calibrated. Then, a directional antenna is placed at a distance of 1 to 5 km from the pole mounted at the traffic junction beside Warta complex. The transmitter, located in the clear area to simulate a clear line of site condition, utility pole, has a height of 7 to 30 m.

Figure 3.10 Transmitter is mounted on a 30 foot tower in the traffic light near Equatorial Hotel

Outdoor path loss measurements are then made around the front sides of the pole, first using a receiver antenna height of 1.5m above ground connected to the spectrum analyzer and then using a receiver antenna height of 3m. 70 local-area measurements were recorded along the front of each pole. Each local-area path loss measurement is calculated. Figure 3.11 shows the detected signal of intensity measurements made at the specific point to get the SS and PSD within the data measured. The size of the region sampled by a measurement depends on the terrain and other objects, the separation of the transmitter and detector, and the environment properties of the site selection.

The equipment (test-bed) at the receiver site was a spectrum analyzer associated with external antenna, computer and GPS device. The signal strength and power spectral density were collected in urban environments using spectrum analyzer as shown in the Table B.2 (Rappaport 2002).

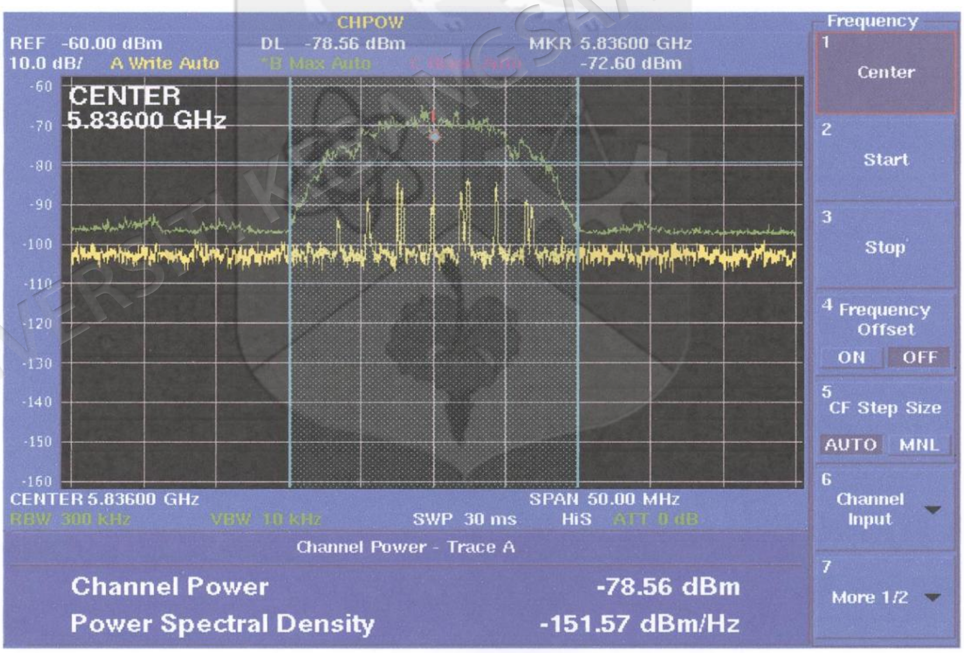


Figure 3.11 Output of the spectrum analyzer

After the first round of outdoor measurements, indoor path loss measurements are made using a receiver with a 1.5m antenna height (average head level). Each path loss measurement is a narrowband power signal averaged over a random track on the second floor due to open space in the specific building. A SS and PSD average is recorded for every place on the second floor. Then the transmitter is moved to a distance of 150-210m from the floor, and the sequence of indoor measurements is repeated. The reason for indoor measurement is to define the effect of reflection and signal absorption from the wall.

3.6.2 Motivation for Received Signal Strength Measurement

It is important to understand the propagation characteristics for a proposed WLAN before the link deployment. One of the important reasons of this is to predict how far a signal can go before installation will confirm that a connection cannot be made in areas where it is not wanted. Iskander & Yun (2002) explained in their paper that the strength, coverage area and range of the transmitter is strongly affected by its positioning in reference to its environment.

Outdoor measurements were carried out with the transmitter and receiver at several traffic light points, since this is the kind of environment were fixed point to point or multipoint receivers are expected to operate. Transmitter and receiver direction antennas were pointed to each other, as will be usually done under actual operation conditions of directional antenna. Very small multi-path components were found in this set of measurements. Apart from the direct component, just two other contributions with small excess delay and low power are present. These components are due to propagation paths generated by reflections on the building walls and/or roofs near the receiver location.

The reason of this measurement is to allow installers of wireless LANs to easily predict the network performance of Line-Of-Sight intelligent traffic light management system. If network performance models are to be based on measurements, then it is very important that it be simple to measure the needed values, such as signal strength and power spectrum density. Therefore, received signal strength indicator using a calibrated spectrum analyzer measured in dB for 5.8 Ghz.

3.7 PROPAGATION MODEL BASED MEASUREMENT

In the urban area of BBB where LOS is used to transfer information, the propagation impairment between the transmitter and receiver has a main influence on the quality of the transferred signal (Bertoni 2000). Buildings are the main source of attenuation but vegetation elements such as trees (Schwengler & Pendharkar 2005, Torrico & Lang 2007) and large bushes can also have some reducing effects, on the propagated radio signal (Greg et al. 1997).

In propagation analysis, the path loss exponent n that minimizes the standard deviation is useful for gaining quick insight into the general propagation (Schwengler et al. 2008). These methods often lead to large, unacceptable standard deviations for prediction at specific locations (Dimitriou & Seriadis 2007). To decrease the standard deviation for a prediction and extract useful propagation information about the site, a more comprehensive propagation model is needed (Devasirvatham 1994; Murch et al. 1995). Specifically, this part explores partition-based models, which lend themselves to efficient computer implementation with relatively little site information (Skidomore et al. 1996). Originally, these models were applied strictly to indoor path loss prediction, partly due to the availability of computer-generated floor plans (Ghahramani & Bonek 1994; Panjawani et al. 1996).

The development of the propagation model based measurement on adding factor to log-distance model due to the topographical area analysis and presents a method for calculating the optimal attenuation values. Referring to the frequency 5.85 GHz, residential path loss measurements show how partition-based models can be applied to outdoor and indoor propagation (Schwengler & Gilber 2000).

There are two basic approaches to design a link planning location. Manual deployment using site survey or by planning using signal propagation models (Mikas et al. 2003). Many studies have publicized that penetration loss depends on the properties of the materials in the propagation medium (Muqaibel et al. 2005; Sarkar et al. 2003). A lot of effort has been done on the prediction of radio signal propagation. While the concept is the similar, many different methods have been proposed by researchers. Various mathematical radio propagation models have been developed which accurately predict the potential propagation of signals within an environment (Durgin et al. 1998; Iskander & Yun 2002; Mikas et al. 2003; Garg 2007). Basically the main approach to modelling radio networks exist, the Empirical method is mostly the deterministic method.

To study the Log-distance path loss model of propagation estimation, measurements was taken the field without any interference from other transmitting signals using the free space principle. Subsequently the signal strength (SS) is measured in dBs which is a log scale the graph shown in the Figure 3.12 has been plotted in contradiction of the log of the distance. A straight line has been fitted to these results and the equation has been displayed in the figure.

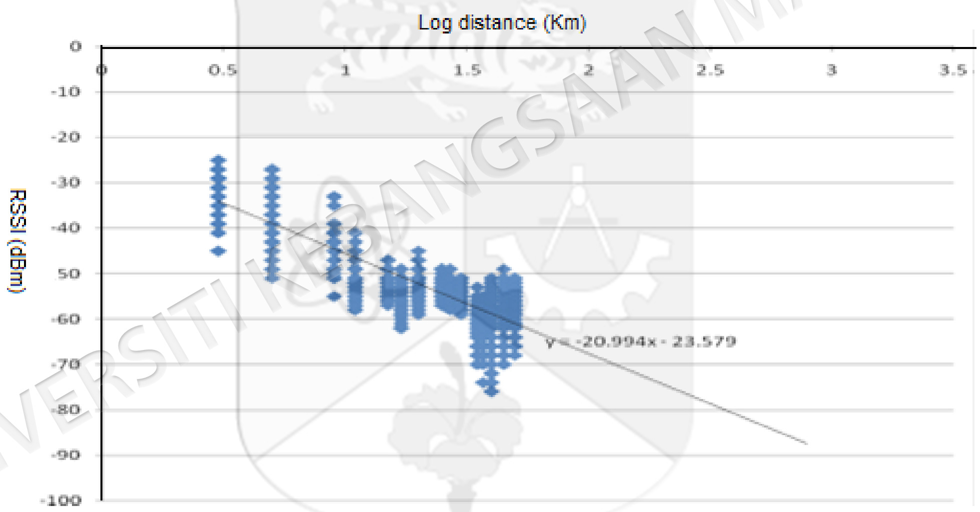


Figure 3.12 Received signal strength vs distance

3.8 MODELING AND SOFTWARE PLANNING TOOLS

The work involves the design of software development for the WLAN propagation model. The architecture of the software in terms of a flow chart is shown in Figure 3.12. The flow of the chart uses a conditioning module for main input and output simulation. A MATLAB-GUI running simulation with data collected from the field measurement as input.

This part gives a brief description of software planning tools (SPT), assuming some basic familiarity with logic programming.

The general information allocated in SPT in the main window as shown in Figure 3.13, is represents all sorts of classes and interface criteria, including start menu, information menu, simulation, calculation and help initializes. An SPT program is a set of definitions of names logical predicates. Execution begins by selecting a predicate to execute as a goal. As in predicate, names start with a lower-case multifaceted, while variables and parameters with a setup the all parameters. Identifiers may contain imported data or an underscore.

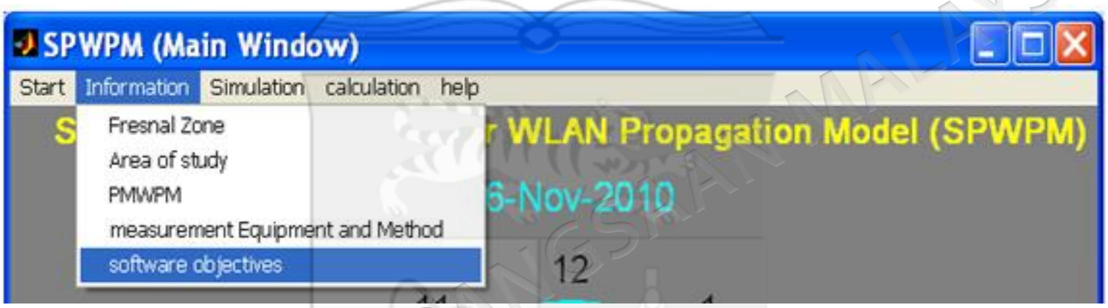


Figure 3.13 Main windows of SPT

Additionally, the final parameters of an identifier function are constant due to the measurement's results. Many function keywords are easy patterns in SPT, carrying essential procedure.

The objective of this Software is to develop tools to automate system-intensive and time consuming processes by implementing an electronic solution to the following:

1. Presenting the Area of study
2. 2D and 3D ray tracing representing applications for a great idea and simplicity of visual understanding.
3. Computation of the line- of- sight (LOS) distance based on obstruction’s peak elevation and distance from the study site.

4. Plotting of the line-of-sight (LOS) ranging diagram with relevant parameters related to the study site.
5. Able to determine the height of Tx and Rx based on the given digital terrain model via ray tracing tools.
6. Inclusion of fixed Fresnel zones to the line-of-sight (LOS) distances to better assess the link.
7. Ability to calculate the system operating margin
8. Link planner desiring to design and plan the Physical Area of the Case Study

Therefore start with a discussion of the different environmental aspects related to the link integration between the traffic lights:

1. Topographical case, such as hills
2. Building and other man-made objects
3. Environmental factors, such as temperature, humidity, pressure, etc
4. The earth curvature
5. Trees

The selected area specifies the link analysis, where the study of an Intelligent Traffic Light proposed through various environmental factors affects the link capability for different infrastructure deployment strategies.

3.9 SUMMARY

A method for thesis plan consideration such as measurement condition, Propagation Modeling, Frequency Selection and Software planning tools have been presented. Fixed antennas installed in the traffic junctions with the geographical information available in the area of BBB were clearly conducted. Propagation impairment characterized as a factor elements that are very specific to the location. A case study of a single frequency network (5.8 GHz) of digital video conference broadcasting (DVB-T) at University Tenaga Nationals (UNITEN) in which has a relatively flat terrain and crowded of trees involved in the measurement condition. The software architecture clarifies the structure of the system in terms of component and interaction among them to accomplish the desired requirements.

CHAPTER IV

PROPAGATION MODELLING AT 5.8 GHZ

4.1 INTRODUCTION

Before realizing any designs and verify planning of wireless communication systems, accurate propagation analysis of the environment should be known. Data collection has been obtained, and presentation measurement issues were presented. The key problem is that, to consider a well link optimization such as Line-of-sight for intelligent traffic light management systems, accurate information about the performance of the planning is needed. The reason for this is that by collecting the signal strength and power spectrum density between a point to point or point to multi points, as accurate information about the link disturbance of the link between points can be known. If the measurement is fully achieved, the performance of that link can be accurately determined.

Received signal strength (RSS) is a measurement of the power present in a received radio signal. RSS-based localization is an attractive research topic where many researchers have proposed techniques by using existing infrastructure to deploy a positioning system such as IEEE 802.11b, wireless LAN (Kaemarungi & Krishnamurthy 2004; Bahl & Padmanabhan 2000; Prasithsangaree et al. 2002; Takizawa 2008). However, when the LOS considered in the certain location, area, antenna setup and signal strength collection will be difficult, due to the sensitivity of the link planning. An empirical model is often defined as the science of collecting, summarizing, and analyzing data. In this chapter, we do have a summarization data aspect, the reduction of large amounts of data into a single number or set of numbers.

A statistic that summarizes an entire dataset without losing any information about the family of distributions or the model is often called a sufficient statistic (Cheng 2005). For these reasons we considered to use the statistic that provides the most information about the model.

The measurement consists of taking a sample and forming a statistic based on the sample of data. Indeed, this method can be applied where many of the existing models often fail to be useful. The signal attenuation and power spectral density vs. distance between transmitter and receiver provides a different perspective for data presented is intended for different propagation impairments, especially in LOS condition.

4.2 SIGNAL STRENGTH AND PATH LOSS ANALYSIS

This part presents a detailed account of the signal strength measurement that includes motivations for working at 5.8 GHz, experimental methodology, descriptions of measured sites. Block diagrams of the measurement hardware, and qualitative trends in the measured data. An engineer with little experience in radio frequency hardware and measurements would find this chapter useful as a reference, since it discusses fundamental concepts in experimental design for site selection path loss measurements.

The measurements are used to develop empirical path loss models and saturation loss models for outdoor transmitter antenna height decision, several different transceiver (TR) split-up distances and a selection of residential area has been considered.

4.2.1 Description of Measurement Sites

The work presented here determines three essential propagation parameters:

a) Indoor measurements

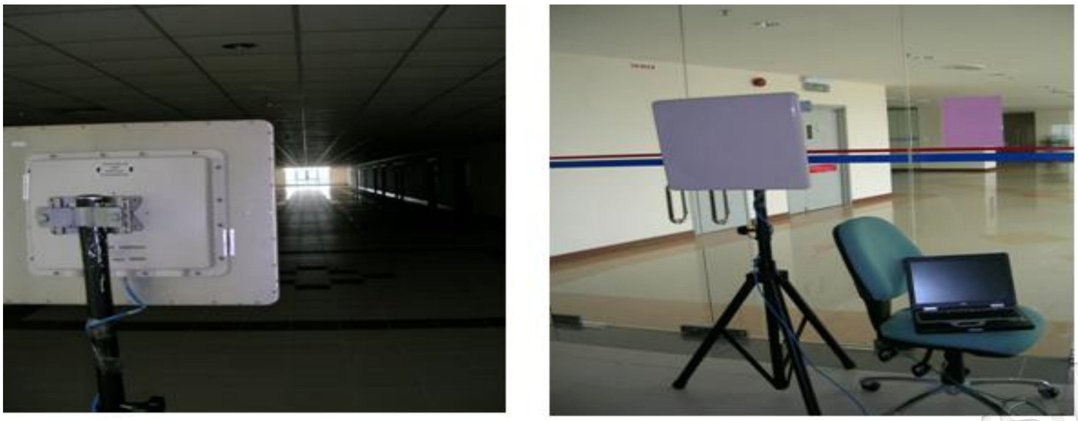
b) Path loss from outdoor base stations to external receiver connected spectrum analyzer in various locations around Bandar Baru Bangi in urban areas.
c) Typical diffusion loss from outdoor base stations in IT College, University Tenaga National as shown in Figure 4.1.
d) Path loss due to area of decision with congested trees.

Figure 4.1 College information technology building (UNITEN). The green arrow circle indicates the location of the transmitting antenna.

4.2.2 Outdoor to Indoor Measurement Prediction

The radio signals scatter in the indoor wireless environment via a few propagation behaviors initiated the wireless condition and require important background information to support the review of outdoor environmental adjustment.

This part focused on the environmental restrictions in single-floor at the buildings' hall (as shown in Figure 4.2). The particular command of the radio propagation in the hall environments is observed and the factors affecting the radio propagation such as wall materials are also measured. To show the received signal variations in an indoor environment, a measurement was conducted in the hall at 5.8 GHz. In this experiment, the transmitting antenna was fixed at the end of the hall (as shown in Figure. 4.2 -A), while the receiving antenna was moved along the hall. The variations of the received signals are shown in Figure. 4.2-B.



(A) (B)

Figure 4.2 The hall in single-floor indoor environment showing location of the transmitting and receiving antennas: (A) transmitter (B) receiver connected to a personal computer for signal record.

The difference of the received signals due to multiple copies of the radio signals arriving through different paths was discussed in Figure 4.4.

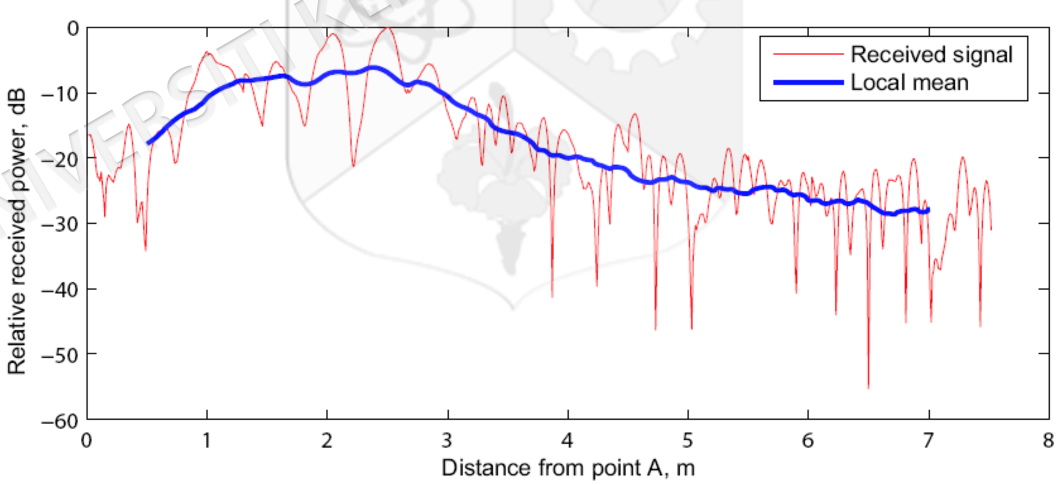


Figure 4.3 Received signal strength in an indoor environment.

The purpose for indoor measurement is to characterize the effect of the received signal strength due to scattered signal and performance limitation to constrain the well plan condition as determined by the slope shown in Figure 4.3. It is clearly indicated that the majority of the measured signal strength in different points was logged in the same range of distances over which the average signal attenuation data points appear.

4.2.3 Description of Path Loss

The path loss is manipulated by terrain contours, environment (urban or rural), propagation medium, the distance between the transmitter and the receiver, and the height and location of antennas.

To measure path loss, the experiment relies on the measurement of a continuous wave (CW) signal at 5.8 GHz. Received power fluctuates over a small area due to multipath-induced fading. However, averaging power along a 20λ rack (about 1m for 5.850 GHz) yields a reliable estimate of the local average power independent of signal bandwidth (Rappaport 1996). The average power *Pi* at the *i*th location is given by

$$Pi = \frac{1}{20\lambda}\int_{0}^{20\lambda} p(x)dx \tag{4.1}$$

Where *P(x)* is the absolute CW power (in watts) received along the local-area track as a function of position. A summation replaces the integral in Equation (4.1) if discrete power data points are taken. Path loss (*PL*) is defined as the ratio of the effective transmitted power to the received power, calibrating out system losses, and antenna gains. All reported path loss values are relative to free space path loss at 1m TR separation. Path loss with respect to 1m free space provides an easy reference for general link budget computations, as given by Equation (4.2):

$$\left[\mathrm{Pr} = Pt + Gt + Gr - [pathloss - w.r.t - 1mFS] + 20\log_{10}\left(\frac{\lambda}{4\pi}\right)\right] \tag{4.2}$$

Where

P_r and P_t are a receiver and transmitter powers in dBm (Rappaport 1996).

G_r Transmitter and receiver antenna gains in dB

G_t Receiver antenna gains in dB

$\boldsymbol{\lambda}$ is the wavelength (0.05m at 5.85 GHz

4.3 OUTDOOR PATH LOSS

Outdoor path loss present the first stage of the process which is the selection of one or more famous kind of trees. Fortunately, this has been aided by work previously undertaken (Durgin & Rappaport 1998). This Study of the tree's effect was carried out to assess their timber and wood-fuel properties when grown at wide spacing as in the area of the implementation of the intelligent traffic, light management system.

Initial tree-planting density as shown in Figure 4.4 had significant effects due to the previous study; we investigated the variability of tree heights, wood density and analyzed the influence of climatic variables on these parameters to the signal.

Figure 4.4 Initial tree densities

Deciduous trees, such as beaches, can be effective shadowy at 5.85 GHz. The wavelength at 5.85 GHz is 5 cm (less than the largest dimension of most leaves) (Greg and Rappaport 1998). Tree shadowing becomes critical in the Area of Bandar Baru Bangi, where the site-plan aimed to operate in. The tree is taller and concentrated at the rooftop level of the buildings. In many cases, it is easier to propagate below the coverage to ground level receivers. This behavior suggests that deciduous trees appear to be floating a lot and typically introduce 10 to 13 dB of loss in excess of free space path loss (Durginn and Rappaport 1998).

Thick stands of trees in Bandar Baru Bangi, such as pines, attenuate a propagating radio wave at 5.8 GHz every bit as much as their deciduous counterparts. Unless intentionally pruned, pine trees grow much thicker at the base than leaf-bearing trees. The measurement results show comparable loss in excess of free space at all receiver heights with typical values ranging from 11 to 16 dB.

The crowded stand of trees exhibited an attenuation of 14.3 dB at a height of 5 m and an attenuation of 8.5 dB at a height of 2.5 m. The deciduous stand of trees showed an attenuation of 12.8 dB at a height of 5.5 m and an attenuation of 4.4 dB at 1.5 m. Attenuation was calculated as the loss in received signal power when moving from the front to the back of the tree line, in addition to the free space path loss. It is computed from averaged path loss values on each side of the tree line. The stands of trees can be treated as partitions of attenuation, which can be applied to many of the partitions- based models outlined in later sections. It's hard to talk about measuring any data because it means different reading to different people.

The methodology described as follows. First, measuring the signal strength level transmitted by the antenna as captured in Figure 4.5. The equipment for capturing spectrum is a spectrum analyzer from 100 kHz to 6 GHz.

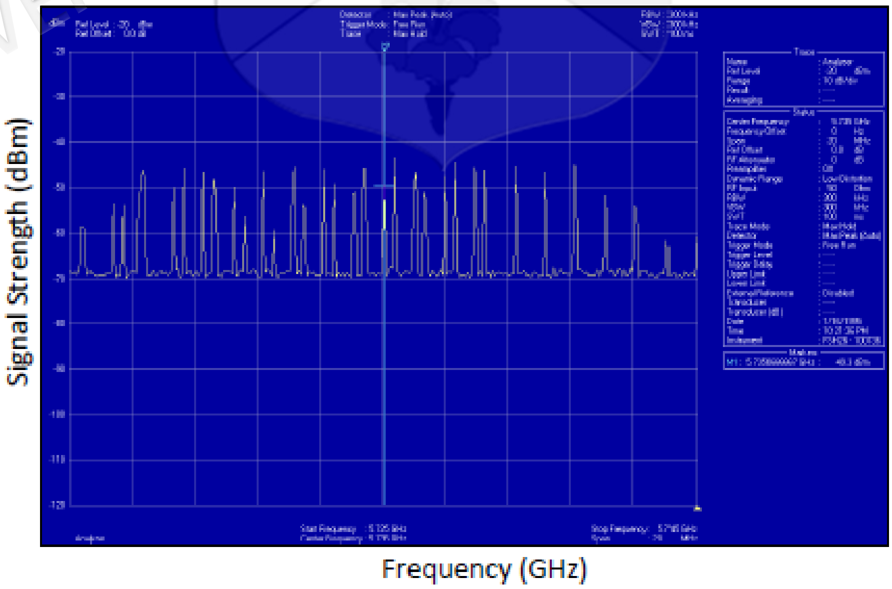


Figure 4.5 Signal strength snapshot using the spectrum analyzer

Figure 4.5 shows a snapshot of the signal strength (SS) and the corresponding power spectral density (PSD) for point to point link optimization. This figure gives a detail about the signal strength at break point. By means of no line of sight.

4.4 MEASUREMENTS RESULT

Data's justification has been traditionally used to capture and correct mistakes by the user and improve their usability skill. Validation checks play the role of a filter on user input, helping users enter valid and correct information (Shawna 1997). The purpose of data validation is to ensure that the data is strongly sorted and correct structure within length limitations.

To fulfill the objective of this study, statistical data analyses were conducted to determine the suitability of the model to the predicted signal strength characteristics in the area satisfactorily. Data collected during measurements must be validated before more extensive analysis can be conducted on the situation referring to verification that the measurement and data collection were stated as desired. Statistical parameters are used to evaluate and compared to log distance model. Consequently, the quality of the fitted models was measured. Ten of these parameters can be described as follows:

4.4.1 Coefficient of Determination (R^2)

This is equivalent to the ratio of the regression sum of squares (SSR) to the total sum of squares (SST), which explains the proportion of difference accounted for signal strength in the dependent variable by the model. It evaluates how well the model fits the data. Various authors (Walden et al. 2005; Tulsa 2003) used R^2 to evaluate the data analysis. The regression sum of squares (SSR) and the total sum of squares (SST) can be calculated from the following formulae:
Regression sum of squares:

$$SSR = \sum_{i=1}^{N}\left(\hat{Y}_i - \bar{Y}\right)^2 \tag{4.3}$$

The total sum of squares:

$$SST = \sum_{i=1}^{N}\left(Y_i - \bar{Y}\right)^2 \tag{4.4}$$

Subsequently, the coefficient of determination (R2) can be calculated as:

$$R^2 = \frac{SSR}{SST} = 1 - \frac{SSR}{SST} \tag{4.5}$$

Where, $\bar{Y}$, $\hat{Y}$, N and Y_1 is the average value of $Y_i(SS)$, estimated value of $Y_i(SS)$, number of data points (observations), and experimental data (PSD) were collected from UNITEN area. The transmitter fixed at Warta traffic light junction pole.

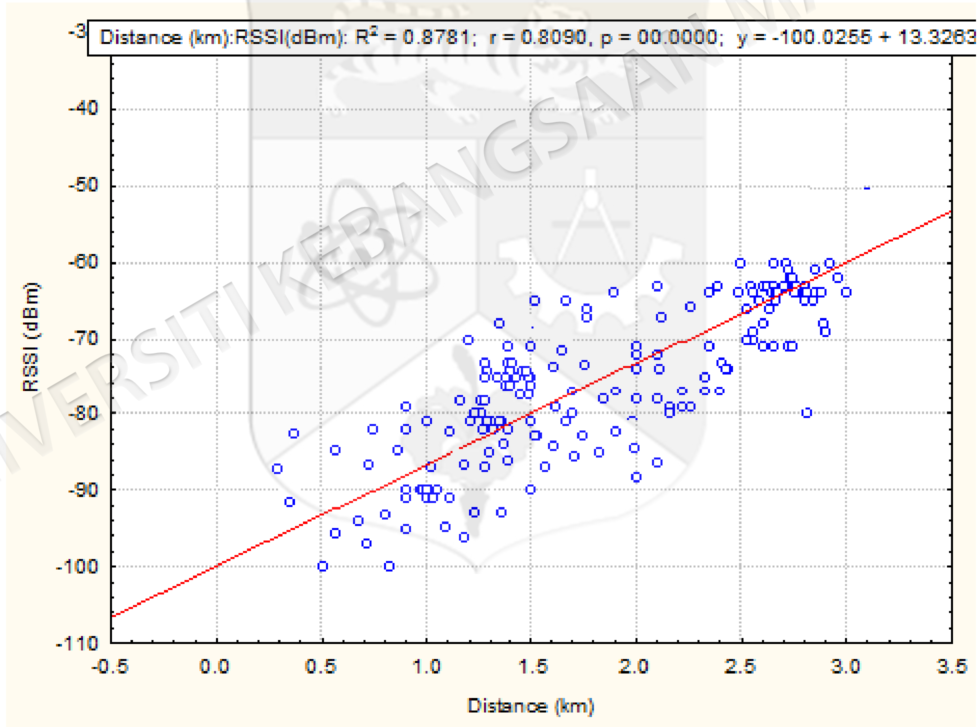


Figure 4.6 Signal strength vs distance for LOS

Figure 4.6 Compute the best mean estimated data of the signal strength content from this sample during morning time, its 91% confidence of a coefficient of determination, and the probability of the link estimation is quite a success.

4.4.2 Adjusted- R^2 (AR^2)

This statistic is interpreted similarly to the R^2 value, except it takes into consideration the number of data of freedom as shown in Figure 4.7. It is adjusted by dividing the error sum of squares and total sums of square by their respective data of freedom (Keller 2001; Peck et al. 2004; Spatz 2001; Vardeman & Jobe 2001):

$$AR^2 = 1 - \frac{SSE/(df_{error})}{SST/(df_{total})} \tag{4.6}$$

Where, *df* is the number of data of freedom and *n* is the unknown parameters. Navidi (2006) calculated AR^2 using the following formula:

$$AR^2 = R^2 - \frac{n}{N - np - 1}(1 - R^2) \tag{4.7}$$

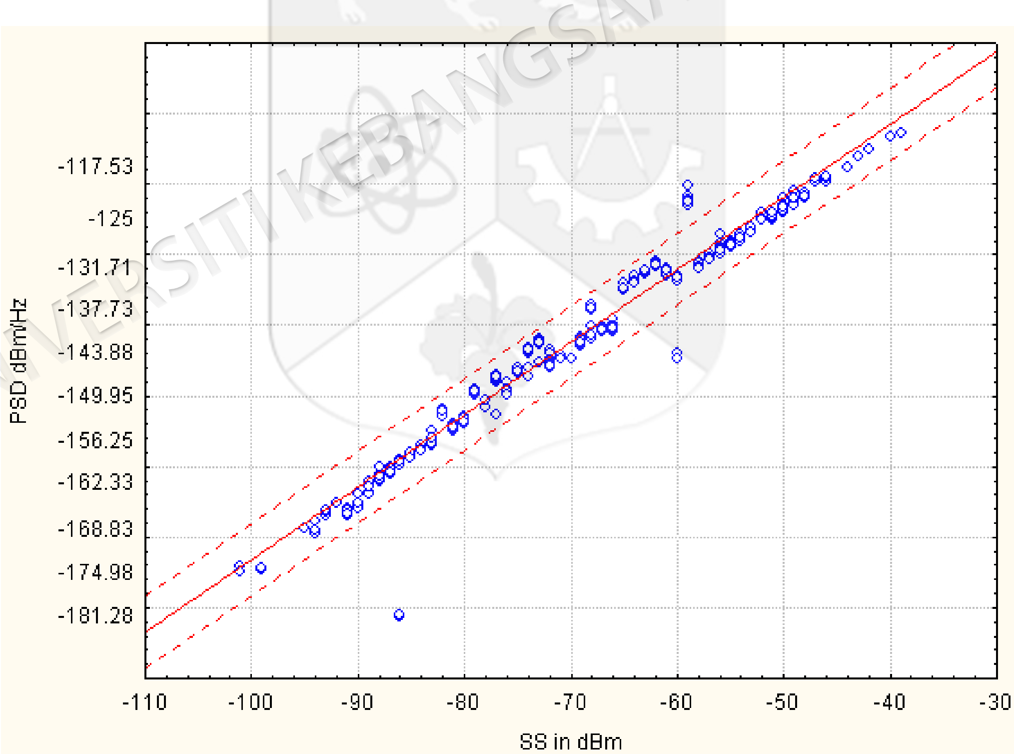


Figure 4.7 Adjusted R^2 for SS and PSD

4.4.3 Error (Residual) Sum of Squares (SSE)

This is the most commonly used to calculate the error indicator in statistical fitting procedures (Robert 2006; Jarque & Bera 1987). It can be given as:

$$SSE = \sum_{D=1}^{N} \left(PM_{\exp,D,} PM_{cal,D} \right)^2 \tag{4.8}$$

Where, $PM_{\exp,D,}$ is measurable value and is $PM_{cal,D}$ Calculated value.

Given an observable in Figure 4.8 and Figure 4.9 was asset value that related to the independent variable to the dependent variable. The deviations of the dependent variable observations from these values are the errors. The regression on some signal strength is deviated on the dependent variable observations from fitted residual's values. However, because of the propagation impairment, the regression processes were distributed on the residual value at different data points varied due to the errors themselves was identically distributed.

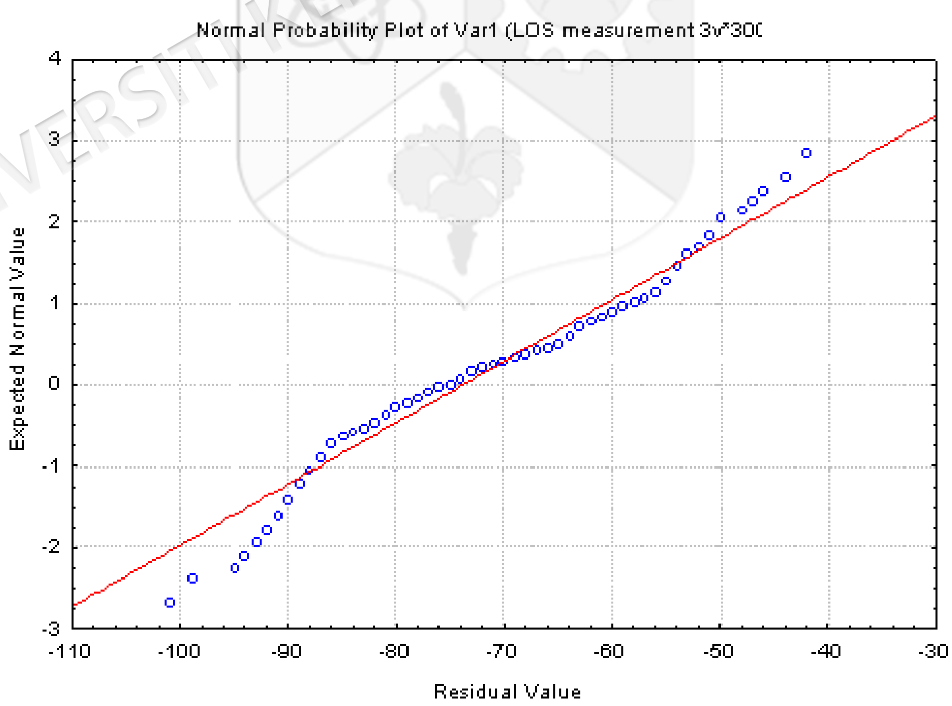


Figure 4.8 Error (Residual) sum of squares for LOS

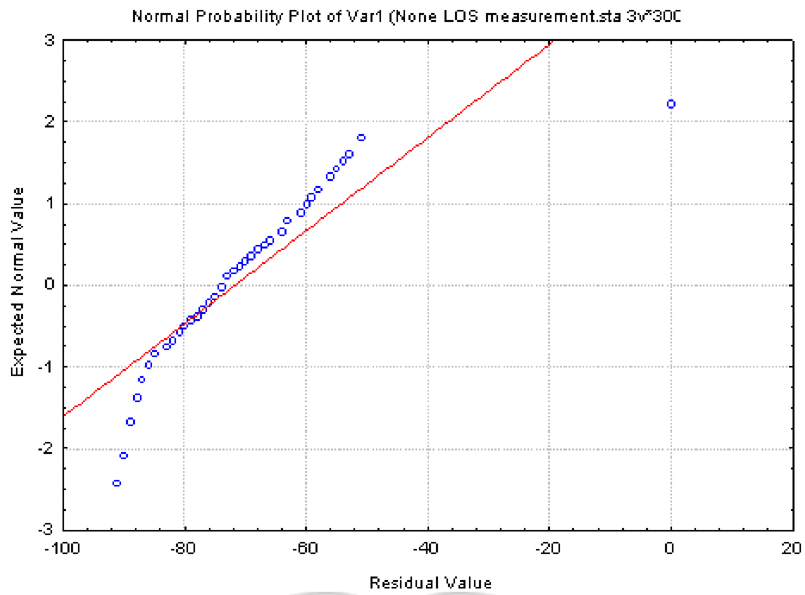


Figure 4.9 Error (Residual) sum of squares for none-LOS

4.4.4 Reduced Sum Square Error (RSSE)

This is the sum of squared differences between experimental and predicted values, adjusted by the total data of freedom (StatSoft 2003.; Durbin & Watson 1951). It can be calculated as:

$$RSSE = \frac{\sum_{D=1}^{N} \left(PM_{\exp,D} PM_{cal,D}\right)^2}{N} \tag{4.9}$$

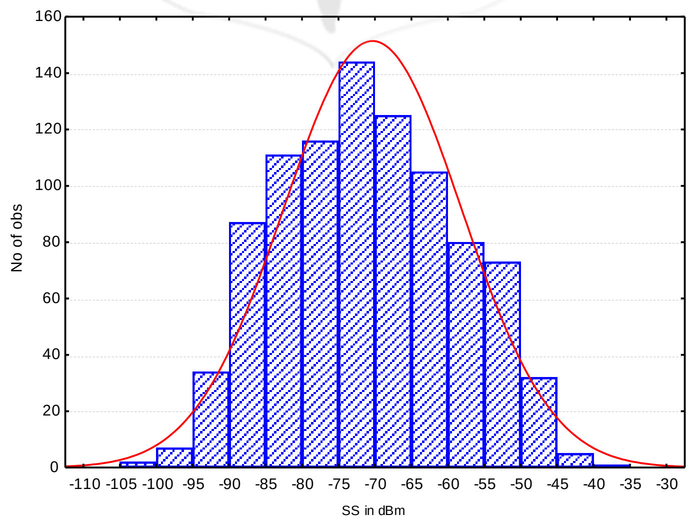


Figure 4.10 Reduced sum square errors for LOS

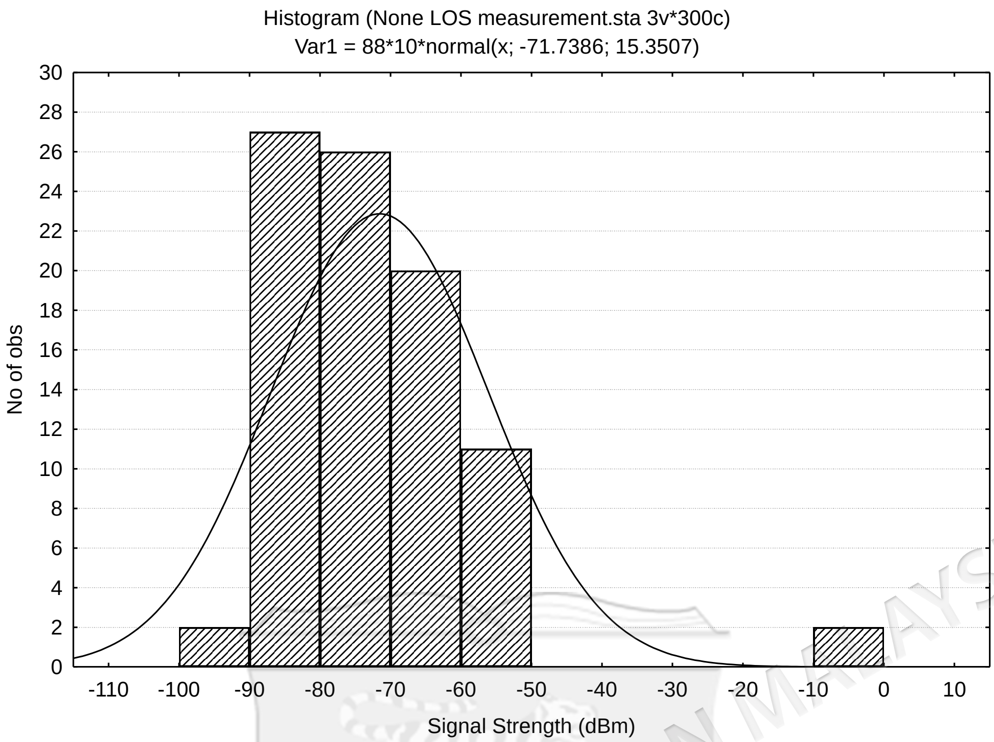


Figure 4.11 Reduced sum square errors for NLOS

A bar graph in Figure 4.10 and Figure 4.11 displays discrete signal strength for LOS and NLOS cases in separate columns with number of observed values. The data categorized are considered unordered and rearranged by the mean value.

4.4.5 Mean Standard Deviation (SD)

This is the mean standard deviation between experimental and calculated values (Ghahramani 2000; Dodge 2003), which is based on relative errors and accounts for data with different orders of magnitude. It can be calculated as:

$$SD = \frac{1}{N}\left[\frac{\sum_{D=1}^{N}\left(PM_{\exp,D}PM_{cal,D}\right)}{MP_{\exp,D}}\right]\times 100 \qquad (4.10)$$

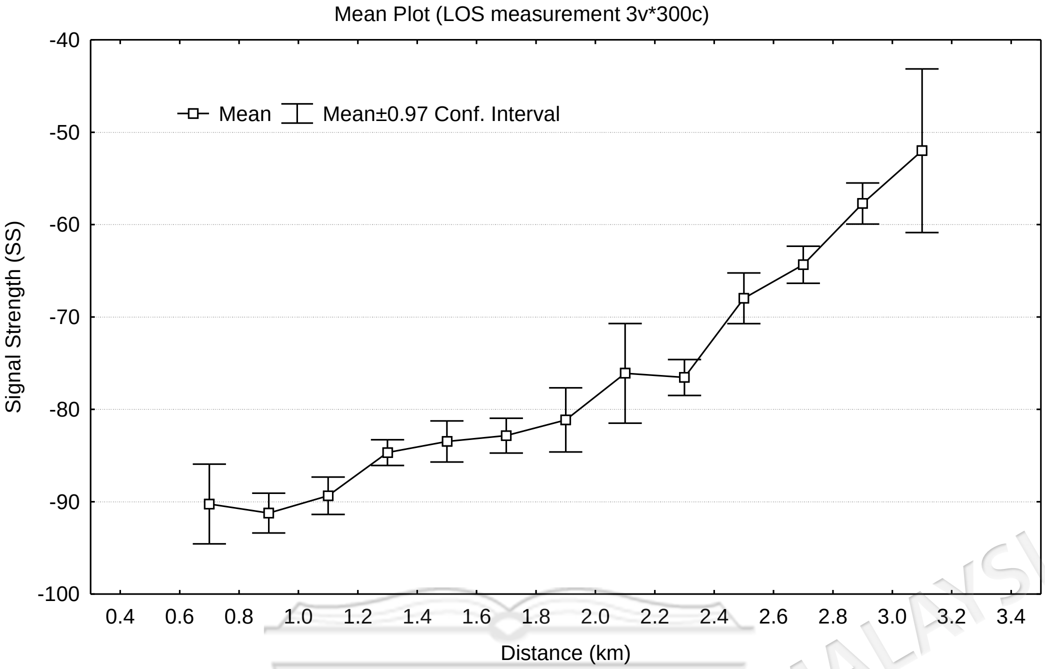


Figure 4.12 Standard error of estimate for LOS

In descriptive statistics, the LOS and NLOS signal strength measurement as shown in Figure 4.12 and Figure 4.13, are convenient for depicting groups of the measured data through their 15 number summaries: the smallest observation indicated observations considered.

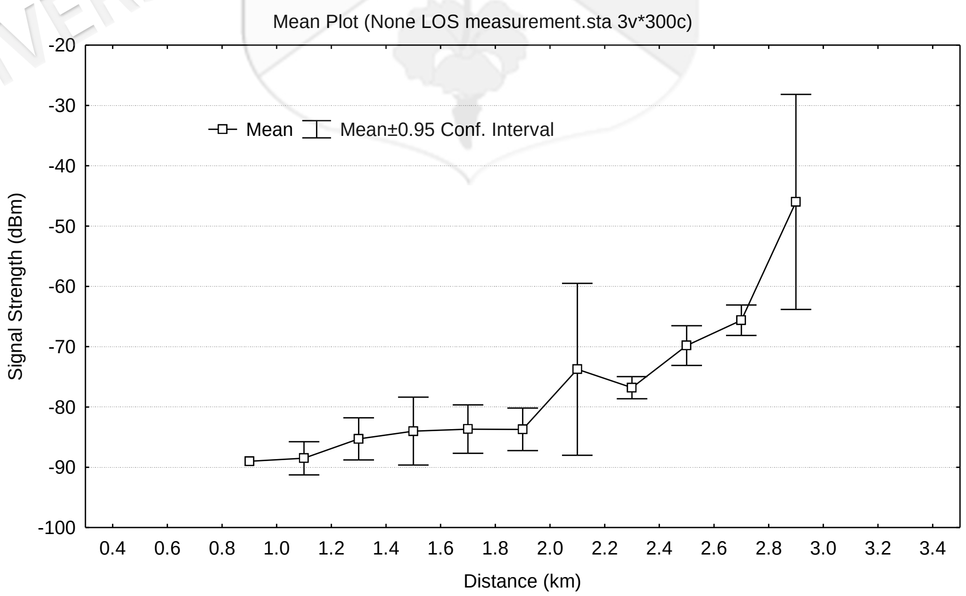


Figure 4.13 Standard error of estimate for none-LOS

4.4.6 Mean Relative Deviation (MRD)

The mean relative deviation between moisture levels gives an idea of the mean departure of the measured data from the predicted one (average values of relative errors) (Hassan & Pahlavan 2002; Roos, 2002; Walpole, 2002)

$$MRD(\%) = \frac{1}{N} \times \sum \left[\frac{PM_{\exp,D} PM_{cal,D}}{PM_{\exp,D}} \right] \times 100 \qquad (4.11)$$

Many authors used the term ($PM_{\exp,D}$) in place of ($PM_{cal,D}$); in the denominator of equation (4.8) .

In addition the expressed variability of the standard deviation for signal strength for LOS and NLOS as exposed in Figure 14 and Figure 15 were commonly used to measure confidence in statistical conclusions. The margin of error in measured signal strength is determined by calculating the expected standard deviation in the results which were conducted in multiple times. The reported margin of LOS data error is typically about a third of the standard deviation for confidence interval.

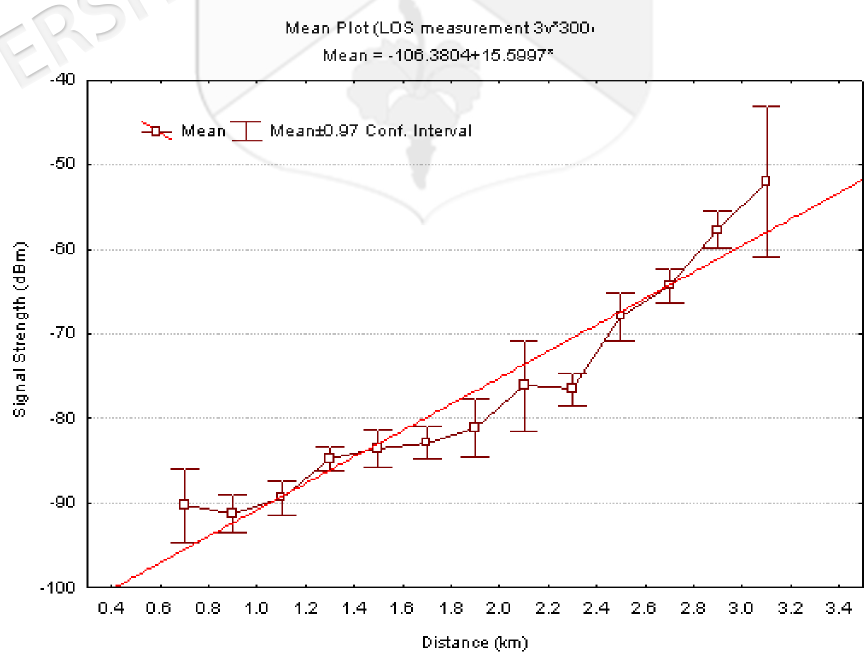


Figure 4.14 Mean sum of squares of errors for LOS

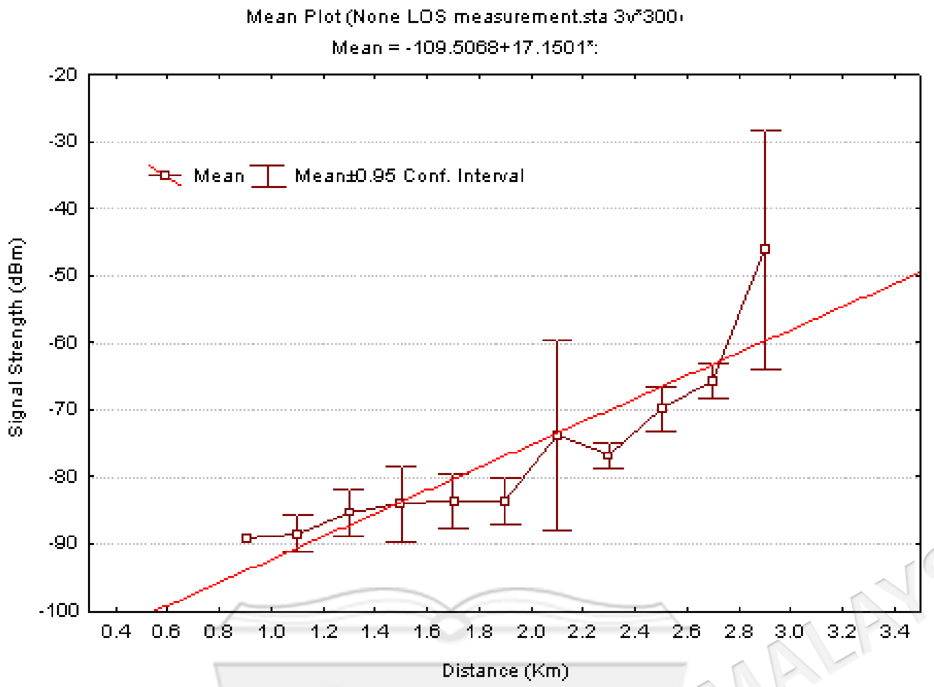


Figure 4.15 Mean sum of squares of errors for none-LOS

4.5 LOG-DISTANCE PATH LOSS MODEL

The log-distance path loss model is one of the famous radio propagation that predicts the path loss signal happened in a building or densely populated areas over distance (Parsons 2000; Rappaport 2002). Is formally expressed as:

$$L = P_{T_{XdBm}} + P_{R_{XdBm}} = L_0 + 10\gamma \log_{10}(\frac{d}{d_0}) + X_g \qquad (4.12)$$

Where

L is the total path loss measured in Decibel (dB)

$P_{T_{XdBm}} = 10\log_{10}(\frac{P_{T_X}}{1mW})$ is the transmitted power in dBm, where

P_{T_X} is the transmitted power in watt.

$P_{R_{XdBm}} = 10\log_{10}(\frac{P_{R_X}}{1mW})$ is the received power in dBm, where

P_{R_X} is the received power in watt.

L_0 is the path loss at the reference distance d_0. Unit: Decibel (dB)
d is the length of the path.

d_0 is the reference distance, usually 1 km (or 1 mile).

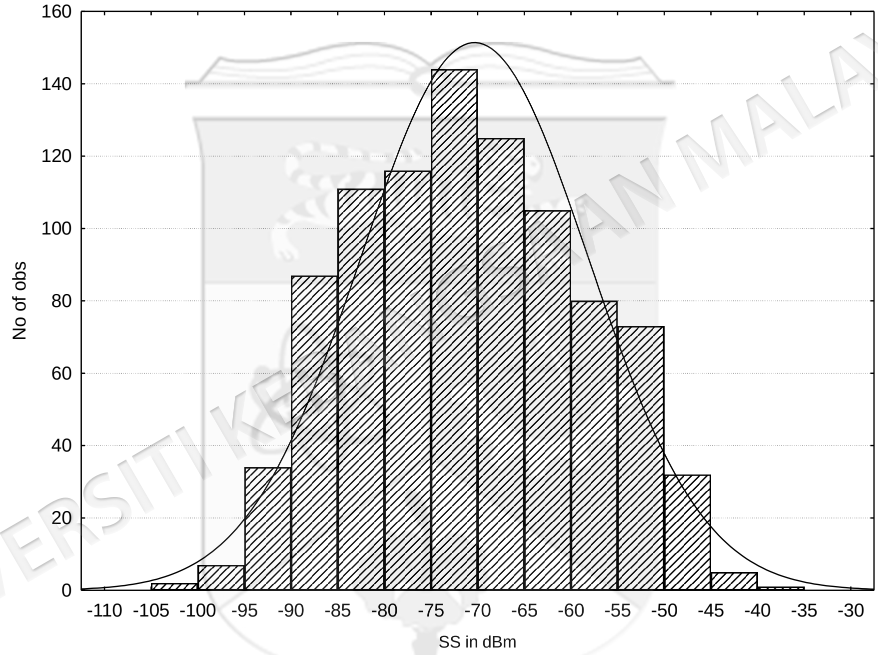
γ is the path loss distance exponent.

Xg is a random variable with zero mean, reflecting the attenuation (in decibel) caused by flat fading. In case of no fading, this variable is 0. In case of only shadow fading or slow fading, this random variable may have a Gaussian distribution with standard deviation in dB, resulting in log-normal distribution of the received power in Watt. In case of only fast fading caused by multipath propagation, the corresponding gain in times may be modelled as a random variable with Rayleigh distribution or Ricean distribution (Seybold 2005; Patrice 2006). The improvement in coverage considered at 5.8 GHz. One of the 70 receiving locations enjoys an increase in received signal power as high as 15.6 dB but there are a few points at which they received signal power decreased slightly after the building was faced the transmitter. Similar observations are made at free space as well. In such a way, there is another measurement done inside the building, as shown in Figure 6.2. The unpredictable difference in the received signal power can occur from the scattering effect in a complex environment, such as glass, thick wall and others. In some locations, where the Line-Of-Sight paths are slightly obstructed by the metal supporting structure of the partitions., the slight positioning error of the receiving antenna can produce a few dB changes in received signal power. Therefore, the difference in the development brought by the man-made can be expected to disturb the received signal. Overall, 92% and 60% of the receiving antenna locations achieve improvement in the received signal power at LOS and NLOS respectively.

4.5.1 Estimation of Path Loss Propagation Exponent

The average signal strength attenuation and the number of time averaged measured the attenuation data points used to calculate that average at each distance are shown in Figure 4.16 using the same logarithmic distance. The average signal attenuation data point over the range. This plot clearly indicates that the majority of the measured signal attenuation was logged in the identical range of distances over the average data points appear linear.

Therefore concluded that the linear regression calculation used to calculate the path loss exponent and it was limited to the average signal attenuation data points calculated using 70 measured signal attenuation. Moreover, it was concluded that the linear regression would be more accurate if the average data points calculated using greater numbers of measured values were weighted more than those calculated using fewer data values (Rappaport 2002).



4.16 Deviation Distribution of Signal Strength as a Number of Data Points

The weighting of average signal attenuation values was defined by

1. The total number of measured signal attenuation data points at each distance divided by one fourth of the minimum number of data points specified above and rounded up to the nearest integer value.
2. The average signal attenuation value corresponding to each distance was placed in the array of average signal attenuation values the "weight" number of times.

3. The distance value was placed in the array of distance values the "weight" number of times such that there was one distance value in the distance array for each of the corresponding "weight" number of average signal attenuation values in the average signal attenuation array.

A plot of the average signal attenuation data and the Log-distance Path Loss Model as a function of distance and the path loss exponent γ = 1.061. The model appears to be a fit to the average signal attenuation data points over the range of the given as was expected.

4.6 MODIFIED LOG-DISTANCE PATH LOSS MODEL

The modified of the empirical Log-Distance Path Loss Model deliberates the meteorological structures of the propagation environment in the model are presented. The method considers the structure within the path link of traffic light communication in the urban areas of Bandar Baru Bangi. The link consideration taking into account that fact that line-of-sight transmissions were at least partially blocked in many conditions as parameters in the modified propagation model. Measurements to verify the model for urban environments were performed. A comparison between the Log-Distance Path Loss Model, the modified prediction model and the measurements discloses the modified of the prediction model.

The area of the path loss prediction requires two parameters, which are power received at the first mile point L_0 and path loss slope A (Anwar et al. 2005) LEE's model (equation 4.4) used to learn the predicted propagation path loss (L) in dB.

$$L = L_1 + A \log (D) + F_0 \qquad (4.13)$$

Where

L_1 is the initial attenuation before corrected at (1 mile)

A is the path loss slope

D is a distance of a mile

F_0 is the correction factor

The LEE's model can be simplified into a simple relation of the propagation path loss and the distance between the transmitter and the receiver.

$$L = A \log (D) + L_0 \tag{4.14}$$

Where those correction factors L_1 and F_0 is included in the first mile (D) losses, and it used to correct the difference between the actual parameters of the transmitter and receiver (Seidel & Rappaport 1992). So the propagation path loss is determined based on distance, considering other parameters to be constant L_0. The propagation path losses will vary linearly with the logarithm of the distance, propagation path loss slope and offset of initial losses after correcting at unit distance L_0.

The Calculating of the free space transmission loss is quite simple. Consider a transmitter with power P_t radiates to the certain directions at a distance (D) from the transmitter. Let say the power flux density is (S)

$$S = \frac{P_T}{D} \tag{4.15}$$

The transmission loss then depends on how much of this power is captured by the receiving antenna. If the capture area, or effective aperture of this antenna is A_r , h can be delivered to the receiver, (assuming no mismatch) is simple

$$P_R = A_r * S \tag{4.16}$$

Where P_R = power received

A_r Depend on what kind of antenna used to receive the power signal, so in our case the antenna type is an isotropic receiving antenna, which means that it must be as the equation (4.17).

$$A_r = \frac{\lambda^2}{4\pi} \tag{4.17}$$

Combining equations (4.15) and (4.17) into 4.16, we have

$$P_R = \frac{\lambda^2 P_T}{4\pi D} \tag{4.18}$$

The free space path loss between isotropic antennas is P_T / P_r. Since we usually are dealing with frequency rather than the wavelength, we can make the replacement of λ to be C/f, where C is the speed of light and f is the frequency, to get.

$$L_P = \left(\frac{2f}{C}\right)^2 \pi * D \tag{4.19}$$

Equation (4.11), shows the dependence of signal level versus distance regarding to our method used. For each record corresponding to a given Tx-Rx separation within the area, the mean received power is calculated by averaging the signal strength over the 700 points of the scanned area. The mean path loss (in dB) is then obtained by subtracting this mean received power (in dBm) from the transmitted power (in dBm). Thus, the space path loss didn't include absolutely the environmental influences as well as the antenna gains and relative orientations. By linear fitting of the curve giving the path loss (in dB) versus the logarithm of the Tx-Rx separation for all the records, the power-distance relationship in the area at 5.8 GHz is:

$$L_P = 23.13 \log(D) + 49.84 \tag{4.20}$$

4.6.1 Modified Log-Distance Model Vs Actual Measurement

In order to determine the signal strength deviation of the model, the linear regressions between the values of the measurement and the modified log-distance models were calculated. For this model, the accuracy was calculated as the mean of the differences between the signal strength of the observed value and that of the expected value, and their standard deviation revealed the error precision (Bagguley 1973). Based on the statistical analysis of data, it was found that the graph as shown in Figure 4.6 was best fitted with the following linear equation and then there is a highly significant positive correlation between the measurement data.

Figure 4.17 presents a graphical summary of the findings of this study, where only those relationships which showed a statistically significant correlation have been shown. An attractive and reflective modified model in this study is that the coefficient of determination showed a significant relationship with measurement data prepared.

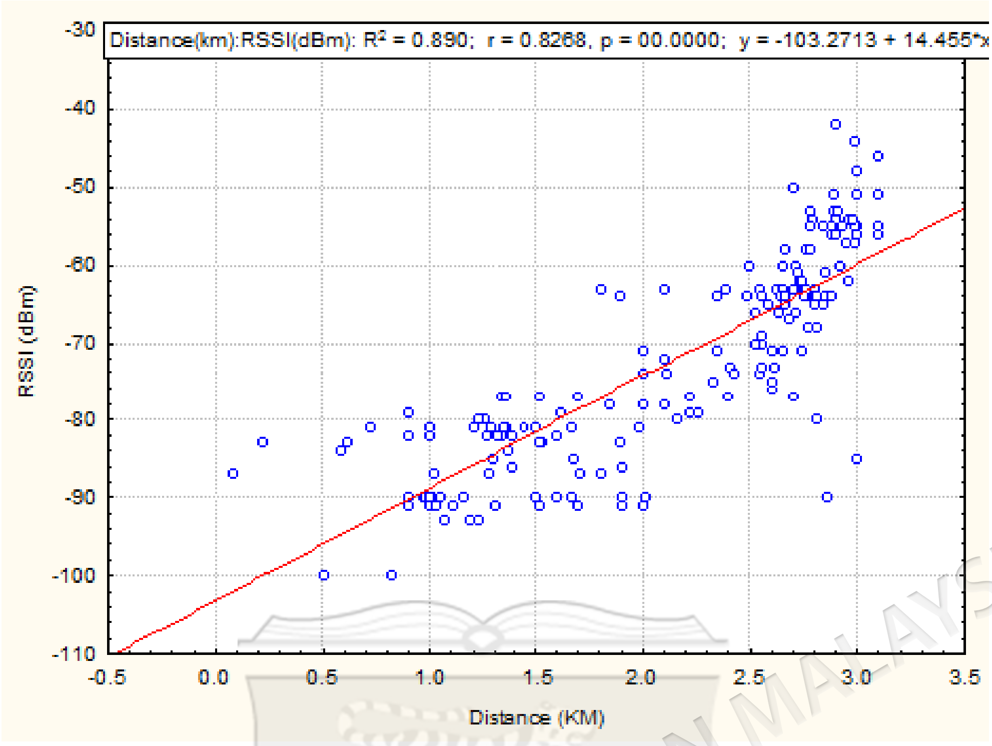


Figure 4.17 Coefficients of determination and error estimation

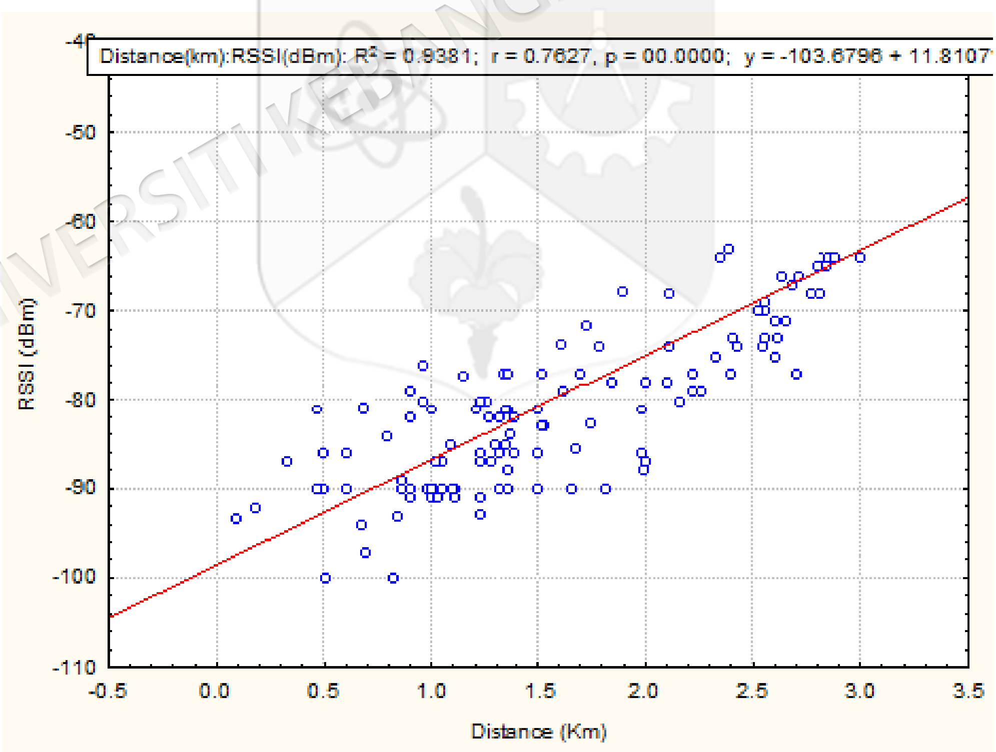


Figure 4.18 Coefficients of the modified model and error estimation

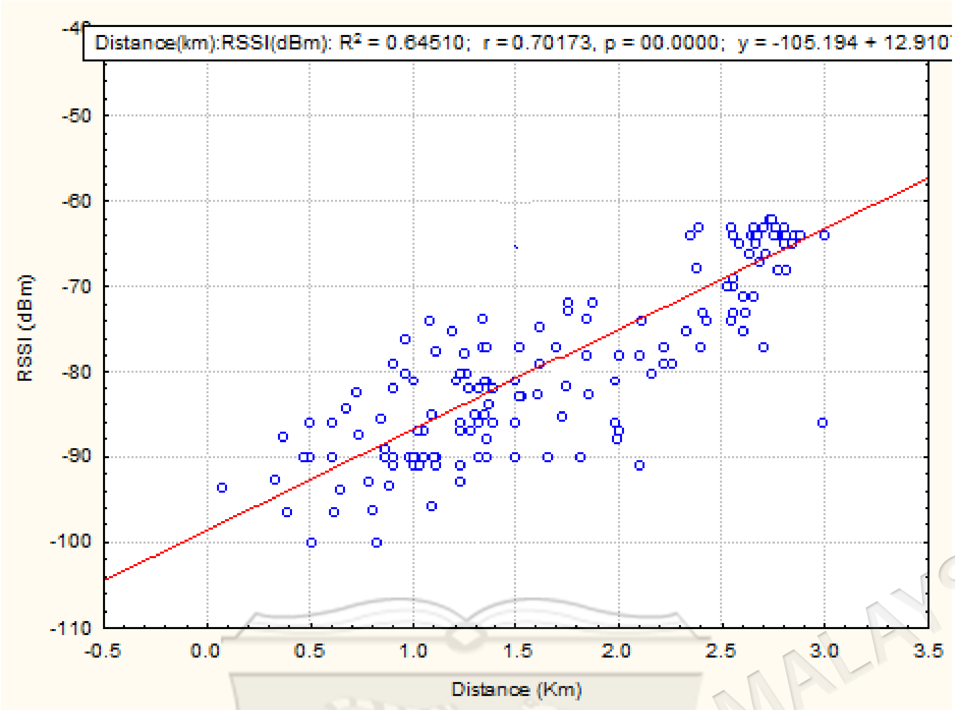


Figure 4.19 Coefficients of the Log-Distance model and error estimation

Based on the statistical analysis of data, it was established that the graph as shown in Figure 4.19 was compared to the data fitted with the following linear equation and then there is a low significant correlation between the measurement data and integrated log-distance model.

4.7 PARTICULAR RAY TRACING REVISION

In wireless communications, understanding of the propagation channels is necessary to achieve optimum performance of a communication system. Even though direct measurements enable accurate evaluation of on-site performance, it requires a considerable amount of time and efforts. Therefore, a computer tool that could characterize the wireless channel from the building plans, and material properties would be a good solution (Thirumaraiselvan et al. 2005).

The most common type of deterministic models is the ray-model in which the electromagnetic fields are approximated as rays. The predictions from the ray-model have been widely used to provide propagation data for evaluation of transmission techniques (Tila et al. 2003).

The ray tracing method represents the most commonly used approach in the calculation of propagation models for urban environments. Some research efforts are underway to help with continued improvement of accuracy and extension of generality Ray Tracing tools to enhance the environmental problem. The term multi-path arises from the fact that, through reflection, diffraction and scattering. Radio wave can travel from a transmitter to a receiver by many paths. It is a very rough to estimate the maximum delay time to be expected in a given environment may be obtained simply for the dimensions of the area from the fact that time (*ns*) for radio pulse respond to travel distance *d* is approximately.

The power received at distance *d*, $P_r(d)$, is given by the power flux density times the effective aperture of the receiver antenna, and can be related to the electric field using equation (Fernando & Perez 1999)

$$P_d(d) = \frac{(E_g)^2}{120\pi} A_e \tag{4.21}$$

Where $P_d(d)$ is the power received in the distance *d* and E_g is the total transmitted electric field after reflection, and A_e is the effective aperture.

$$G_r = \frac{4\pi A_e}{\lambda^2} \tag{4.22}$$

Where G_r is the receiver gain, by assuming that the electric field is vertical (Leon 2006), the reflection coefficients Γ.

$$\Gamma = \frac{-\varepsilon_r \sin\theta_i + \sqrt{\varepsilon_r - cons^2\theta_i}}{\varepsilon_r \sin\theta_i + \sqrt{\varepsilon_r - cons^2\theta_i}} \tag{4.23}$$

Where ε_r is the relative permittivity and $\theta_i = \theta_o$ in the case of reflection method.

The formula (4.23) used to compute the reflection coefficient of the path as shown in Figure 4.20.

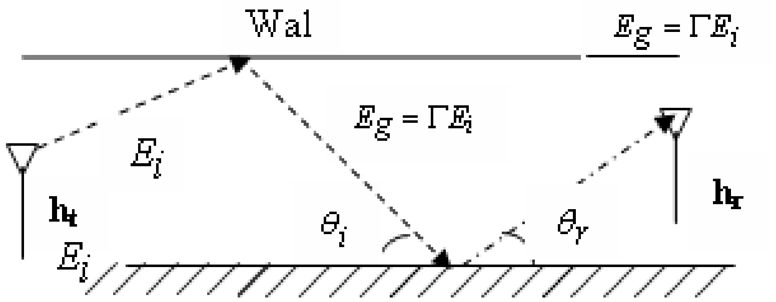


Figure 4.20 Electrical field ray reflection model

Where h_t is the antenna transmitter and h_r is the antenna receiver. E_i is transmitted electric field (constant for all material parameters).

This part considers an approach for developing such a simulation tool using ray tracing. The simulator has been implemented in Matlab. Assuming that the scattering objects are much larger than the wavelength, the electromagnetic waves are modeled as rays. Rays are launched from the transmitter in all directions. Their interactions with the surroundings, i.e. material reflections and transmissions, are tracked using a three-dimensional shoot-and-bounce ray tracing technique.

The geometry of the ray tracing method is described in Figure 4.20. This geometry is positioned at an altitude h (point O) with the sub-platform point. Point O denotes the position of a transmitter served by the radial coordinate having an elevation angle a. Point B represents the receiver from the principle of geometry..

For ray tracing study techniques, the coordinate system is located at the center of the antenna transmit with radius R and refractive index (n). The ray collection is incident to the r-axis pointing counter to the incoming rays. Every occurrence ray can be represented by its impact parameter A, which can be expressed as

$$b = R \sin(\phi) \tag{4.24}$$

Due to the proportion application, the intensity distribution of the ray can be represented as a function $f(A)$ depending only on the radial coordinate A in Figure 4.20.

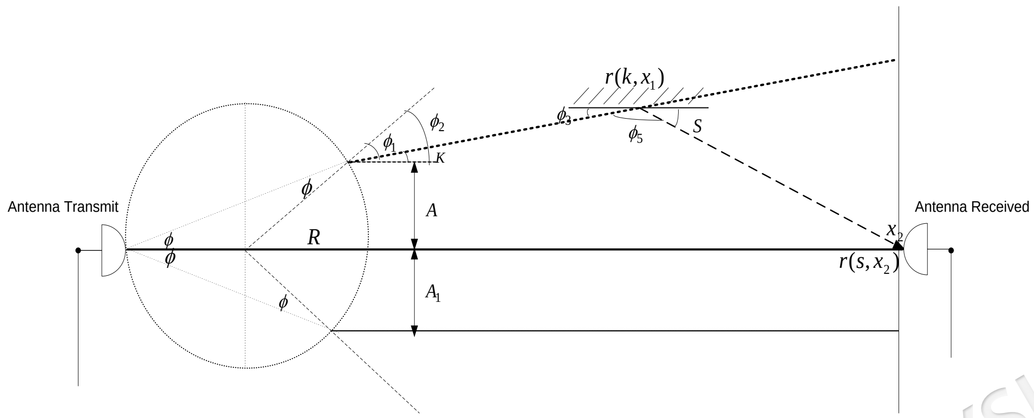


Figure 4.21 Ray-tracing method for a reflecting subject

From the law of reflection one can determine that the inner angles ϕ of the small triangles at the circle border are identical because each triangle has two sides equal to the radius R of the sphere. Thus

$$A = A_1 \text{ and } \phi_2 + \phi_1 = 4\phi$$

$$A = R\sin(\phi_1)$$

The law of refraction state that

$$\sin(\phi_1) = n\sin(\phi)$$

Using this information, we can derive the formula for the reflection angle k to be

$$k = 4\sin^{-}\left(\frac{\sin\phi_1}{n}\right) - 2\phi_1 \tag{4.25}$$

At a distance z from the origin the transverse coordinates of the reflected ray are given by.

$$r(x,z) \cong R\sin(\phi + x) + z\sin x \tag{4.26}$$

Taking into account the fact that z >> R. These transfer function maps the transverse coordinates of an incident ray to that of the corresponding reflected rays. It can be approximated by a Taylor series expansion.

$$x \cong \frac{2\phi}{n}(2-n-\frac{\phi^2}{4}) \tag{4.27}$$

Using this approximation, the maximum reflection angle is x_m where

$$x_m = 4\left(\frac{2\phi}{n}\right)^{\frac{3}{2}} \text{ for } \phi_m = 2\sqrt{\frac{2-n}{3}} \tag{4.28}$$

The exact back reflection occurs for $x = 0$ when

$$\phi_1 = \phi_0 \equiv 2\sqrt{2-n} = \sqrt{3\phi_m} \tag{4.29}$$

Equation (3.17) can now be written as

$$x \cong -\frac{\phi}{2n}(\phi^2 - \phi_0{}^2) \cong -\frac{\phi}{4}(\phi^2 - \phi_0{}^2) \text{ with } n \approx 2 \tag{4.20}$$

On the other hand, the intensity distribution of the reflected beam is inversely proportional to the illuminated areas. Therefore, one can equate.

$$f(r,z) = f[b(r)]\frac{bdb}{rdr} \approx [R\sin\phi]\frac{R^2\sin 2\phi}{z\frac{d}{d\phi}[R\sin(\phi+x)+z\sin x]^2} \tag{4.21}$$

Where, *F(r,z)* is the intensity distribution of the reflected beam and *fEb(r)]* is the intensity distribution of the input beam. For simplicity of the following derivations, we assumed a constant intensity profile of the input beam and not a Gaussian distribution. For incident rays near the angle of maximum positive deflection,

$$\frac{dr}{d\phi} = \frac{R\cos(\phi+x)\left[1+\frac{dx}{d\phi}\right]+z\cos x\frac{dx}{d\phi}}{z\cos\phi} = 0 \tag{4.22}$$

The intensity distribution *F(r, z)* approaches infinity. This leads to the condition

$$\frac{dx}{d\phi} = \frac{R\cos(\phi+x)}{z\cos\phi + R\cos(\phi+x)} \approx 0 \quad (z << R) \tag{4.23}$$

In order to understand how this occurs, the relationship between ϕ and x, as expressed in Equation (4.16), is plotted in Figure 4.22 for refractive indices above and below n = 2. The curves in this figure are (A) for a refractive index n = 1.98, (B) n = 2.00, and (C) n = 2.02. This Figure obtained to show the principle of ray-optical propagation models in link line of sight consideration to support the idea of the software planning tools developed in this thesis. The view of the three antenna setup obtained in the Figure is defined based on the terrain profile between the traffic junctions to generate clear LOS and to calculate the probability of the delay.

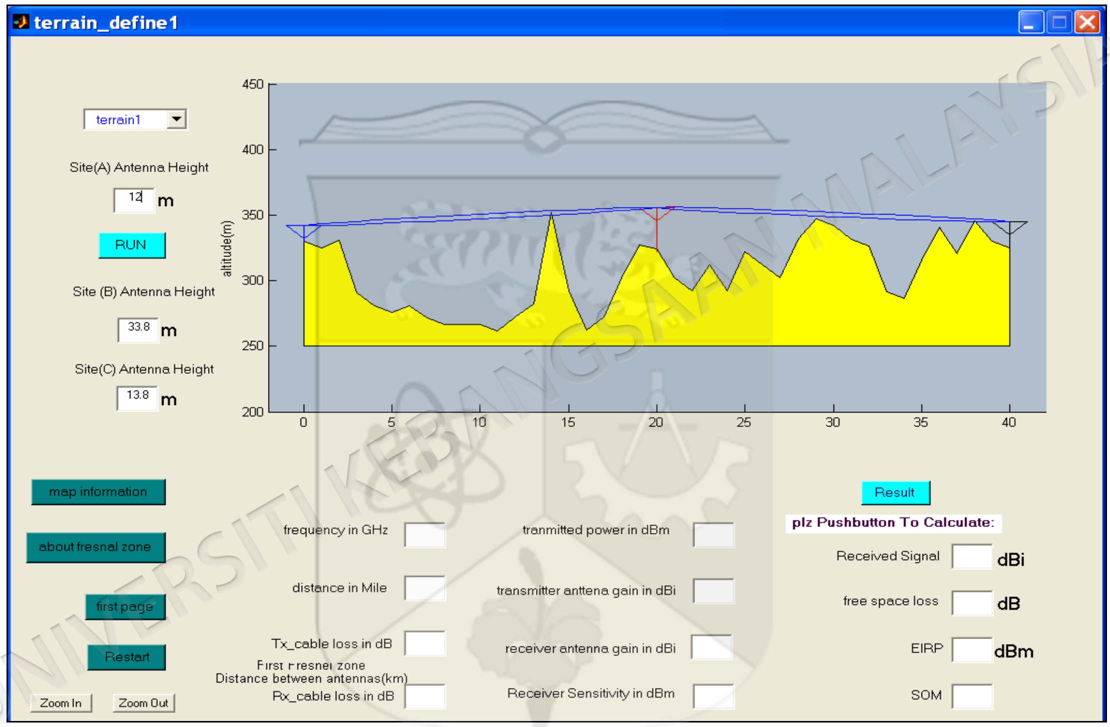


Figure 4.22 Delay spread with refractive indices

4.8 LINK PREDICTION AND ANALYSIS

The ability to predict traffic conditions is important for optimal control. For example, if we would know that some road will become congested after some time under current conditions; this information could be transmitted to road users who can circumvent this road, thereby allowing the whole system to relieve from congestion. Furthermore, if accurately predict the consequences of different driving strategies, an optimal (or at least optimal for the predicted interval), decisions can be made by comparing the predicted results. The simplest form of traffic prediction at a junction is by measuring traffic over a certain time, and assuming that conditions will be the same for the next period. One approach to predicting is presented in (Wahl 2005), where neural networks are used to perform long-term prediction of the queue length at a traffic light. A multi-layer perception (Al-mudhaffar 2006) is trained to predict the queue length for the next time-step, and long-term predictions can be made by iterating the one-step predictor. The resulting network is quite accurate when predicting ten steps ahead, but has not yet been integrated into a controller.

4.8.1 Environmental Factors

The ITLMS technique is the control of multi traffic light strategy in BBB. It is originally developed to increase road safety and to decrease lost time and to maintain the vehicles at signalized junctions.

K-Factor measures the ratio of average energy in the fixed link (LOS) to the average energy in the scatter link. The complex path gain of a narrow-band radio channel is composed of a fixed component and a fluctuating component (scatter component). The former is due to the LOS path between the transmitter and receiver, and the latter is due to multipath. If the scatter component has a complex Gaussian distribution, the time-varying magnitude of the complex gain will have a Ricean distribution. The Ricean K-Factor is the key parameter of this distribution (Abdi et al. 2001). The WLAN propagation is ruled by the principles of reflection, diffraction, and refraction. The direct straight ray between antennas represents line-of-sight wireless link between two locations (Afullo & Odedina 2006). A high K-Factor is indicative of LOS conditions, while a zero or low K-Factor indicates an NLOS domain. According to the Baker & Palmer (2003), the K-Factor distribution is found that, it facilitates to model the empirical of an effective earth radius factor.

The required path clearance is usually expressed, for a particular *k*-factor, as some fraction of the first Fresnel zone radius (Ashraf et al. 1995). Radio transmission loss in tropospheric propagation depends on characteristics of the atmosphere and the terrain. The most important atmospheric parameter is the refractive index gradient near the earth's surface. This surface gradient largely determines the bending of a radio ray through the atmosphere. The refraction index of air is very close to unity. The radio refractivity *N* is defined as:

$$N = (n-1)\times 10^{6} \tag{4.24}$$

Where *n* is the index of refraction.

At radio frequencies, the radio refractivity may be approximated by (Bean et al. 1966):

$$N = 77.6\frac{AP}{T} + 3.73\times 10^{5}\frac{H}{T^{2}} \tag{4.25}$$

Where, *AP* is atmospheric pressure (mbar), *T* the absolute temperature (Kelvin), and H water vapor pressure (mbar).

The effective earth radius *K* which considered as a function of the refractivity gradient or of the mean surface refractivity *N* acterize average atmospheric conditions. The effective earth's radius for regional different regional difference spheric conditions is defined as:

$$K = 6370[1 - 0.04665\exp(0.005577N_S)]^{-1} \tag{4.26}$$

The actual radius of the earth was taken to be 6370 kilometers. The refractivity, N_S and *are* face refractivity reduced to the sea level. Ashraf et al. (1995) shows minimum monthly mean values of radio refractivity *N* through the world. The corresponding surface refractivity N_S is then:

$$N_S = N_o \exp(-0.1057h_S) \tag{4.27}$$

Where, h_S is the elevation of the earth's surface in kilometer above the mean sea level.

The areas of the plan involved Bandar Baru Bangi. The data were collected from UKM meteorological stations. K-factor was defined as the ratio of the effective earth radius and real earth radius (Naveen et al. 2011). Figure 4.23 represented the values of K-factor in the area from January to April (2009). Figure 4.24 gives the value of K-factor at the Bandar Baru area in five years cumulative (2006 to 2010). Figure 4.23 & 4.24 define that; the average of K-factor is equal to 2.1 respectively. We have to consider the condition or propagation impairment due to the K-factor even it appears a clean line-of-sight. When K< 4/3, The beam will be bent upward. That means the actual path going up. When K> 4/3, the beam will be bent downward. Depending on the K-factor criteria (Ashraf et al. 1995.; Robert et al. 1993).

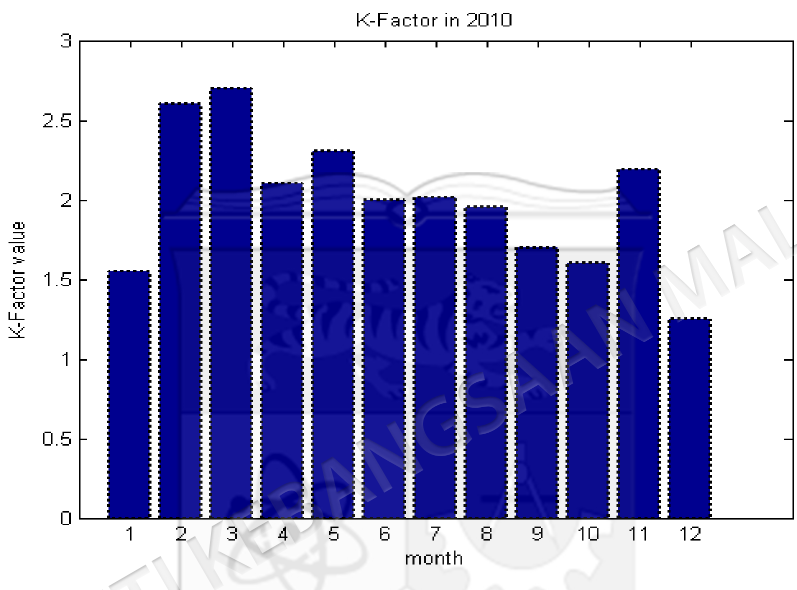


Figure 4.23 K-Factor in 4 months

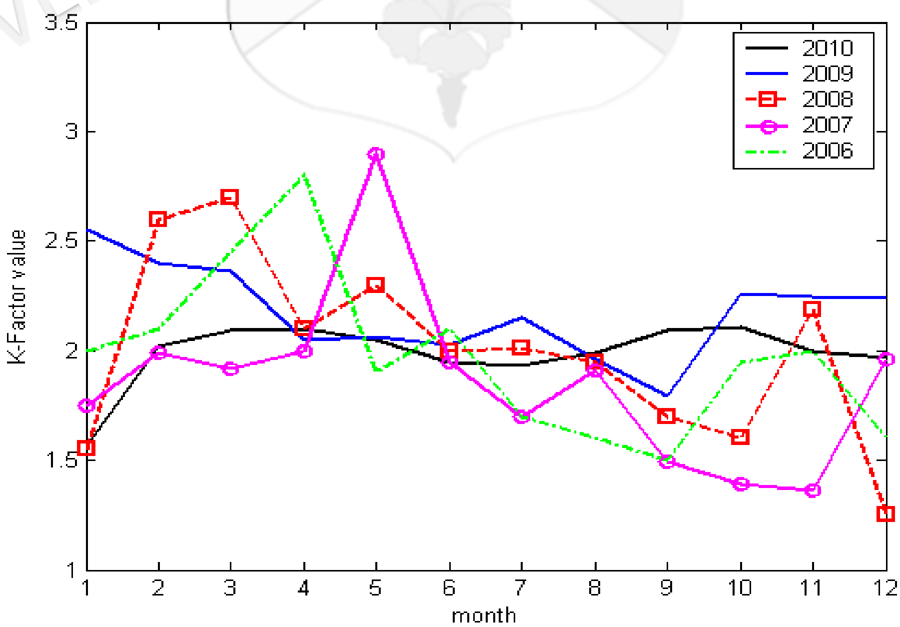


Figure 4.24 K-Factor in 5 years

Tom (2006), mentioned that the direct beam in line-of-sight link curves slightly due to refractive index gradient, although it is shown as straight lines on shape figure. The actual curve of the wave is transferred through the terrain profile of the pathway. With the restriction of preserving point to point link, the actual height of the wave above the ground index which is affected by atmospheric temperature and pressure (Afullo & Odedina 2006).

4.9 SUMMARY

The requirements of data users must be considered when planning data justification for an environmental project. The graph depends on the data quality objectives, proposed use of the data, and preference the main elements affecting the data. Using principles from Functional Guidelines, the level of data reviews can be performed using various levels and focus. Two criteria were applied to validate the developed propagation exponential model. The values of the data measurements versus predicted values, and the residual versus predicted values. The results confirmed the suitability of the model to predict the signal strength characteristics of the area satisfactorily. The modified model showed the almost similar performance of the term exponential model with R^2 = 0.961564 compared to 0.936287 for the term of exponential measurements. Together LOS and NLOS systems are administrated by propagation characteristics of the same environment and path loss optimization. However, an NLOS system is the one with the most problems in the case of directional antenna which the signal can work in the certain area due to scattering and reflecting signal.

CHAPTER V

DEVELOPMENT OF SOFTWARE PLANNING FOR ITLMS

5.1 INTRODUCTION

The quick growth of wireless systems for communications and other uses by fixed and mobile platforms has been phenomenal. Wireless LAN technology has enabled a wide variety of available and potential applications and services, including communications, GPS for direction finding and on-demand navigation, remote sensing and distributed sensor networks, wireless virtual university, and wireless LAN system optimization. The antenna radio channel places fundamental limitations on the performance of wireless communication systems. While it is possible to build transmitters, receivers and antennas with defined characteristics, radio waves are submitted during their travel between transmitter and receiver to physical acts over which we have no control. The practical results of these acts are so important that they affect the circuit quality to a far greater extent than the terminal equipment. If the designers did not take these acts into account, the link would often be impossible to build, and even if it were possible, extreme resources investment would be needed.

The transmission pathway between the transmitter and receiver can differ from simple line-of- sight (LOS) to one that is severely affected by external factors such as rain, temperature, humidity, trees and terrain effects. The effect of these factors depends on the characteristics of the installation (frequency, antenna height). The external factors are random variables in time and location.

This software presents a Line-of-Sight (LOS) Ranging System. It consists of detailed 3D terrain data and uses a simple mathematical-capable database application as an approach to building a line-of-sight (LOS) situational awareness in the plan view.

The main issues to note here is the language code structure, in which a MATLAB program element in Figure 5.1, and the extensions to the logic concept, such as argument list patterns, transitive end standard predicate, and comprehensible steps, which make it possible to achieve many programming tasks without multifaceted.

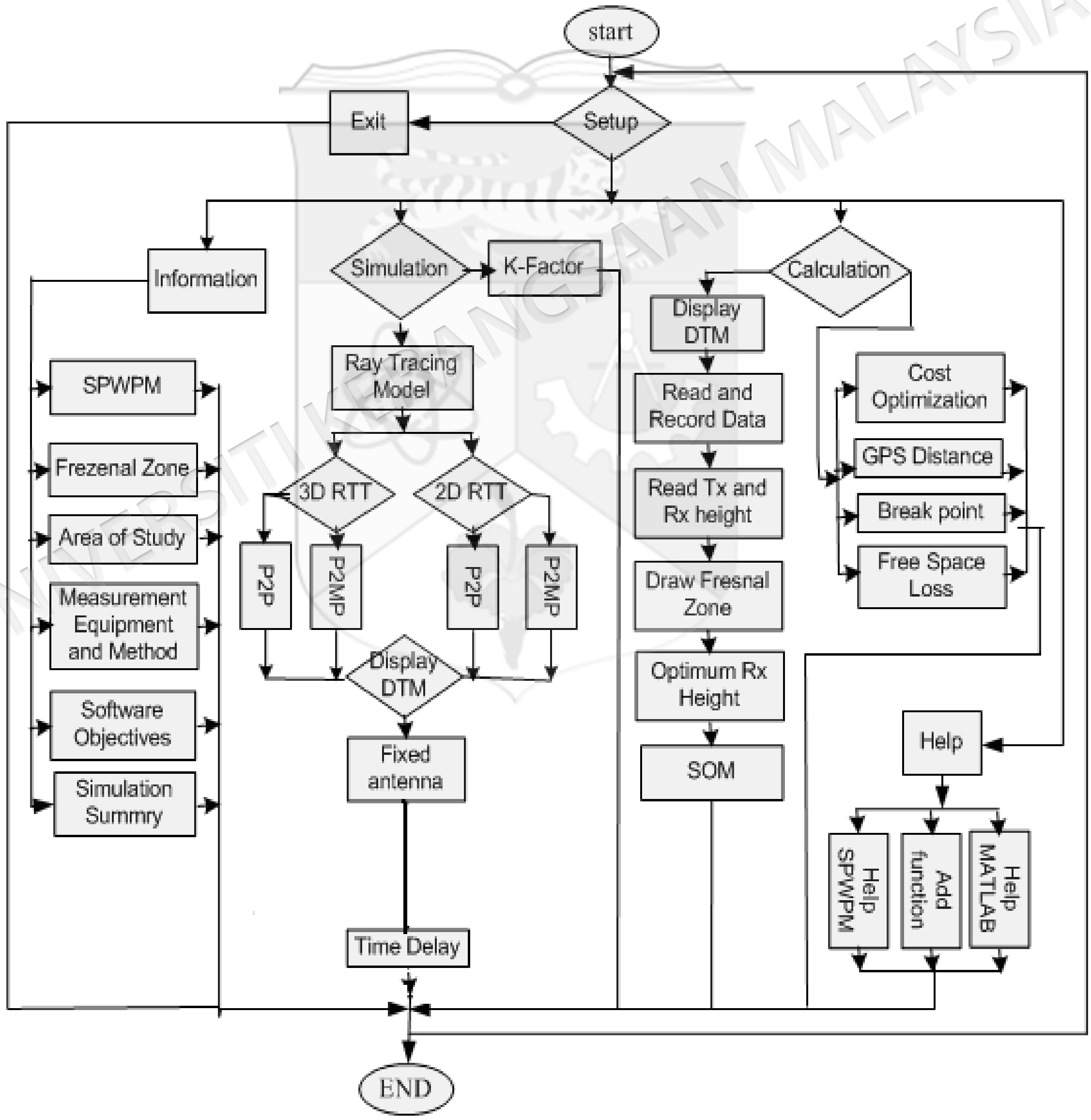


Figure 5.1 Flowchart architecture of software planning tool

5.2 SPWPM PROGRAMMING LANGUAGE

Presented here is software for link line of sight planning prediction. Software calculation process and parameters using ray tracing for accurate prediction are explained. Also given is the measurement equipment used to set up and confirm the calculation process in the 5.8 GHz as shown in figure 3.10. Many software of prediction has been developed, in both accuracy and calculation time required (Zhong et al. 2010; Hoppe et al. 2000).

5.2.1 Language Syntax

Matlab tools language and functions are a declared the language, belonging in the logic-programming concept, designed for the task of selecting for the software program elements. Two primary applications were considered such as import data and key in parameters at the time when the language was first conceived:

1. Upload the constant value for aspect, where the software can serve as a powerful substitute of indicates the structure. They indicate expressions of constant selection can select the point from the code onto which an aspect is to be applied. The expression function output carries out the specific execution, which has been noted in the literature review. ILMTS was designed to address these limitations, providing greater flexibility to the useful mechanism, although it has integrated into specific solutions.

2. Expressing the conditions making up concepts for use in basic programming, including multi-type concepts. Concepts are a key issue in the generic function, since they make clear the test of whether a given set of classes are legible as parameters for a given generic construct. As a concept specification function, ILMTS can be used, for each instruction to explicitly limit the set of functions to which it can be applied.

5.3 PATH SURVEY

This path loss survey carved out to be the most important step in the design of a LOS link concern. Site review reflection must clearly inspect in question. The uses of GPS receiver are helpful to confirm geographical positions along the path with signal prediction, including attitudes, latitude and longitude (Holland 1993).

The first step in the plan consideration path is to observe large topographic maps along the path line for possible obstruction points. Obstructions to the sides of the path line such as trees or buildings should also be noted, especially if they can be considered reflective (Grosskopf 1996).

In most cases, the path design derived from the map study must be confirmed by a field survey. Investigation of the potential link sites is usually necessary, and information on man-made obstructions as well as confirmation of natural obstructions should be obtained (Lebherz et al.1989). Possible reflection points may also be determined. A line of sight path designed and installed without the benefit of a field survey is a high risk except for the types of paths where the rays are directed and the path is short. A typical link survey report generated by the survey contractor will contain most of the site data needed (Conan & Bradley 1992).

In the case of potential indication points observed along the path, it is possible to design a path to reduce the possibility of the signal break by a reflected signal. Calculation of the potential link in the areas that would cause cancellation may be made in advance of the definite fieldwork, minimizing the need for extensive field investigation along the path (Davol 2001).

Several methods of data validation and analysis of this information have been used. Uses of a curved based on data collected to correspond to each curve or use of a curved model to draw the path loss based line of sight (Grosskopf 1996). With the initiation of the scientific calculator, the easiest method is to use a straight path line with the necessary clearance over each obstruction calculated and shown by a symbol.

Both the earth curvature and the desired Fresnel clearance must be calculated and added in order to plot the clearance target above each obstruction.

5.4 KEY ASSUMPTIONS

The analysis presented made the following assumptions.

1. The frequency of operation of the intelligent traffic light management systems considered to be 5.8 GHz.
2. The only directional antenna transceiver is considered.
3. No interfering base stations are arranged in a square grid in the setting plan due to the different frequency selected.

The model-estimation represents a terrain scenario with buildings and trees

5.5 VALUABLE SOLUTIONS

Although many frameworks and characteristic certain programmings try to address the problem of code complexity in enterprise applications, we argue that neither of all programming, in its current form, is sufficient to get the actual and accurate solution for LOS condition. We now examine in some detail the limitations of each approach in literature review, concluding in the need for integrating into a logical solution.

5.6 LIMITATIONS OF ITLMS-BASED SOLUTION

Ideally, with present function structure, the developer only has to implement the specific site planning consideration used for intelligent traffic light management system. This logic function is none other than what the ITLMS calls functional concerns. Various services provided by the function handle what is known as import and export files, even though the ITLMS structure simplifies enterprise application programming and reduces the tangled code, there are limits to such benefits. The reason is, any variation on the functionality of the determination output is therefore, by re-input of parameter's persistence, using what is called “input the window"” persistence.

ITLMS works by changing existing code, often on a program-wide extent advertised at the help window as a means for breaking the implementation into its novel concerns; accordingly, the characteristic may replace or process the implementation of the functions, and even change its type by introducing new instruction. This change is unhelpful, since the other functions touched by feature cease to exist in their original form; only the modified form exists, and in particular, there cannot be instances of the original classes in function structure.

5.7 SPWPM OVERVIEW

The theory of the propagation conditions will lead to the numerical results, which can be put to practical use for the establishment of radio communications. The first propagation model described in this thesis serves as an aid in the selection and design of the propagation path and enables the maximum effective range between the transmitter and receiver, and the Fresnel zone clearances to be computed.

The purpose of this Software is to help and provide the designer with accurate information about the radio path. The goals are an optimum selection of antenna heights and the preparation of foundation information to estimate the radio path reliability. In modeling ray paths, the earth and atmosphere are often idealized to a spherical system.

The design of a PTP LOS link involves four basic steps

1. Site selection and preparation of a path profile.
2. Deicide the place of the transmitter
3. Calculation of tower heights
4. Running a path/site survey

The contribution of a LOS radio link begins with a selection of operational sites for the installation and operation of the radio equipment. After site selection, a path profile of the link is prepared to determine the heights of radio towers to achieve LOS. There is the considerable iteration between site selection and path profile preparation to optimize the route Sites are primarily selected using large topographical maps. Basically, there will be two terminal sets, where the system begins and ends. Along the way, repeater sites may be required to either bridge the large distance or just function as a data interchange.

5.8 CALCULATION OF TOWER HEIGHTS

Assume now that sites along a route have been carefully selected. The next step in engineering is the determination of tower heights. The objective is to keep the tower heights as low as possible and yet still maintain effective communication. The towers must just be high enough for the radio beam to overcome obstacles in the path. However, the towers that are built for the antennas can significantly affect the cost of the link (Gibilisco 1999).

If there are obstacles such as trees or hills at some points on the path, towers of even greater heights may be necessary to provide clearance. Towers of this height require guy wires to support them. This is because the cost of self-supporting towers is too expensive since the cost increases almost exponentially with height (Chen 1997). In both cases, the amount of land required for the towers increase considerably with tower height. Although this may not be a problem in the countryside where land is usually available, in towns or cities, there is often limited space at the terminal exchanges for building high towers. These sometimes necessitate mounting the towers on the roofs of exchange buildings, in which case the structural adequacy of the roof must be carefully evaluated. In addition, the local building codes and air-traffic regulations can impose restrictions on the height of the towers. In rural areas, local soil conditions must also be taken into account. Extra costs can be incurred in areas with hard- rock, which must be moved or in very soft soil areas where extra-large concrete bases need to be built. Furthermore, wind loading must be taken into account, or movement of the tower will cause outages. Even the antennas themselves can cause problems if there are too many placed on one tower in an imbalanced configuration (Evans 2004).

5.9 SOFTWARE HIERARCHY

The Software View displays the currently loaded geometry. After the calculations have been run, most of the result output can be displayed in the graph view. Several viewing modes are available: 2D or 3D, wire frame or solid, and in 3D mode: orthographic or perspective. The user has full control over zooming, panning, and rotating in all view modes.

The Software hierarchy provides suitable resources to navigate within the input and output files of a project. Each level in the hierarchy can be expanded to view the unique levels. Selecting element and right click can be used to access the properties and editing options for most items. The software is especially useful for viewing and plotting output.

5.10 TRANSMITTER AND RECEIVER SETS

The software defines sources as transmitters and output sampling locations as receivers. Entering these quantities is straightforward in it. Points and curve can be defined graphically, or their locations can be read from data files. Antennas are assigned to each set along with the waveform definition. Editing tools allow the locations of *Tx/Rx* sets to quickly be modified. Each *Tx/Rx* set can be designated as active as shown in Figure 5.2, which determines if it can be in the data base. This eliminates the need to add or delete locations from the data files when making a series of calculations for different active sources.

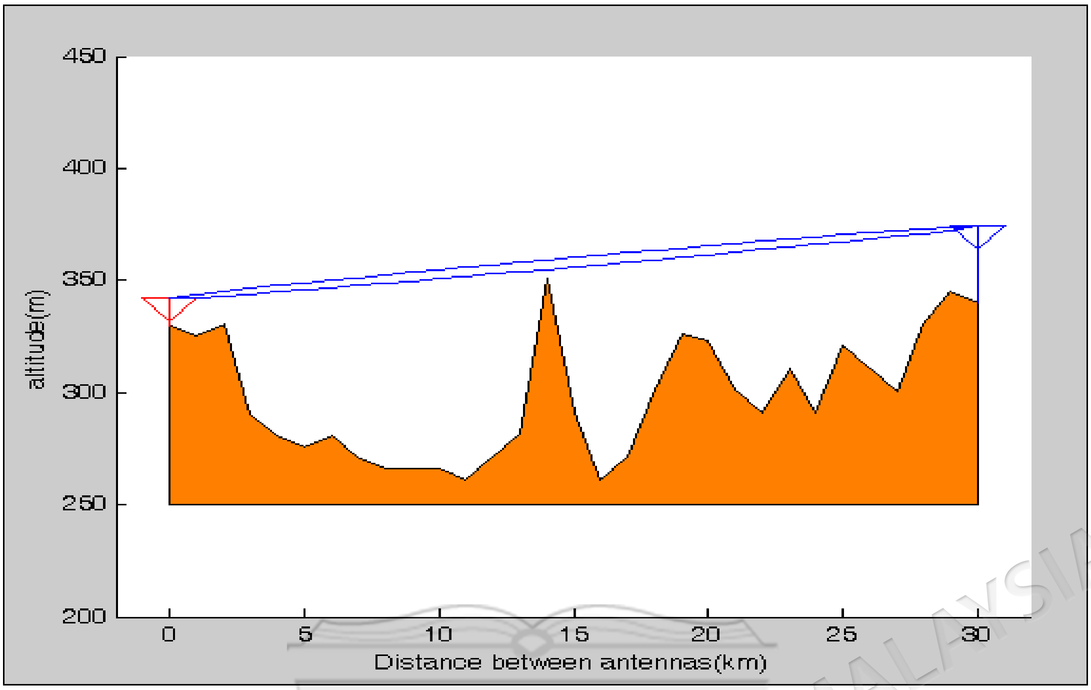


Figure 5.2 Transmitter and receiver link

5.11 POINT-TO-POINT ANALYSIS

The Software involves 2D and 3D propagation model predicts the paths by which energy travels from the transmitting antenna to the receiving location. The graphical interface makes it easy to view direction-of-arrival, complex impulse response, wave vs. time, and heights of antennas vs. frequency for each transmitter-receiver link. Figure 5.3 gives an idea about link planning and point to point analysis procedure.

This thesis briefly describes the necessary steps for doing a link LOS plan, but a proficient path analysis that will ensure the radio link will perform satisfactorily. The management of site plan allowed monitoring the achievement of link objectives.

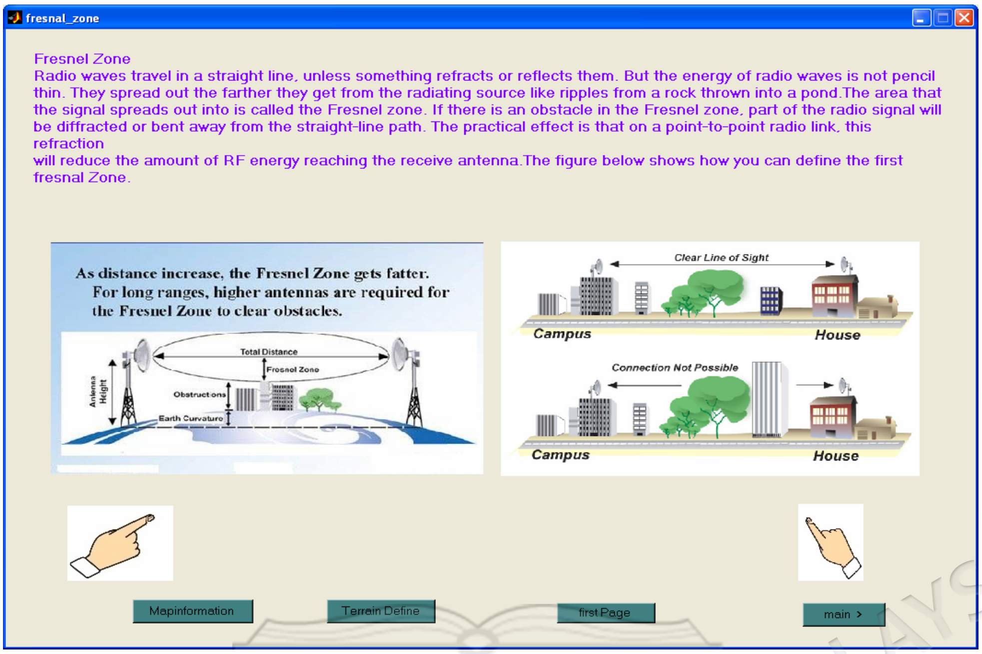


Figure 5.3 Fresnel zone platform

5.12 TERRAIN DATABASES

Train databases are the basis for the link line-of-sight analysis of most WLAN planning tools and handling the value of the data for the most critical part. If the effort to define the scenario (terrain database) is too large, it makes no sense to plan the WLAN with a software tool. The software modules are optimized so that the user will get the results within a few seconds.

To accelerate the definition of terrain databases, uncomplicated planning model has developed an innovative software product to make the handling of terrain databases as simple as possible. The user can import the data (i.e. Building, hills, trees, etc.) in a present way, through axles or any file format is supported. All these features are integrated in with the software editor. A short guide of the terrain model on how to import terrain databases are available under the directory. Help directory offers also an easy-to-use a feature to build databases. Figure 5.4a and 5.4b shows the details about the terrain profile examples.

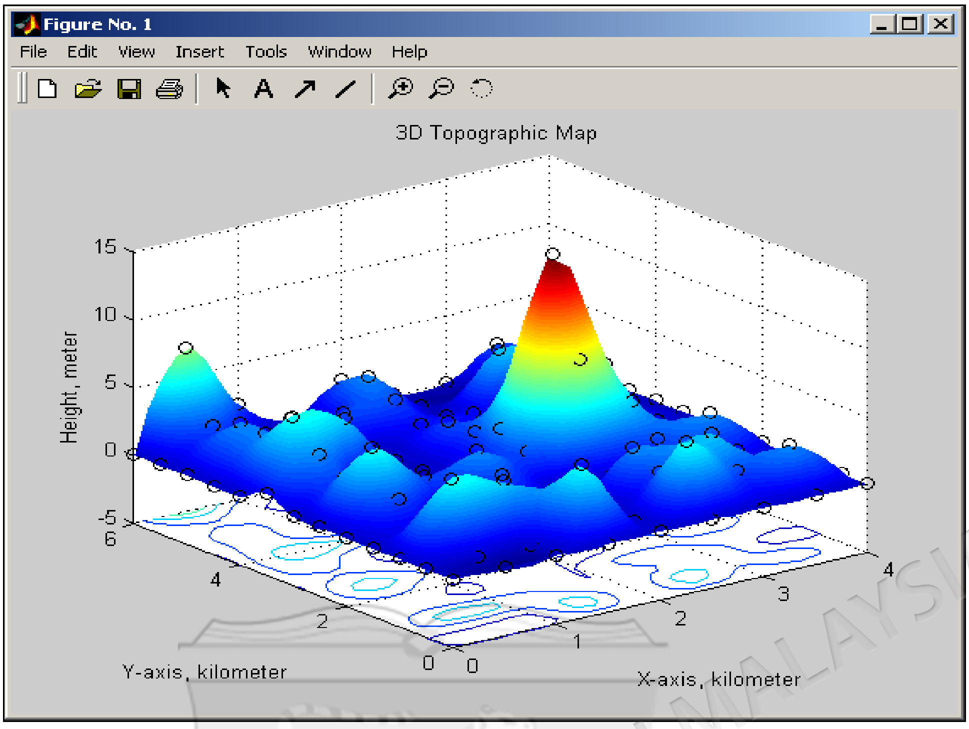


Figure 5.4a 3D terrain model

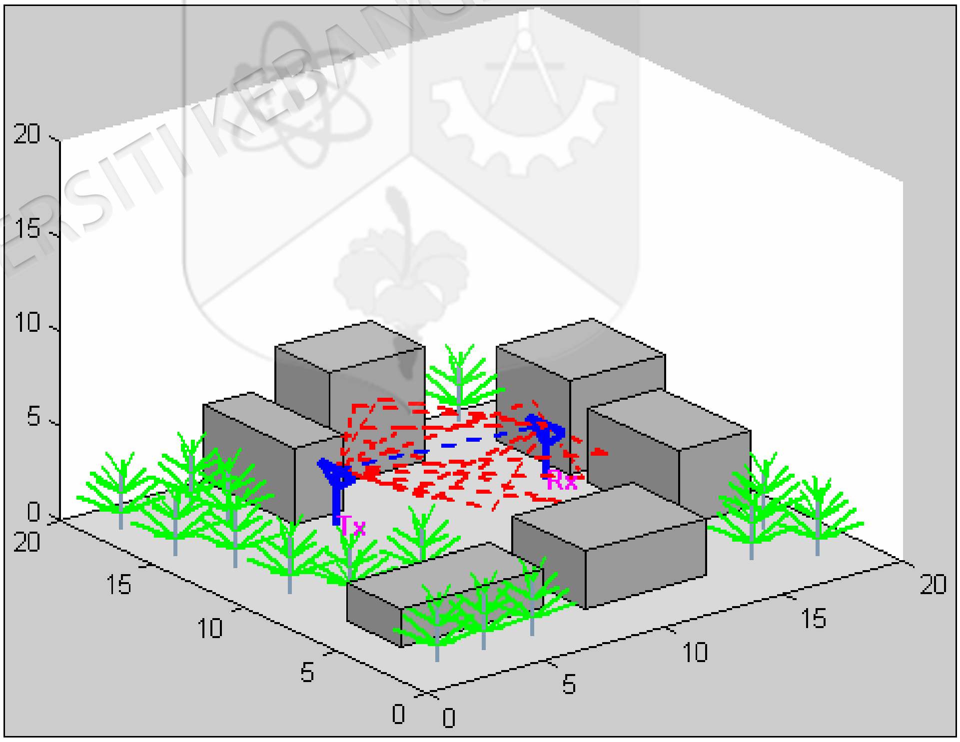


Figure 5.4b Selected environment terrains model

5.13 SITE SELECTION

Digital Ortho-image denotes an image of an area obtained from satellite imagery through Google's earth software. This information is often used as a visual reference of the area under consideration.

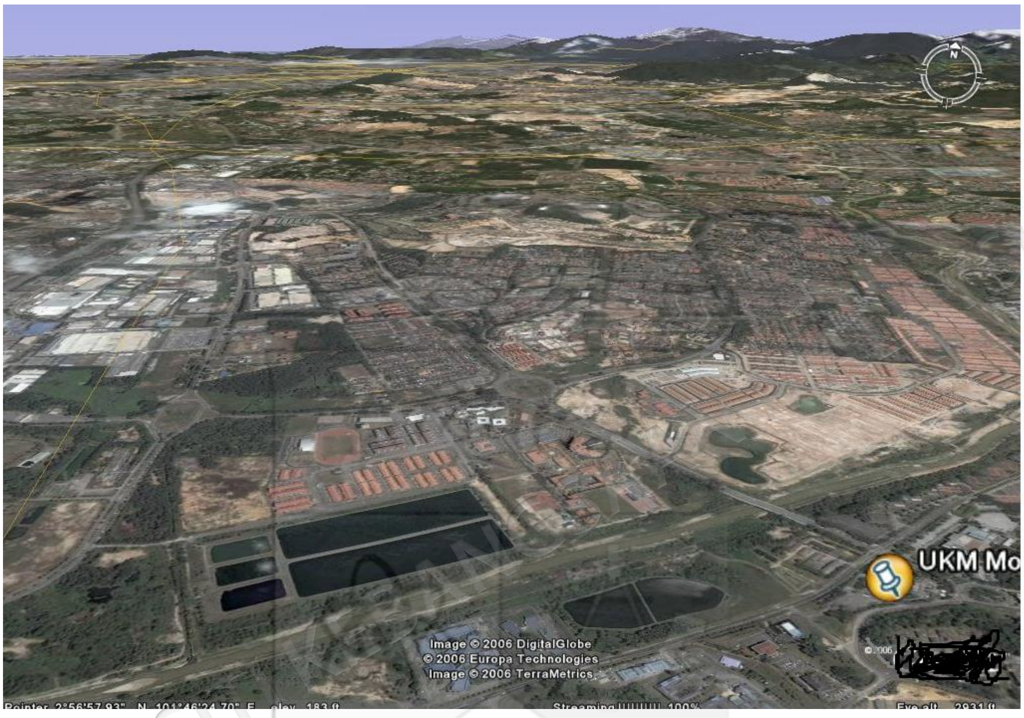


Figure 5.5 Orthogonal imagery of BBB areas
Source: Google earth 12.10.2012

Figure 5.5 shows a residential area of BBB Malaysia. The houses constructed as a mini-capital of much of the nation's government.. RF signals travel in a straight line, when the clear line of sight between antennas is ideal, and the locations of the desired links fixed. The planning of the wireless link services involved collecting information and made decisions that the sites proposed to use the line- of- sight connection in all the communication between the traffic lights. Figure 5.6 shows the traffic light proposed in the area of study.

The area under consideration of this study consisted of 14 traffic light's junctions from UKM at (Kajang) Bandar Baru Bangi to Kajang tool in the same area.

For each of two traffic lights, a set of the digital terrain model (DTM) was produced, using site survey. The counters from these maps were digitized manually, and the height's information was then converted to a DTM in which terrain heights were stored as the mean height along straight-line path between any two given points in the study region were recorded, using MapInfo. In order to calculate the height of the antenna at a fixed point in the profile the system automatically calculates the antenna received, depend on the antenna transmit topology, which could point-to-point or point-to-multipoint.

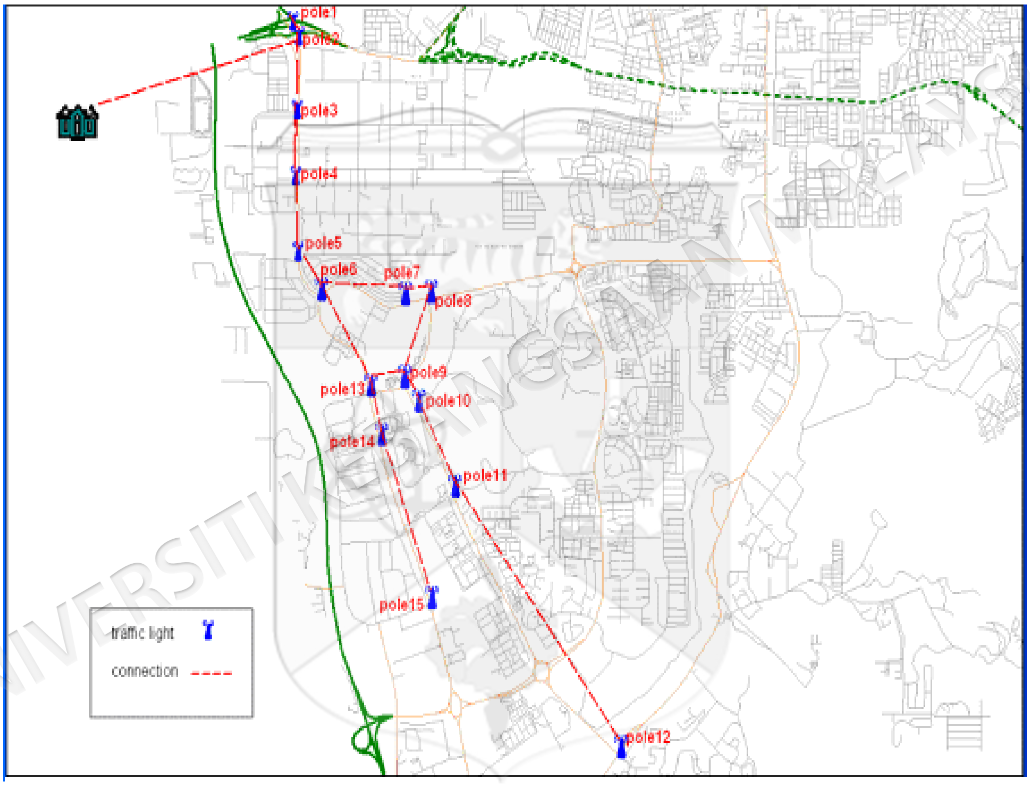


Figure 5.6 Study area and site selection

The most convenient environment database for a 3-D ray tracing software consists of many factors that represent the surfaces of buildings, trees and terrain. A large proportion of surface that cause of any significant effect on the propagation of radio waves, such as rain accumulated with the trees, humidity and other factors are easy to describe numerically and allow simple MATLAB simulation to carry it. The connection aimed to have clear edges and corners, which makes it easier to model the propagation. A software based environment model can be constructed easily using software planning tools. Hence, a software model of the terrain builds with different stage is most suited for 3-D ray tracing.

The description of the environment has to be complete and as error free as possible to obtain accurate results for the predictions. This would mean that a large number of surfaces would have to be modeled while describing the environment. However, the computational complexity of ray tracing software increases with the total number of surface (Hakkert 2001).

5.14 IMPLEMENTATION

Programming with measurements is by using the MATLAB software development. MATLB has graphical capabilities provide an integrated development environment in which to incorporate the software tools for code generation, such as a Digital Terrain Model (DTM).

The GUI used to control and obtains output from the MATLAB function converter to display the graph. Thus, the main application of the SPWPM is to execute all the codes on it. In this work, Log-Distance propagation model with measurements and ray tracing tools have been used for integrated ray detection and automatic recognition system. It is used because the ray arrival processing which represents signals in terms of time delay is often unsuitable for processing signals and it does not transparently represent the variety of wave content with time.

5.15 SUMMARY

After extensive review of the current research in wireless link planning, it can be concluded that there is a need for extensive linking predictive models. While some basic information is available in the literature, no attempts have been made to predict wireless LOS under propagation impairment based on site-specific. Furthermore, the ability to predict the actual LOS of a wireless LAN in different locations can be critically defined for efficient wireless network. Therefore, this thesis focuses on developing a link quality index throughout the software to measure the implication of site-specific to obtain an extensive measurement campaign, and creating a prediction model.

The presented SPTWPM as an application used in specific areas and prime motivation for the actual LOS plan introduced for Intelligent Traffic light management system. This software is based on Matlab programming language. The language shows that the SPTWPM integrates well with the current architecture of LOS platform. It also makes it possible to think of existing services as an aspect, while unifying the deployment process. The software shows that the input data allowed the programmer's code to be advised without being tampered with. Programmers can define methods that provide functionality while being oblivious to the various services applied to these methods. The software in particular including ray-tracing, used for checking of requirement and symmetrical data processing. By using SPTWPM enclose and aspects are useful, and have a more defined target than the other software corresponding item. Furthermore, even though the same feature can be applied (possibly with different parameters) to several environments, each such application can only affect its specific application target. Therefore, the SPTWPM aspects are easy to understand, and it is extension programs for more improvement to develop a LOS link planning based applications, enhancement and replace the services planning provided by change functions contain with the services of the selected area.

CHAPTER VI

LINK QUALITY BASED TRAFFIC QUEUE MANAGEMENT

6.1 INTRODUCTION

This chapter presents a model to estimate the levels of the environmental effect on queue management for ITLMS such systems operating at 5.8 GHz point to point and multipoint distribution.The model is site-specific in that it uses statistical analysis distribution parameters obtained from several metropolitan sites in Bandar Baru Bangi, using Map information systems (MapInfo) to describe the topographical area. This helps to obtain a realistic estimate and analyze the packet received and RSSI between the traffic junction. Together with propagation impairment allow the system to decide on an optimal setting for traffic junction control within the selected study area. These results are investigated and predict the average propagation impairment estimation.

Traffic junction control is a very important economic need. Many of the modern cities suffer from the serious traffic problems in the traffic junction control. Due to costs, lack of available space and environmental impairments, it is impossible to extend the current traffic infrastructure in many of the cases. So it is required to optimize traffic strategies to obtain better performance based on the existing traffic infrastructure.

6.2 TRAFFIC LIGHT CONTROL MODEL

The existing techniques for traffic light control are not efficiently designed, in terms of performance and queue management. Khalil et al. (2010) proposed an intelligent traffic light flow control system using wireless sensor networks, which is not adequately efficient in terms the queue management and performance effort needed. Furthermore, the impact of this system concentrating on specific junction only and not considered thoroughly to another junction. Link quality based traffic queue management utilizes and effectively managed traffic light flow is presented. Particularly, intelligent traffic light management system based on wireless to control the traffic flow sequences and queue management.

ITLMS has been introduced to the field of transportation technology as a response to the many problems that they are already starting to resolve. Really, this technology has been very useful in such aspects as traffic safety while driving, efficiency in transportation industries and different technical aspects relating to trafficking management. As these are probably the most important considerations relating to trafficking managements system, their enhancement through ITMLS constitutes a major motivation for the development of a collaborative traffic management system. Wireless communication has a strong potential to improve traffic light flow, traffic safety and driver comfort (Median et al. 2005). It can be used to provide warning information to the driver, for example at intersections, or can be used to automate tasks like lane merging or as a traffic junction control system.

Because of the deep impact of traffic control strategies, the design and decision of these strategies require much effort for traffic control. The traffic system is very complex. Thus to design better strategies and predict the results after the implementations of the strategies, it is essential to apply simulations on the dynamics of the traffic light system. The measurement, conducted to address the traffic simulation problem is based on the ITLMS theory, because of ITLMS's flexible and comprehensive modeling ability and its support to distributed simulation (Zeigler et al. 1999).

6.3 PROPOSED LINK QUALITY BASED ITLMS CONTROL

ITLMS is developed as a hierarchical intelligent system model for vehicles in the traffic light management system. This has facilitated analysis of control tasks in the vehicles queue. The proposed link quality carried out the control tasks performed for the vehicles and it is applied in the proposed system model. In many conditions, due to the high costs and safety concern, field tests and evaluations may not be applicable. Therefore, we evaluate and analyze the traffic link network via computer simulations. In this chapter, the data analysis concerned acknowledge the development of the traffic link simulator, which is designed for aiding driver and traffic control studies, such as testing, verification, evaluation leading to improvement of vehicle flow control methods and traffic management strategies. Figure 6.1 shows the link control associated in the control room.

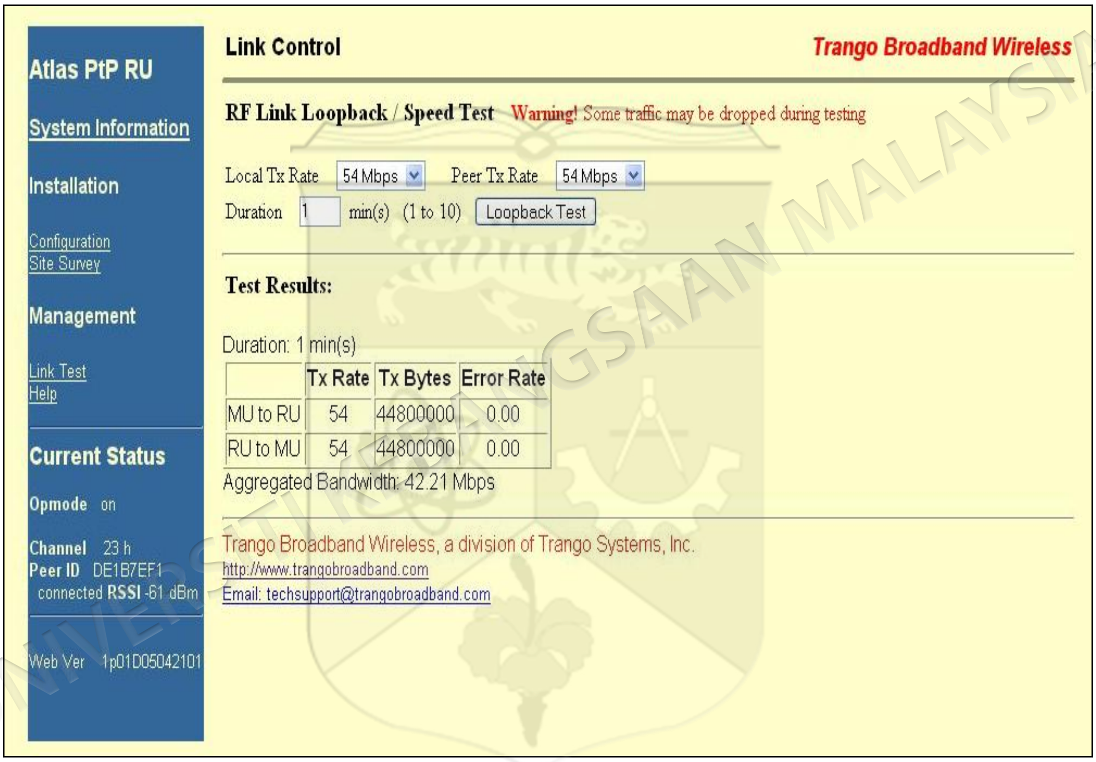


Figure 6.1 Windows view tester (RF link loopback)

6.3.1 Traffic Queue Management

ITLMS traffic simulators are simulation model that is able to manage traffic conditions to a significant level of accuracy. The principal advantage of this system is that the infrastructure is incorporated directly, and the vehicle queue is modeled based on an intelligent control level. ITLMS designed for modeling wireless traffic light management with advanced traffic control, monitoring guidance systems, is provided by researchers from Universiti Kebangsaan Malaysia. This study is investigating different aspects of traffic control and delay specification for wireless communication among traffic lights, especially implications regarding traffic efficiency based on the design of an intelligent system model as proposed. The original aspect of this analysis was based on a traffic junction and a car waiting avoidance systems. The plan considered specific data and video for evaluating such an application via the wireless link configuration system. Table 6.1 shows the time setting due to the expected lane in Warta junction for traffic control.

Table 6.1 Traffic junction parameters

Traffic Name	Queue Length	Speed Limit	Inter car Distance	Car crash Probability	Time delay
Warta junction West	300m	2m/s	5m	0.1	60 s
Warta junction East	400m	2m/s	5m	0.02	90 s
Warta junction North	100m	1m/s	5m	0.3	30 s
Warta junction South	300m	1m/s	5m	0.1	60 s

Although the model is concerning vehicle movements using a car subsequent queue, lane changing and traffic signal responding, logic with detailed traffic networks in the traffic junction network model includes the part of the program related to the traffic management and information system about the link environment, such as a signalized traffic loop, length of lanes, and speed determination, which are controlled under traffic lights with the system-defined cycling time.

The intelligent system is an automatic model which has counted the lane of the car and time allocation in the worthy cause. The systems are controlled by the position of the cars, whenever the long queue happens, the situation of the cars should be recalculated according to the input and output arrangement and the relative position between cars and the limit of the distances between cars.

ITLMS is designed for a wide range of performance of the traffic junction, including application, monitoring procedure and interrupt activity.

6.3.2 Traffic Queue Analysis in Normal Condition

The traffic junction performance and test case are the same as a use case or normal function with no environment impairments involved. Just as with a process test case, the test steps that should be carried out and the expected result of each step must match perfectly. Software via computer test script is a program created by a windows view tester as shown in Figure 6.1 and performed all the important output in the test case. As a user generally ran a single or multi test script, including data and video display using the Graphical User Interface (GUI); the simulation of a real time is sending the same network traffic status.

The normal scenario test is a description of how a set of traffic junction should be run properly. The outlines in Figure 6.2 demonstrate the report of the received signal strength indicators (RSSI) and give details on how the times a traffic flow could be run concurrently. The aim of a scenario is to simulate real traffic light usage of a system.

Performance analyses are tests that verify start to end timing of various times in auto allocated and critical processes transactions as well, while the system is under a normal condition. This situation of performance prospect under a given configuration of wireless communications highlights the testing process if modifies to need to be prepared before load testing is carried out. The test result has incorporated in a statement that had been optimized with a normal condition which could be occupied the end to end load test.

```
#> linktest 14 Control Center
local tx rate = 54 Mbps
peer  tx rate = 54 Mbps
packet size = 1600 bytes
# of packets per period = 1000
# of Cycle = 20
0>   [tx] 1000 [rx]  999 [rssi] -68  peer: [tx] 1000 -> 42.74 Mbps
1>   [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 -> 42.79 Mbps
2>   [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 -> 42.76 Mbps
3>   [tx] 1000 [rx]  999 [rssi] -69  peer: [tx] 1000 -> 42.73 Mbps
4>   [tx] 1000 [rx] 1000 [rssi] -69  peer: [tx] 1000 -> 42.82 Mbps
5>   [tx] 1000 [rx]  999 [rssi] -68  peer: [tx] 1000 -> 42.81 Mbps
6>   [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 -> 42.83 Mbps
7>   [tx] 1000 [rx] 1000 [rssi] -69  peer: [tx] 1000 -> 42.80 Mbps
8>   [tx] 1000 [rx]  999 [rssi] -68  peer: [tx] 1000 -> 42.74 Mbps
9>   [tx] 1000 [rx]  999 [rssi] -68  peer: [tx] 1000 -> 42.77 Mbps
10>  [tx] 1000 [rx]  999 [rssi] -68  peer: [tx] 1000 -> 42.74 Mbps
11>  [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 -> 42.79 Mbps
12>  [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 -> 42.76 Mbps
13>  [tx] 1000 [rx]  999 [rssi] -69  peer: [tx] 1000 -> 42.73 Mbps
14>  [tx] 1000 [rx] 1000 [rssi] -69  peer: [tx] 1000 -> 42.82 Mbps
15>  [tx] 1000 [rx]  999 [rssi] -68  peer: [tx] 1000 -> 42.81 Mbps
16>  [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 -> 42.83 Mbps
17>  [tx] 1000 [rx] 1000 [rssi] -69  peer: [tx] 1000 -> 42.80 Mbps
18>  [tx] 1000 [rx]  999 [rssi] -68  peer: [tx] 1000 -> 42.74 Mbps
19>  [tx] 1000 [rx]  999 [rssi] -68  peer: [tx] 1000 -> 42.77 Mbps

-->  [tx] 1000 [rx]  999 [rssi] -68  peer: [tx] 1000
-->  [Local PER]   0.05
-->  status: connected
```

Figure 6.2 RSSI report on the normal condition

Figure 6.2 shows a sample report generated by windows view tester RF link loop back simulator that analyzes the measurement characteristics of the link control set, providing all the necessary distributional values.

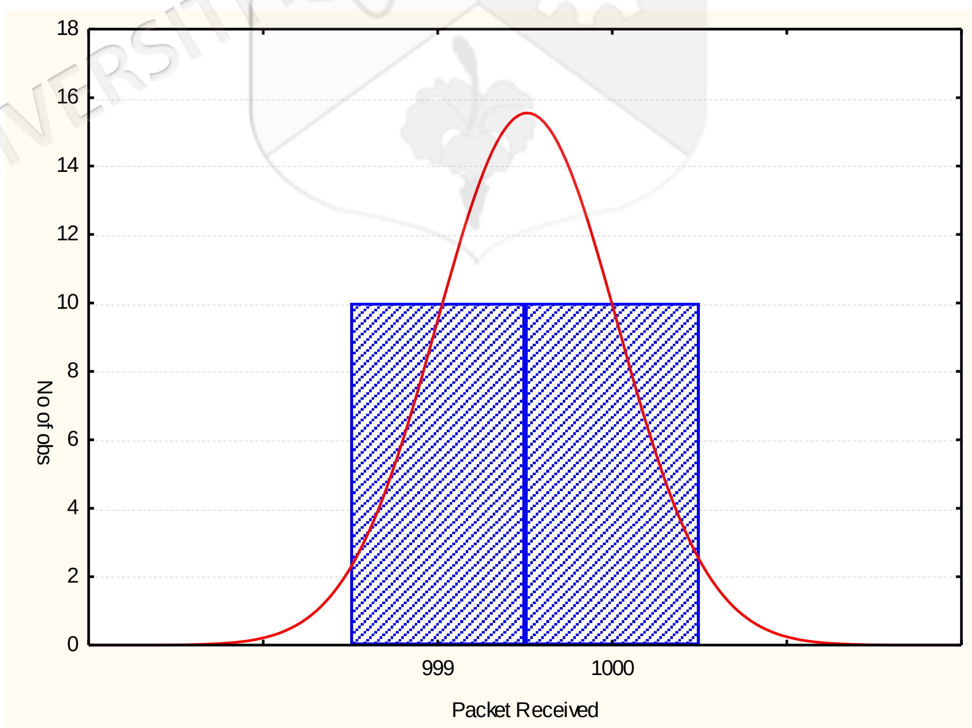


Figure 6.3 Packet received and its observation

The Packet received and its observation matches in Figure 6.3 shows the distribution of the average chief packet. The two largest observations are shown as histogram outliers. In particular, a value of 999 and 1000 packet received outlets is expected to be happening in the receiver direction of bias.

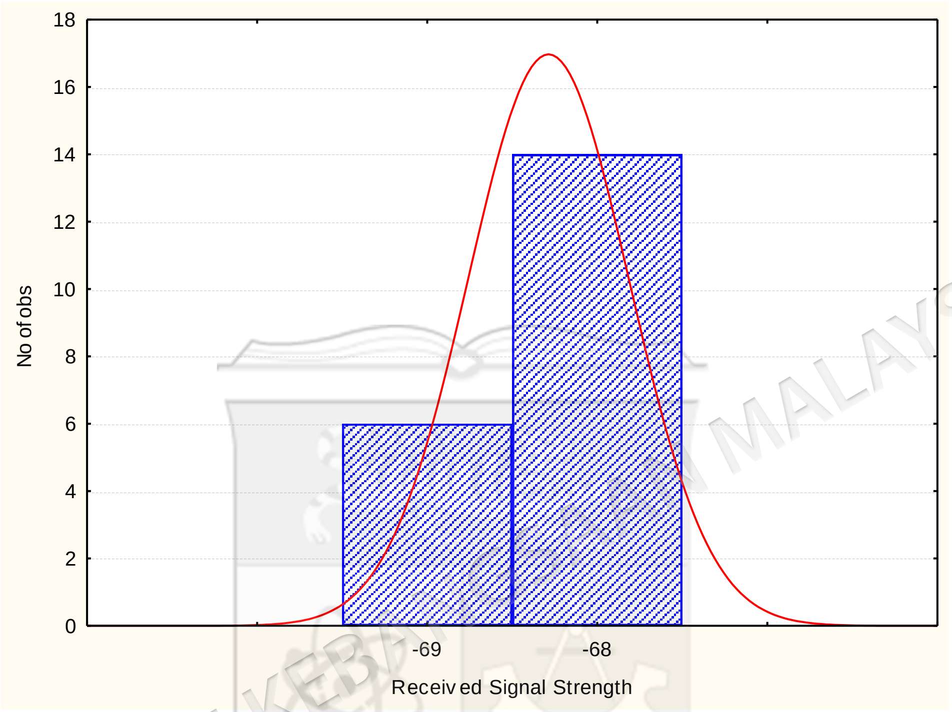


Figure 6.4 Received signal strength indicators and its observation

The received Signal Strength indicators gathered the data and its observation matches as in Figure 6.4 showing the distribution of the average acknowledged of RSSI. The two largest observations are shown as histogram outliers. In particular, a value of -69 and -68 received outlets are expected to be happening on the receiver track.

The data rate received at the receiver site and its observation matches in Figure 6.5 shows the distribution of the average acknowledged of data rate. The two largest observations are shown as histogram outliers, a value between 42.72 to 42.83 Mbps which are expected to be happening on the receiver track.

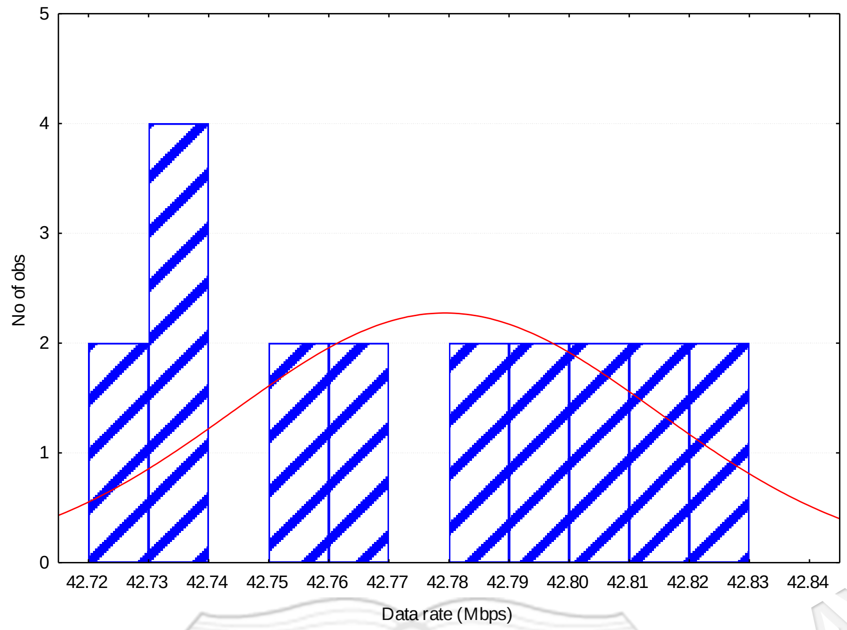


Figure 6.5 Data rate and its observation

Initially, the plots of the data rate received and dropped over the time as well as the cumulative number of each, as shown in Figure 6.5, clearly indicate the data rate at which the pattern of packets received was interrupted. For the major part, it was observed that the dropped packets corresponded to situations of propagation impairments interrupt the line-of-sight signal paths. In addition, the cumulative amount of data rate received plotted and shows how the effects of the lost packets add up over time and provide an overall percentage of packets received for the entire data set.

One objective of the project was to determine the effect of propagation impairment for the 5.8 GHz Wireless LOS link. To characterize the link behavior, the effects of environmental factors were not considered in performance to the average of the received signal strength measurements as a function of the packets received. This average was executed by sequentially conveying each transmitted and received packet in the entire data packets transmitted and received within a one hour margin of the given packet. Received packets related to signal strength was done with respect to a given period, as shown in Table 6.2. This table evaluates and visualize the strength of the relation between RSSI, and packets received dependent variable.

Table 6.2 Optimal packet received vs. RSSI

RSSI (dBm)	Received Packet	Standard deviation
-69	999.3	± 0.5
-68	999.6	± 0.3

6.3.3 Queue Management-base Propagation Impairment

As noted in this chapter, the key to achieve the success of the traffic light connection through wireless in the changing environment is flexibility and a good understanding of main concern for both operational and propagation impairments.

By performing simple measurements, the traffic light approach's performance in the worst case in most concepts runs the system successfully. Reasons of Traffic Controller, extracted from ITLMS, which provides a real-time environment where various types of antennas, control policies, and traffic management strategies can be analyzed, tested and evaluated under different propagation impairments. The simulator can interact with the antennas and controls on a real-time source. Further, it adds to realistic representations of traffic behavior at the traffic junction's points. The simulator is based on a real time simulation scheme, which updates the junction location and allocated time for each traffic junction irregularly. The input traffic light data are defined via posting the details as shown in Figure 6.2 Besides standard traffic data, which include scenario input, the administrator can input specified intersection control data, such as successful connection. Moreover, the antenna's range is also defined by administrator to simulate different types of traffic flow. The data collected from each individual junction is definitely characterized by the system performance and condition as displayed on the monitor screen as the simulation progresses.

In expressing the traffic control procedure for the worst case intersections, it is necessary to consider the relevant traffic sensations that take place during peak time. When the flow management is miscarrying, the subsequent dependent conditions will not be in steady-state. Hence, when controlling traffic at any cycle, the control arrangement should account for conditions during current cycle as well as conditions during the previous cycles. This is a critical consideration that decreases or increases the problem in much more complicated than steady-state conditions in which one cycle can enhance and applied for the entire study period. Figure 6.6 shows that the offsets are similar regardless of the queue length. It means when the queue length of the queue lane is longer, the offset for the management traffic should be longer. The result indicates that a more accurate trend of offsets would be like queue-based and the queue-based offsets were predicted on the basis of typical assumptions of speed, discharge headways and acceleration rates for giving queue lengths. Furthermore, for the worst case conditions, when a queue management does not clear completing and vehicles are left behind at the end of the green light, these vehicles should be involved in the subsequent cycle. Therefore, traffic coordination procedures that are appropriate performance for Pass conditions without congestion and less queues (Trans) indication are needed.

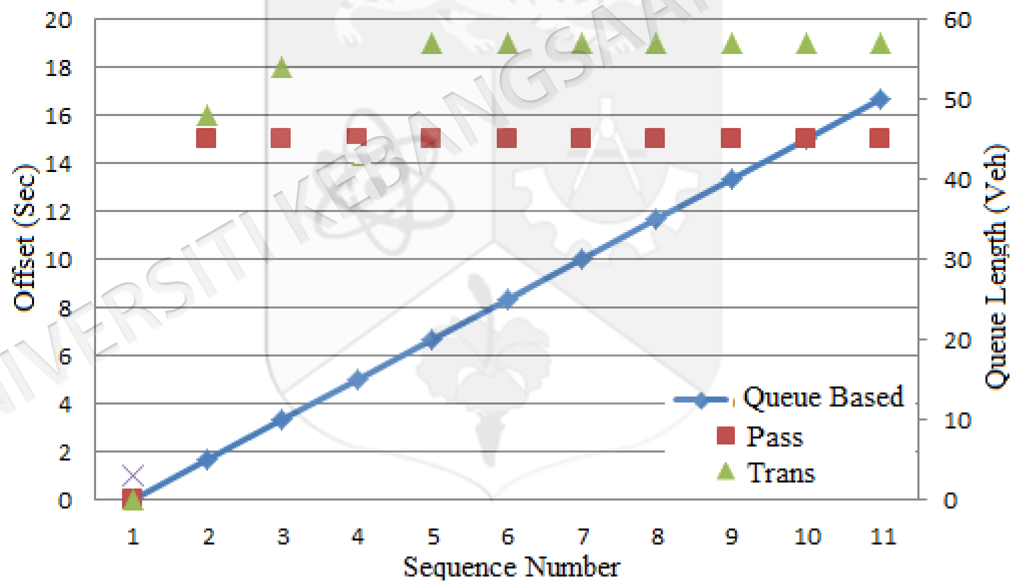


Figure 6.6 Deviations of offsets with queue length

6.3.4 Link reliability Based Traffic Light Condition

This report shows the top ten traffic lights which transmitted or received the most retry frames on an 802.11 wireless network at 5.8 GHz. A graphical break down by transmission and reception below allows one to see which access points are having a problem for clear line of sight. A few retry frames is not a serious problem. If one has retry frames, look to see if the number of retries is significant compared to the total number of frames transmitted or received due to link affected by propagation impairments. The measured frame error rate as a function of traffic condition is shown in Figure 6.7. It is reasonably flat with values typically of less than 200,000 frames at all absolute frames, due to the significant influence on system reliability.

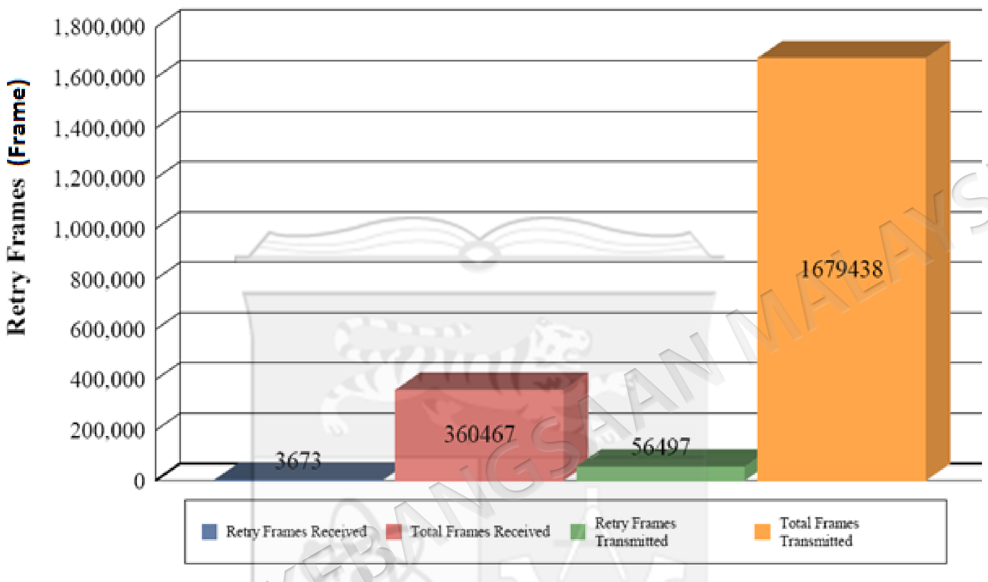


Figure 6.7 Top ten traffic light retry frames received

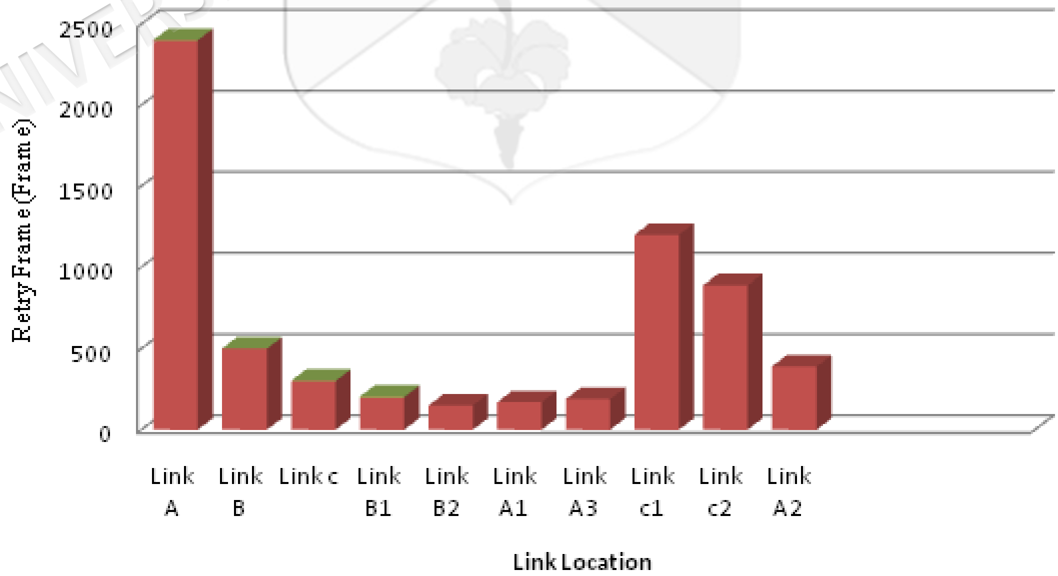


Figure 6.8 Top ten traffic light retry Frames received throughout rain accumulated with trees

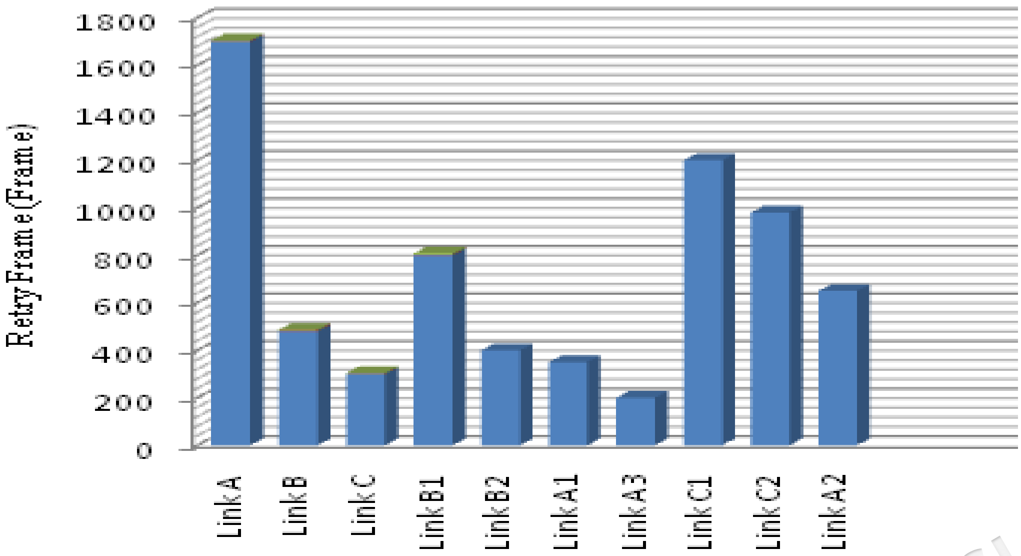


Figure 6.9 Top ten traffic light retry frames received throughout humidity accumulated with trees

The propagation impairment effect on the distribution of received packet data from the respective traffic is described in Figure 6.8 and Figure 6.9 for packet error rate analysis. If the data points that are considered as dropped packets and the packets that are kept in the brief distribution area considered as a received packet, the packet error rate of the measurement can be evaluated with plotting packet over the packet error rate. The differences and similarities between the two curves can evidently be seen in Figure 6.8 and Figure 6.9, a significant portion of the lost packets was lost as a result of this propagation factors effect.

The outline in Figure 6.10 expressed the report of a received signal strength indicator (RSSI) and given details on how the other parameters in the traffic flow could be run concurrently.

Figure 6.11 shows a sample report generated by windows view tester RF link loop back simulator that analyzes the measurement characteristics of the link control set, providing all the necessary distributional values via propagation impairment.

```
#> linktest 14 Control Center
local tx rate = 54 Mbps
packet size = 1600 bytes
# of packets per period = 1000
# of Cycle = 20
0>  [tx] 1000 [rx]  660  [rssi] -88  peer: [tx] 1000 ->  32.13 Mbps
1>  [tx] 1000 [rx]  661  [rssi] -100 peer: [tx] 1000 ->  31.20 Mbps
2>  [tx] 1000 [rx]  712  [rssi] -91  peer: [tx] 1000 ->  22.05 Mbps
3>  [tx] 1000 [rx]  712  [rssi] -91  peer: [tx] 1000 ->  22.11 Mbps
4>  [tx] 1000 [rx]  633  [rssi] -99  peer: [tx] 1000 ->  35.25 Mbps
5>  [tx] 1000 [rx]  704  [rssi] -80  peer: [tx] 1000 ->  21.13 Mbps
6>  [tx] 1000 [rx]  627  [rssi] -92  peer: [tx] 1000 ->  25.15 Mbps
7>  [tx] 1000 [rx]  625  [rssi] -105 peer: [tx] 1000 ->  26.12 Mbps
8>  [tx] 1000 [rx]  618  [rssi] -100 peer: [tx] 1000 ->  22.36 Mbps
9>  [tx] 1000 [rx]  705  [rssi] -81  peer: [tx] 1000 ->  12.75 Mbps
10> [tx] 1000 [rx]  747  [rssi] -76  peer: [tx] 1000 ->  13.19 Mbps
11> [tx] 1000 [rx]  772  [rssi] -72  peer: [tx] 1000 ->  20.31 Mbps
12> [tx] 1000 [rx]  771  [rssi] -86  peer: [tx] 1000 ->  11.15 Mbps
13> [tx] 1000 [rx]  779  [rssi] -91  peer: [tx] 1000 ->  11.14 Mbps
14> [tx] 1000 [rx]  732  [rssi] -101 peer: [tx] 1000 ->  18.68 Mbps
15> [tx] 1000 [rx]  781  [rssi] -67  peer: [tx] 1000 ->  13.05 Mbps
16> [tx] 1000 [rx]  773  [rssi] -96  peer: [tx] 1000 ->  13.55 Mbps
17> [tx] 1000 [rx]  785  [rssi] -82  peer: [tx] 1000 ->  11.65 Mbps
18> [tx] 1000 [rx]  790  [rssi] -80  peer: [tx] 1000 ->  12.85 Mbps
19> [tx] 1000 [rx]  782  [rssi] -85  peer: [tx] 1000 ->  12.54 Mbps

--> [rx]  129 [rssi] -68  peer: [tx] 1000
--> [Local PER]   0.78 %
--> status: Connected
```

Figure 6.10 RSSI report in the case of propagation impairment

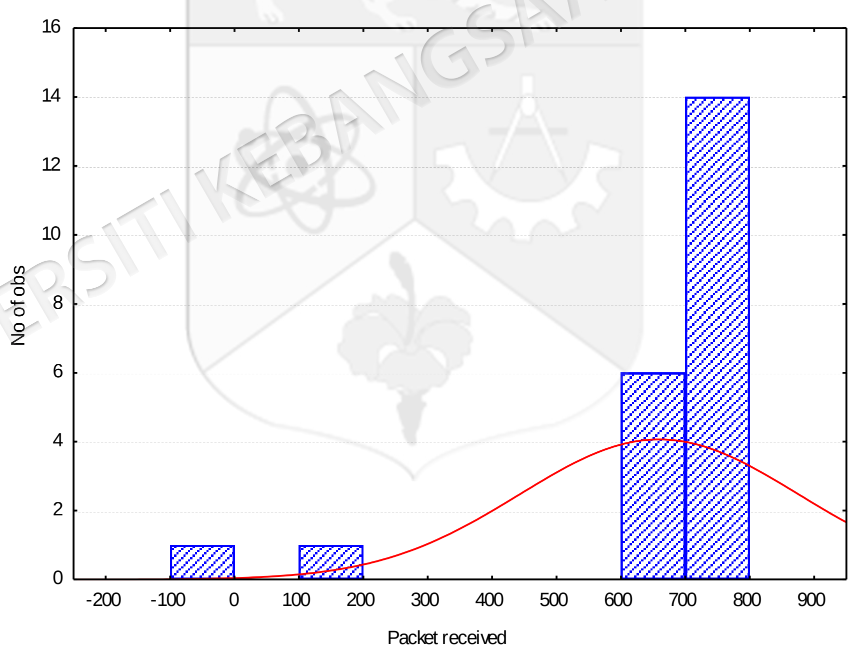


Figure 6.11 Packet received and its observation

The packet received and its observation matches in Figure 6.11 shows the distribution of the average received packet. In general, the maximum value of 800 packets received outlets is expected to be happening when the environment is involved in the propagation impairment.

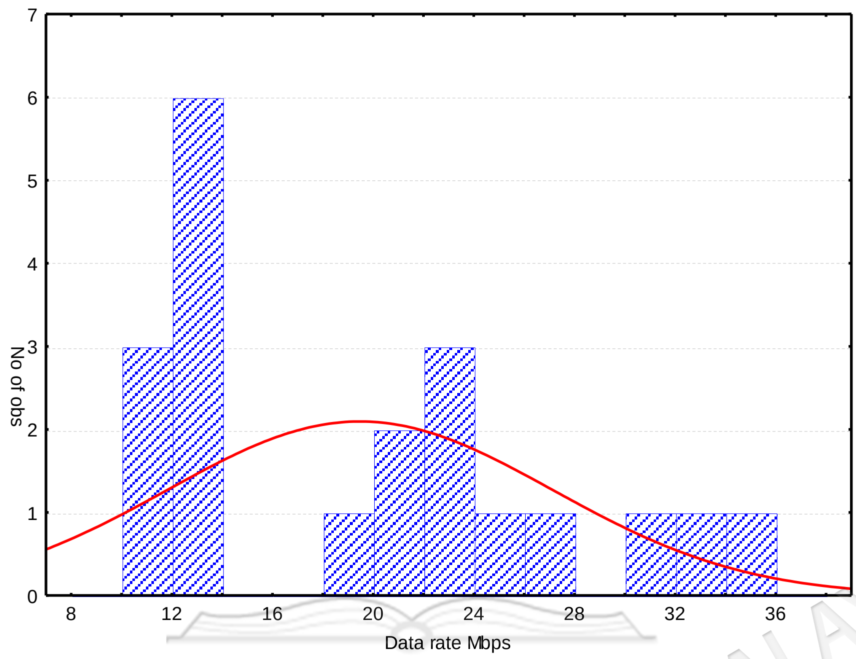


Figure 6.12 Data rate and its observation

The data rate received at the receiver site and its observation matches in Figure 6.12 shows the distribution of the average acknowledged of unstable data rate due to propagation impairment. The largest observations are shown as histogram outliers are quite low values expected to be happening in the receiver path.

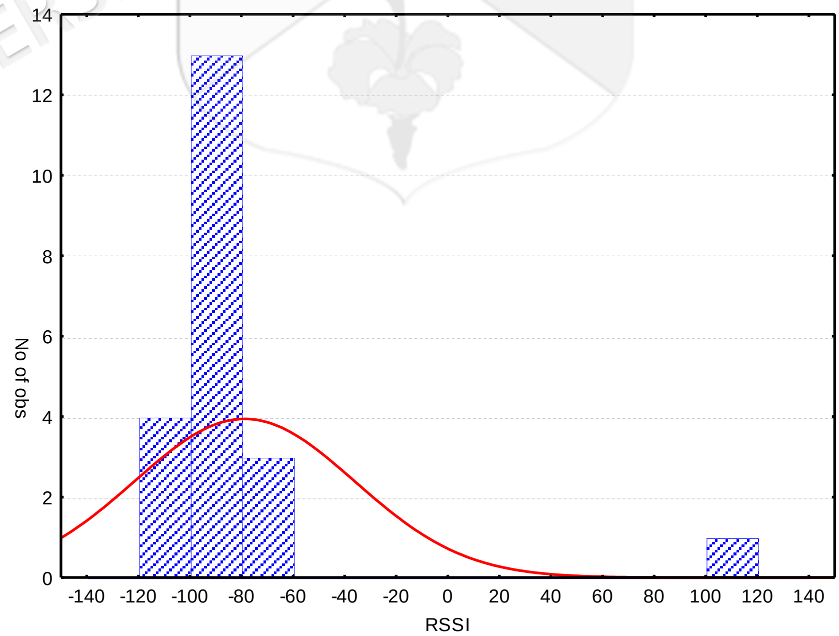


Figure 6.13 RSSI and its observation

The RSSI received at the receiver site and its observation matches in Figure 6.13 shows the distribution of the average acknowledged of the unstable value of RSSI due to propagation impairment.

6.4 RECEIVED SIGNAL STRENGTH INDICATOR

The data analysis observed the correlation between the transmitted data, and they kept packet delivery as a link connection status to be a failure or connected successfully. A possible explanation for link scenario indication is shown in a brief description of the received signal strength indicator (RSSI).

The PER curve for the reference implementations of the ITLMS in various channel condition such as humidity and rain accumulated with the trees. It is evident from this plot that the actual performance of the receiver can be measured by applying the PER values in the curve shown in Figure 6.14. Adding the required PER for each point to the receiver noise floor generated the PER vs. Received signal strength indicator curve for various data rates. Figure 6.14 shown the effect of environmental factors indicated the rain accumulated with the trees, humidity accumulated with the trees and the trees respectively.

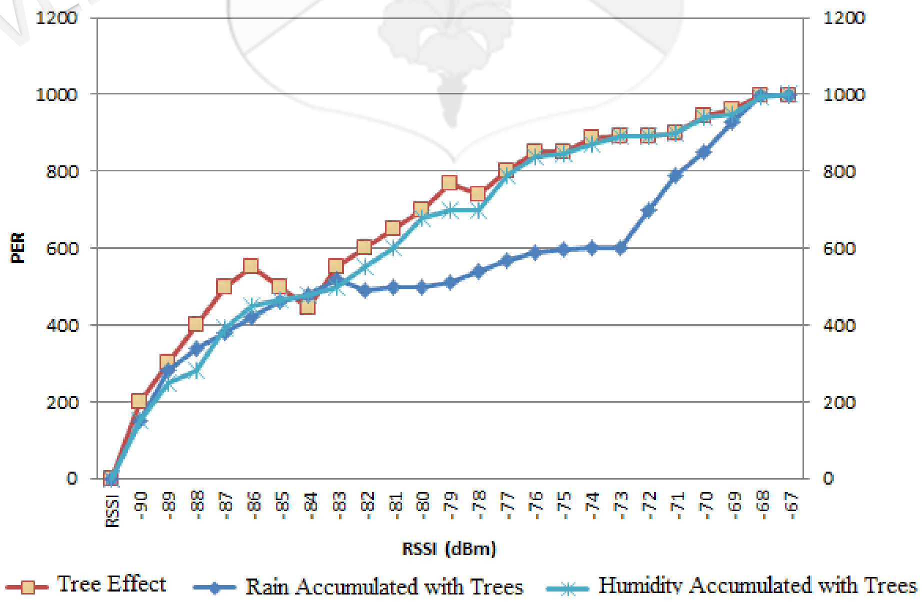


Figure 6.14 PER vs. RSSI

The results in Figure 6.15 showed the relation between RSSI of the respective traffic light management system and the cause for the packet delivery of the clear line of sight in real time link.

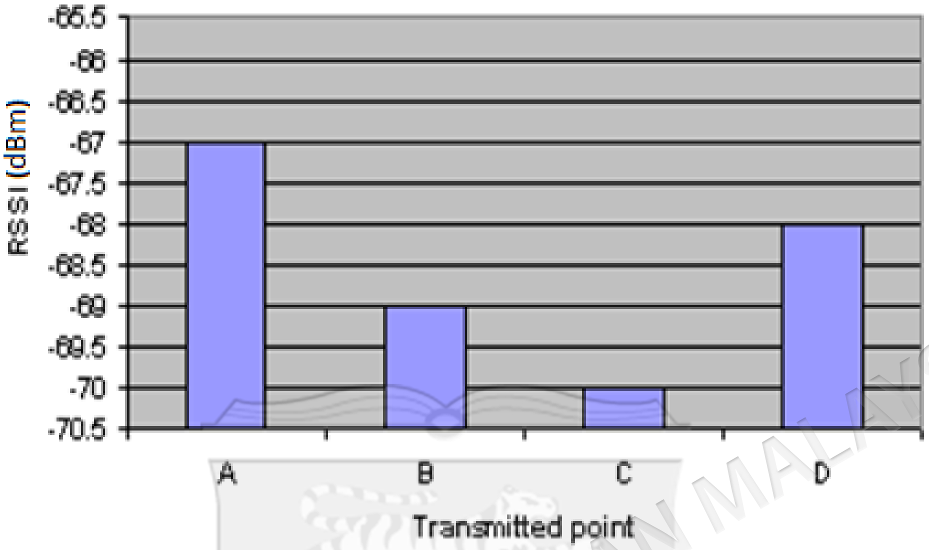


Figure 6.15 RSSI of the respective traffic light management system

The reported RSSI values of the respective traffic junctions of a correctly received link survey packet are the ratio between the correctly received and the transmitted link probe packets over a certain period. Figure 6.15 displayed the sample link of RSSI from the received link survey and data at the ends of the link. From the plot, it is shown that the side C and B have more influence to the trees and other man-made factors.

6.4.1 Queue Management Based Impairment Condition

From the data collected, it is observed that the delicate correlation between the sending and keeping in the RSSI. There are links where the RSSI is quite weak when involving crowded trees in-between. Figure 6.16 showed the relationship between the interval time and packet received for a worse case link connection.

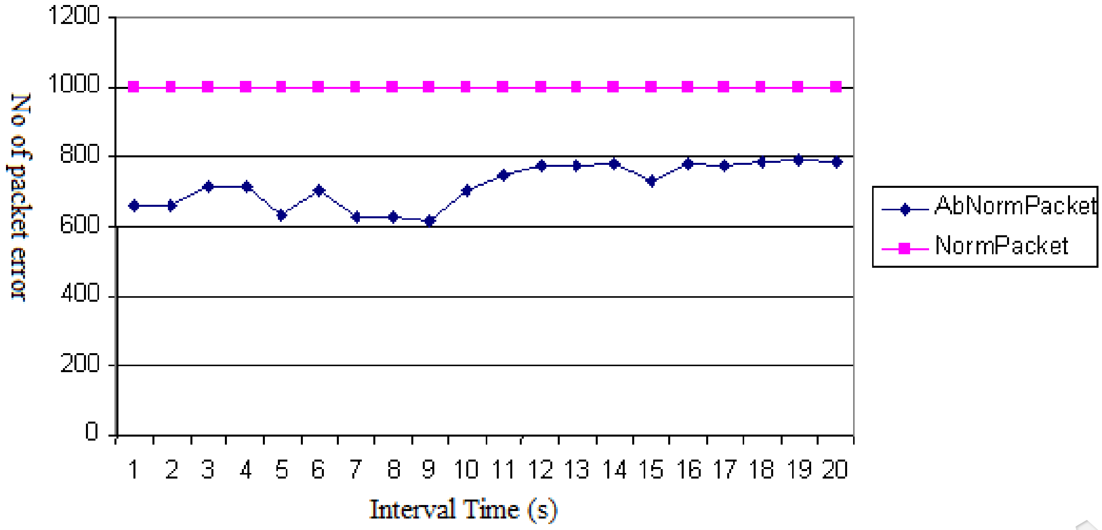


Figure 6.16 Packets error rate vs interval time in normal and abnormal condition

Figure 6.16 shows the correspondence analysis of packet received during normal and abnormal condition analyzing some measure data collected in the receiver while involving propagation impairment. The results provide information, which is related in nature to those involved with propagation factors, and they allow exploring the setting of variables included in the traffic junction.

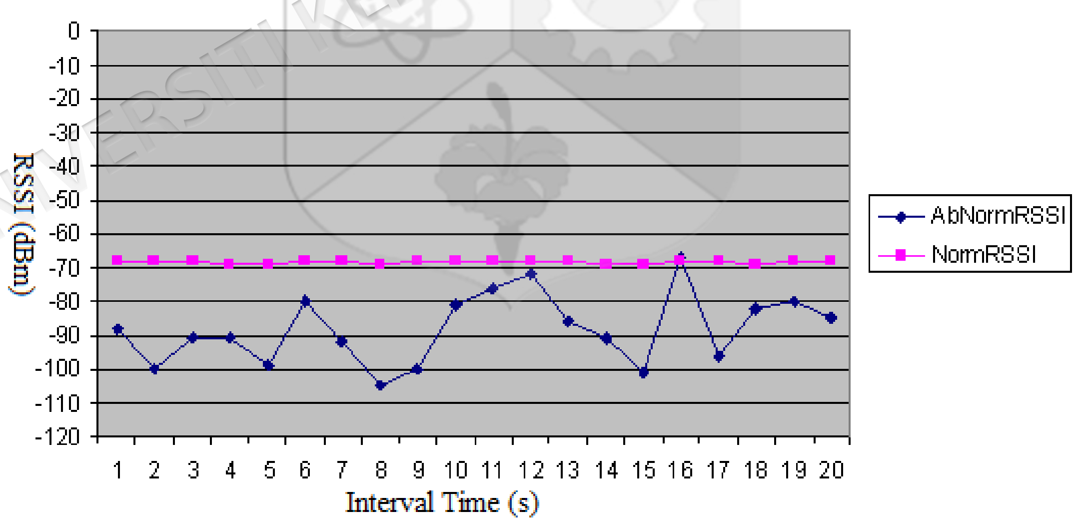


Figure 6.17 RSSI in normal and interval time

Figure 6.17 shows the correspondence analysis of the received signal strength indicators in normal and abnormal condition analyzing some measure data collected in the receiver while involving propagation impairment. The results provide information, which is related in nature to those involved with propagation factors, and they allow exploring the setting of variables included in the traffic junction.

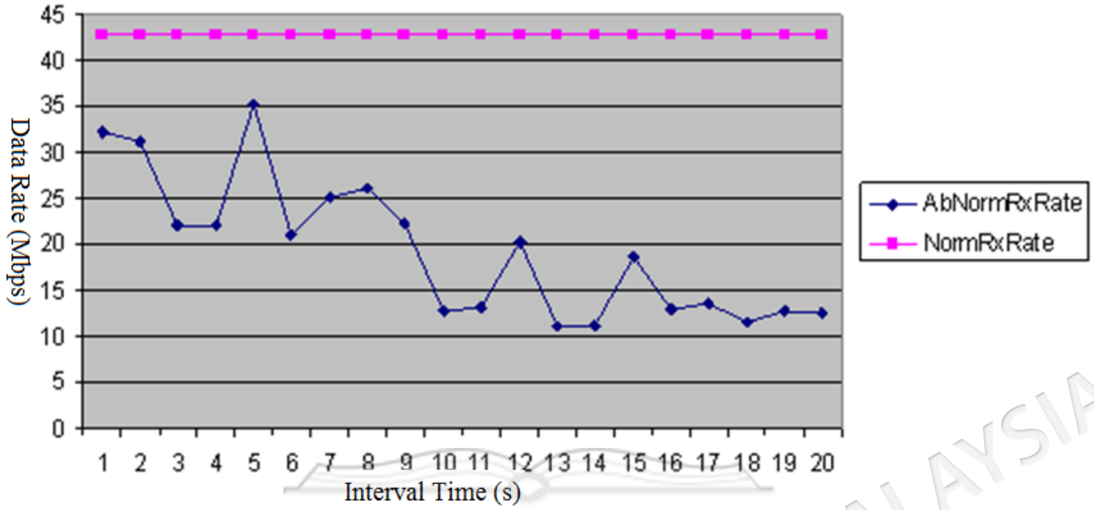


Figure 6.18 Data rate in normal and abnormal condition

Figure 6.18 shows the results that define the correlation between RSSI in normal and abnormal condition due to rain accumulated with trees on attenuation and other propagation impairments. From the measurement, it can be concluded that the RSSI and packet received can be the cause for the observation of lots of links having a good RSSI or otherwise. Therefore, a variable received by RSSI in abnormal condition in Figure 6.18 indicates the packet received dropped higher when the rain increased. Furthermore, the results show that the correspondence of RSSI with the effect when the channel engaged by the propagation impairment, so it can be concluded that propagation impairment has an important impact on the RSSI and PR relationship.

6.5 TRAFFIC ANALYSIS FOR INTERSECTION SIMULATION RESULTS

ITLMS is modeled after a traffic junction control and for safety requirements. It is a model that can be used in all traffic light management. To make the test in a simple manner, the measurement considered point to point and point to multipoint traffic light link optimization. Thus no changing parameters are allowed. The measured variables were calculated as follows and analyzed based on signal strength, packet delivery and propagation impairment.

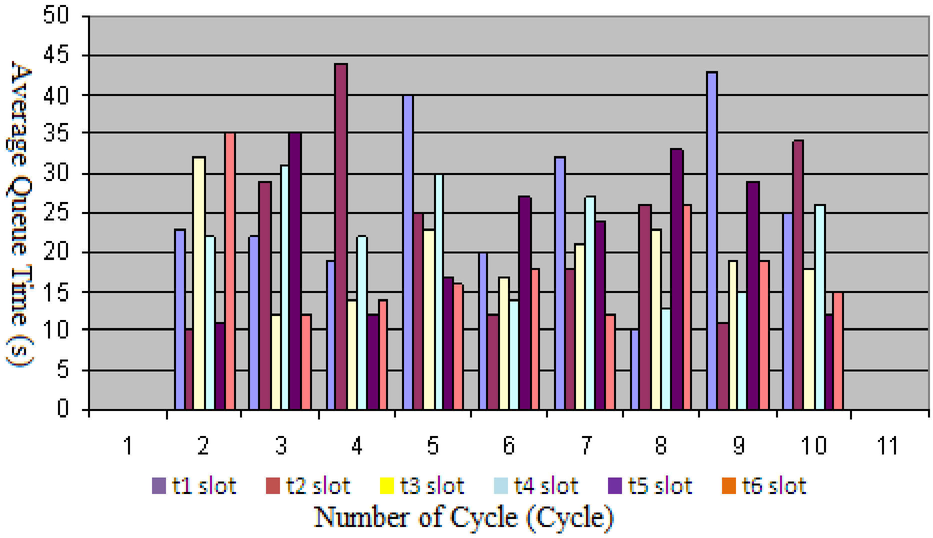


Figure 6.19 Average queue time vs. number cycle

Figure 6.19, show the results reporting for average queue time in normal condition variations over number of cycle time, the design of an intelligent traffic light management control system, utilizing and efficiently managing wireless link optimization, are presented. An adaptive traffic signal time management based on traffic queue infrastructure using system performance is proposed on a single traffic intersection.

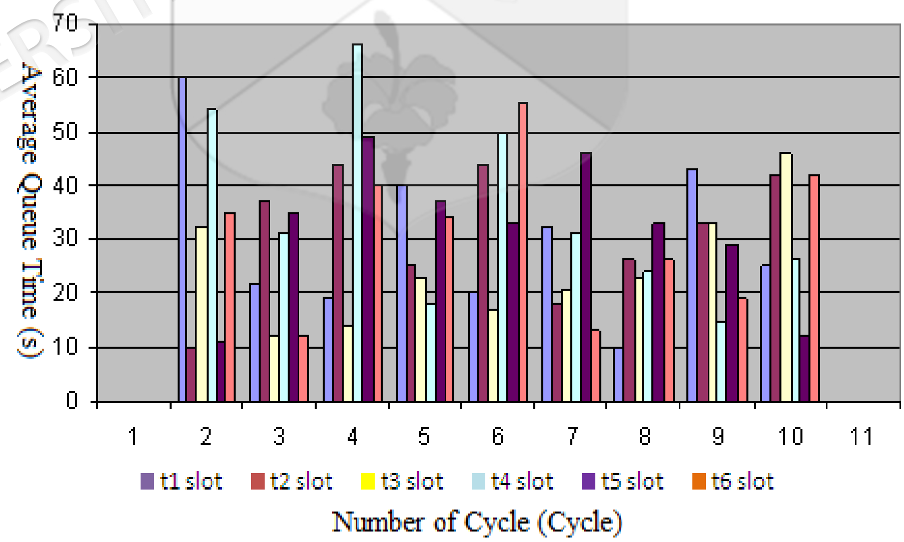


Figure 6.20 Average queue time vs. number of cycle time involving propagation impairment

Figure 6.20 shows the results reporting for average queue time in abnormal condition variations over cycle time. The proposed arrangement with its fixed algorithms is confirmed to play a major role in improving the congestion problem while compared to incompetent usual traffic control systems. In addition, the plan for a traffic control system can be simply installed and applied to the existing traffic light infrastructure considering propagation impairment and within a reasonable time. Table 6.3 shows the link successful rate for wireless connection, based on receiving signal strength indicators and packet received.

Table 6.3 Link successful rate, based on RSSI and packet received

Case considered	Packet received	Signal strength (dBm)	Successful rate %
1	1000	> -68	= 100
2	999	> -69	> 97
3	897	> -70	> 85
4	630	> -87	> 47
5	466	> -93	> 41

6.6 SUMMARY

Propagation impairments are key components in the traffic studies. In this chapter, four different measurements covering urban area and intelligent traffic light sharing networks are measured such as RSSI, packet received, data rate and delay. It is obtained to be accountable for providing real-time information in the whole traffic network. In doing so, they account for such elements as traffic functioning condition, data throughput, and path selection. The car control flow and traffic management strategies are maintained as auto defined, so users can follow the rules and regulation. The results can be summarized as follows. The measurement verified the links concerning to the packet delivery rate as well as the RSSI is mostly related factors. The default in the signal strength mainly found to be the reason for the irregularity in the PR values. The signal strength and the packet delivery rate of a link are strongly correlated. The correspondence is unstable when the channel operation is effected to propagation impairment. Finally it conclude that the impact of queue length and probability of car crash can be managed more efficiently.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

This chapter concludes the entire research on propagation modelling and link planning for intelligent traffic light management system at 5.8 GHz. Propagation environment for line-of-sight in outdoor areas utilizing wireless technology is becoming an interest of the research community in recent years. This study initially discussed the character of the topographical area and analyzed the data transmission between a PTP and PTMP for ITLMS infrastructure for normal and up-normal case and define how that is driving the necessity to design a communication system involving the traffic junction for service applications in Bandar Baru Bangi. Furthermore, it extends the indication of the utility of the frequency 5.8 GHz as a free license for hosting these intelligent communication link systems. The optimum system performance cannot be guaranteed without accurate knowledge of the fundamental physical channel between the link. This research reviewed the existing models and it was found that the existing models do not cover the case of propagation impairment factor effects as an index, which means that there must be a way to improve the propagation model for link LOS.

To fulfill the objectives of this study, four steps were conducted as mentioned in the methodology. The first step is carried out by collecting data from the field measurement for accurate prediction model as stated in the second step. The third step involves the development of the software planning tool for link planning for ITLMS. The fourth step modeled the impact of propagation impairment of ITLMS to cover the data validation.

Wireless Line-of-sight link design, also known as wireless planning, is a very complicated task for engineers and most results do not motivate a high level of confidence since there has never been a general theory that can be used in every geographic location because of the multiplicity of situations. SPT-ITLMS, with the support of statistic, has the capability to analyze a variety of geographic related factors from data collection. A regression model was built during this research represent the correlation between the residuals of the free space model for the predicted signal strength and urban area cover effect.

7.2 CONCLUSION

The study has identified that the topography of BBB area has a high buffering capacity of buildings and trees. The description of the environment has completed and as error-free as possible to obtain accurate results in the establishment model predictions.

The proposed model was able to predict the link quality index with high precision. This model provides a low end alternative to link quality techniques and can allow decision makers to plan for a more developed one.

Software planning tools have been developed for link planning operation with a quality target. Initial study has been done for link quality assessment and success rate. Although the software is presented for ITLMS networks, the concepts are general enough to be applicable to any wireless link network with similar infrastructure.

Finally, the queue management has been achieved due to the impact of propagation impairment. The measurement verified the links concerning to the packet delivery rate as well as the RSSI is mostly related factors. The default in the signal strength mainly found to be the reason for the irregularity in the PR values. The signal strength and the packet delivery rate of a link are strongly correlated. The correspondence is unstable when the channel operation is affected by the propagation impairment.

In general all objectives have been achieved, however the software limitation for link planning need to be applied and truly tested in real-time under normal and worst condition.

7.3 RECOMMENDATION

For future work and based on the limitation of the research, the following are possible subjects:

a. It is recommended that for future planning, the link quality should follow and identified the development model to fit the condition. In line with the general objectives of the study, the research should be directed to assess the implication of such characteristic on the future planning for building and trees.

b. Although the good planning can give very accurate representation of the link quality in a controlled condition, it is highly recommended to include genetic algorithms or neural network for more accuracy.

c. Despite the precision achieved by the application of link quality index model on BBB; it has not yet been tested in another area due to limitations of the scope of this study. It is recommended that future studies should be able to further test the current model on a regional scale.

d. ITLMS need to be upgraded for more advance system to detect the connection fault and restart the link failed.

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APPENDIX A

LIST OF PUBLICATION

JOURNALS

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APPENDIX B

MEASUREMENT CAMPAIGN AND ITLMS SYSTEM SETTING

Figure B.2 Height survey

Figure B.1 CCTV setup for ITLMS

Figure B.3 Pole setup

Figure B.4 Traffic junction in front of UKM gate

Figure B.5 Video display in control room from different traffic junction

Figure B.6 Antenna fixed in the pole

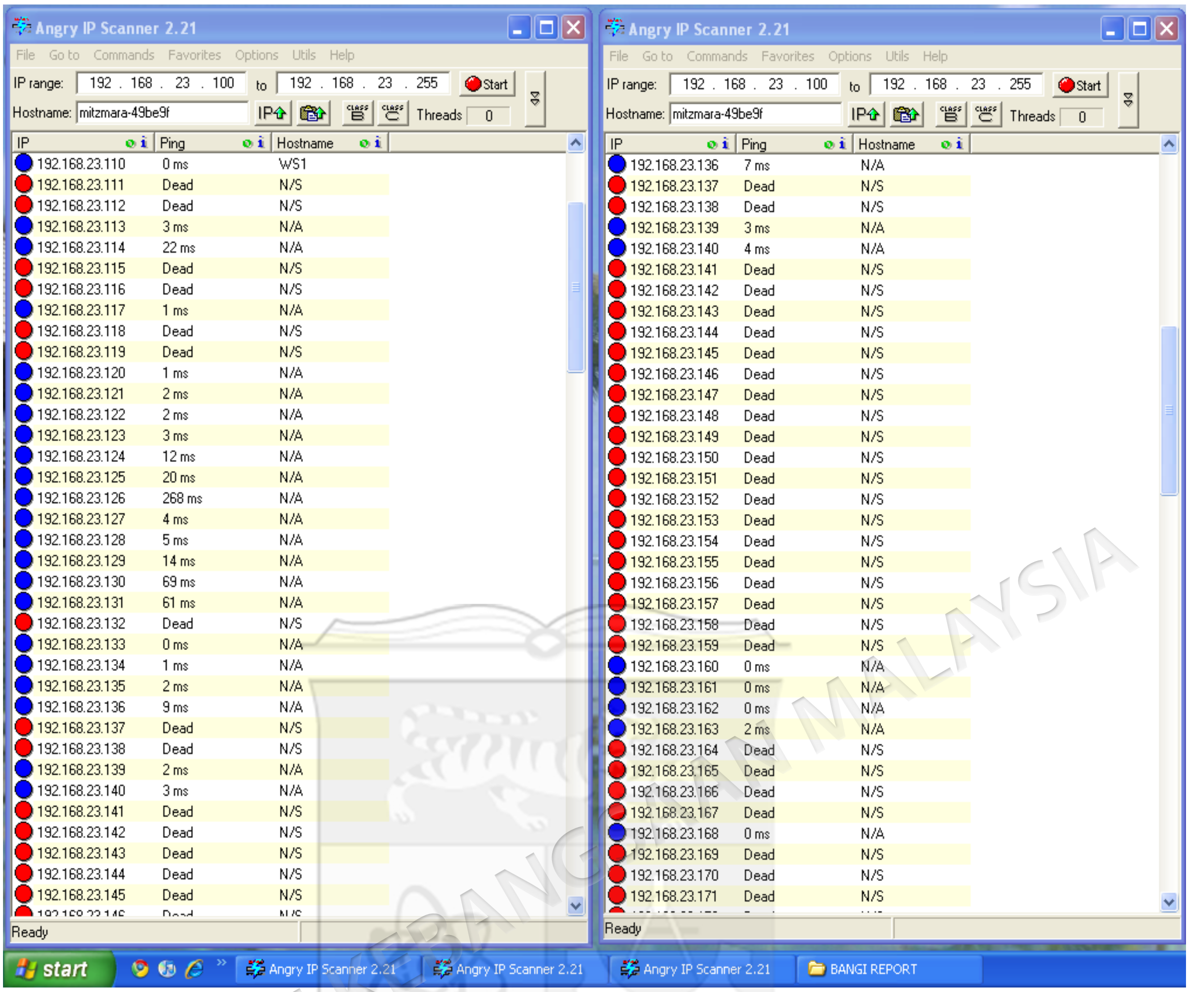

Figure B.7 Traffic light Status

Table B.1 Pole allocation

NO	LOCATION	RADIO	ADAPTER	P.O.E	LIGHTNING	REMARK
1	SHELL POLE	FSU			1	NOT INSTALL
2	TASKA POLE	AP			1	TESTED - OK
4		FSU			1	TESTED - OK
5	PIZZA POLE	AP			1	NEW INSTALL - OK
6		ATLAS	1	1	1	TESTED - OK
7	WARTA POLE	FSU			1	TESTED - OK
8	TASIK POLE	FSU			1	TESTED - OK
9	30 METER POLE	AP			1	NEW INSTALL - OK
10		ATLAS			1	NEW INSTALL - OK
11		ATLAS			1	NEW INSTALL - OK
12	TNB	ATLAS			1	TESTED - OK
13		ATLAS			1	TESTED - OK

14	FAKULTI	ATLAS		TESTED - OK
15	JKR OFFICE	SENAO		NOT INSTALL
16	JKR POLE	SENAO		NOT INSTALL
17		ATLAS		TESTED - OK
10	MASJID TOWER	ATLAS	**1**	TESTED - OK
		SENAO	**1**	NEW INSTALL - OK
	GUARD POLE	SENAO	**1**	NEW INSTALL - OK
		ATLAS	**1**	TESTED - OK
11	FAKULTI	ATLAS		TESTED - OK
12	EMPANGAN POLE	ALFA-X		TESTED - OK
13	FAKULTI	ALFA-X		TESTED - OK
14	GATE 2 POLE	ALFA-X		TESTED - OK
15	FAKULTI	ALFA-X		TESTED - OK

Table B.1 Received signal strength traffic (RSSI): sample of test result

639>	MU -69 dB	RU -69 dB	Connected
640>	MU -69 dB	RU -69 dB	Connected
641>	MU -69 dB	RU -69 dB	Connected
642>	MU -69 dB	RU -69 dB	Connected
643>	MU -69 dB	RU -69 dB	Connected
644>	MU -69 dB	RU -69 dB	Connected
645>	MU -69 dB	RU -68 dB	Connected
646>	MU -69 dB	RU -68 dB	Connected
647>	MU -69 dB	RU -68 dB	Connected
648>	MU -69 dB	RU -69 dB	Connected
649>	MU -69 dB	RU -68 dB	Connected
650>	MU -69 dB	RU -68 dB	Connected
651>	MU -69 dB	RU -69 dB	Connected
652>	MU -69 dB	RU -69 dB	Connected
653>	MU -69 dB	RU -69 dB	Connected
654>	MU -69 dB	RU -68 dB	Connected
655>	MU -69 dB	RU -68 dB	Connected
656>	MU -69 dB	RU -68 dB	Connected
657>	MU -69 dB	RU -68 dB	Connected
658>	MU -69 dB	RU -69 dB	Connected
659>	MU -69 dB	RU -69 dB	Connected
660>	MU -69 dB	RU -69 dB	Connected
661>	MU -69 dB	RU -69 dB	Connected
662>	MU -69 dB	RU -69 dB	Connected
663>	MU -69 dB	RU -69 dB	Connected
664>	MU -69 dB	RU -68 dB	Connected
665>	MU -69 dB	RU -68 dB	Connected

666>	MU	-69 dB	RU	-68 dB	Connected
667>	MU	-69 dB	RU	-69 dB	Connected
668>	MU	-69 dB	RU	-69 dB	Connected
669>	MU	-69 dB	RU	-69 dB	Connected
670>	MU	-69 dB	RU	-69 dB	Connected
671>	MU	-69 dB	RU	-69 dB	Connected
672>	MU	-69 dB	RU	-69 dB	Connected
673>	MU	-69 dB	RU	-69 dB	Connected
674>	MU	-69 dB	RU	-69 dB	Connected
675>	MU	-69 dB	RU	-69 dB	Connected
676>	MU	-69 dB	RU	-69 dB	Connected
677>	MU	-69 dB	RU	-69 dB	Connected
678>	MU	-69 dB	RU	-69 dB	Connected
679>	MU	-70 dB	RU	-68 dB	Connected
680>	MU	-69 dB	RU	-68 dB	Connected
681>	MU	-69 dB	RU	-68 dB	Connected
682>	MU	-69 dB	RU	-69 dB	Connected
683>	MU	-69 dB	RU	-69 dB	Connected
684>	MU	-69 dB	RU	-69 dB	Connected
685>	MU	-68 dB	RU	-69 dB	Connected
686>	MU	-69 dB	RU	-69 dB	Connected
687>	MU	-69 dB	RU	-69 dB	Connected
688>	MU	-69 dB	RU	-68 dB	Connected
689>	MU	-69 dB	RU	-68 dB	Connected
690>	MU	-69 dB	RU	-69 dB	Connected
691>	MU	-69 dB	RU	-68 dB	Connected
692>	MU	-69 dB	RU	-69 dB	Connected
693>	MU	-69 dB	RU	-68 dB	Connected
694>	MU	-69 dB	RU	-69 dB	Connected
695>	MU	-69 dB	RU	-69 dB	Connected
696>	MU	-69 dB	RU	-69 dB	Connected
697>	MU	-69 dB	RU	-69 dB	Connected
698>	MU	-69 dB	RU	-69 dB	Connected
699>	MU	-70 dB	RU	-69 dB	Connected
700>	MU	-69 dB	RU	-69 dB	Connected
701>	MU	-69 dB	RU	-69 dB	Connected
702>	MU	-69 dB	RU	-69 dB	Connected
703>	MU	-69 dB	RU	-69 dB	Connected
704>	MU	-69 dB	RU	-69 dB	Connected
705>	MU	-69 dB	RU	-69 dB	Connected
706>	MU	-69 dB	RU	-69 dB	Connected
707>	MU	-69 dB	RU	-68 dB	Connected
708>	MU	-69 dB	RU	-68 dB	Connected
709>	MU	-69 dB	RU	-69 dB	Connected
710>	MU	-69 dB	RU	-68 dB	Connected
711>	MU	-69 dB	RU	-69 dB	Connected
712>	MU	-69 dB	RU	-68 dB	Connected
713>	MU	-69 dB	RU	-68 dB	Connected
714>	MU	-69 dB	RU	-69 dB	Connected

```
715> MU  -69 dB    RU  -69 dB    Connected
716> MU  -69 dB    RU  -68 dB    Connected
717> MU  -69 dB    RU  -69 dB    Connected
718> MU  -69 dB    RU  -68 dB    Connected
719> MU  -69 dB    RU  -69 dB    Connected
720> MU  -69 dB    RU  -69 dB    Connected
721> MU  -69 dB    RU  -68 dB    Connected
722> MU  -69 dB    RU  -68 dB    Connected
723> MU  -69 dB    RU  -68 dB    Connected
724> MU  -69 dB    RU  -68 dB    Connected
725> MU  -69 dB    RU  -68 dB    Connected
726> MU  -69 dB    RU  -69 dB    Connected
727> MU  -69 dB    RU  -69 dB    Connected
728> MU  -69 dB    RU  -69 dB    Connected
729> MU  -69 dB    RU  -69 dB    Connected
730> MU  -69 dB    RU  -69 dB    Connected
731> MU  -69 dB    RU  -69 dB    Connected
732> MU  -69 dB    RU  -69 dB    Connected
733> MU  -69 dB    RU  -69 dB    Connected
734> MU  -69 dB    RU  -69 dB    Connected
735> MU  -69 dB    RU  -69 dB    Connected
736> MU  -70 dB    RU  -69 dB    Connected
737> MU  -69 dB    RU  -69 dB    Connected
738> MU  -69 dB    RU  -69 dB    Connected
739> MU  -69 dB    RU  -69 dB    Connected
740> MU  -69 dB    RU  -69 dB    Connected
741> MU  -69 dB    RU  -68 dB    Connected
742> MU  -69 dB    RU  -69 dB    Connected
743> MU  -69 dB    RU  -69 dB    Connected
744> MU  -70 dB    RU  -69 dB    Connected
745> MU  -69 dB    RU  -69 dB    Connected
746> MU  -69 dB    RU  -69 dB    Connected
747> MU  -69 dB    RU  -69 dB    Connected
748> MU  -69 dB    RU  -69 dB    Connected
749> MU  -69 dB    RU  -69 dB    Connected
750> MU  -70 dB    RU  -69 dB    Connected
751> MU  -69 dB    RU  -69 dB    Connected

Success.
#> link test 12 12
link: not found.
#>
#> linktest 12 12
local tx rate = 12 Mbps
peer  tx rate = 12 Mbps
packet size = 1600 bytes
# of packets per period = 1000
# of Cycle = 10
0> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  11.29 Mbps
```

```
1> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  11.29 Mbps
2> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  11.29 Mbps
3> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  11.29 Mbps
4> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  11.29 Mbps
5> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -68 ->  11.29 Mbps
6> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  11.29 Mbps
7> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  11.29 Mbps
8> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  11.29 Mbps
9> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  11.29 Mbps

--> [tx] 10000 [rx] 10000 [rssi] -68  peer: [tx] 10000 [rx] 10000 [rssi] -68
--> [Local PER]   0.00 %  [Peer PER]   0.00 %

Success.
#> linktest 24 24
local tx rate = 24 Mbps
peer  tx rate = 24 Mbps
packet size = 1600 bytes
# of packets per period = 1000
# of Cycle = 10
0> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  21.44 Mbps
1> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  21.43 Mbps
2> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  21.44 Mbps
3> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -68 ->  21.43 Mbps
4> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  21.44 Mbps
5> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  21.43 Mbps
6> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  21.44 Mbps
7> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  21.44 Mbps
8> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  21.44 Mbps
9> [tx] 1000 [rx] 1000 [rssi] -68  peer: [tx] 1000 [rx] 1000 [rssi] -69 ->  21.44 Mbps
```

APPENDIX C

SOFTWARE OPERATION

C1. HOW TO OPERATE THE SOFTWARE?

1. You only need to click on the file in the main window. When your browser asks you what to do with the downloaded file, select "ok" (your browser's wording may vary) and pick appropriate parameters. If that doesn't work, for some reason, on Matlab Window you can exit the program with the second mouse button (Exit) to get the pop-up menu and select "ok Target As..." (again, the files downloading).
2. It is strongly recommended to use another program if you're downloading large data files. SPWPM doesn't support download from other formats rather than excel or notepad, and will not help you out if there is a problem with your download.
3. You should try the mirrors before reporting broken links. We're using mirror links to balance the file load for numerous download requests and, sometimes mirror links can be faster than the main download link.

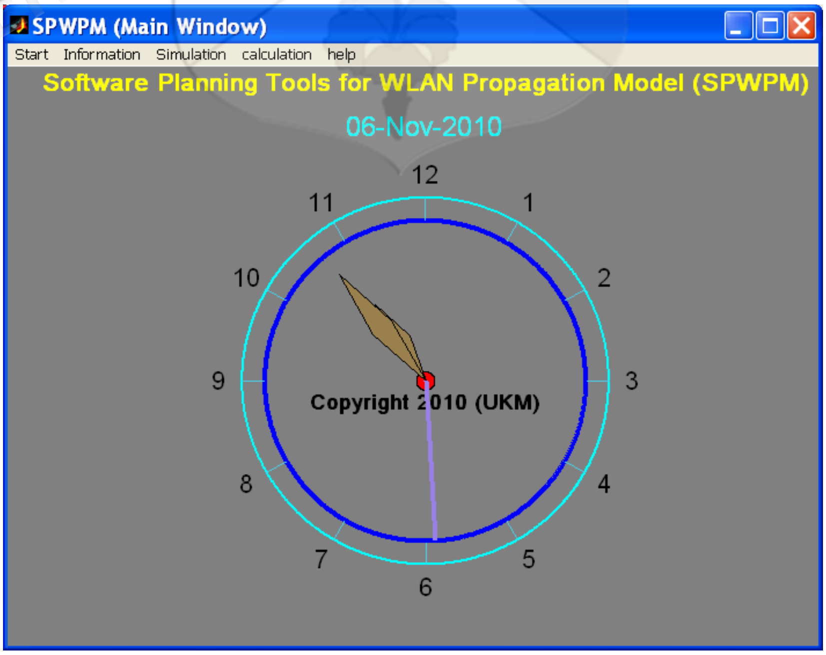

Figure C.1 Main window

C.1.1 Start Menu

The start menu is a feature that automates an operation and helps you perform that operation. It displays a dialog box that asks you to agree in order to load the all parameters or reject the operation. If you agree, the wizard will load all the parameters according to your files given to instruction. Use it to create program categories you need and sort your programs by them. It allows you a simple handling and complete control of applications, which starts with Windows. The controlled starting mode makes it possible to start the programs in a defined order and optionally specify a good alternative to the software Start Menu as friendly and intuitive. It provides quick access to your favorite parameters, files.

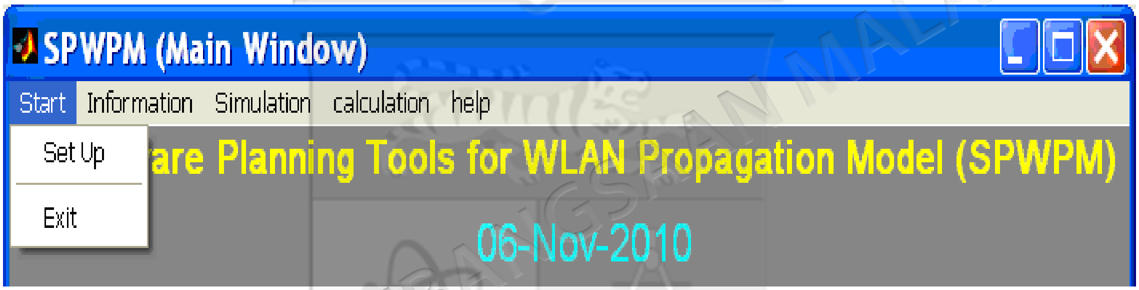

Figure C.2 Windows start to setup or exit

The software dialog box appears only when you first start the software as shown the windows menu. After you select (no) to close the window or (ok) to load the files related to the software. The dialog box won't appear until the next time you start the software again.

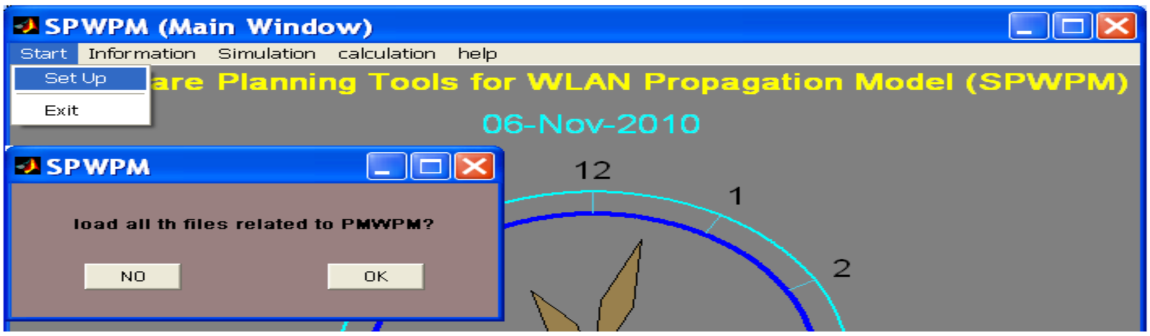

Figure C.3 Select the method you want to use to run the software

C.1.2 Information Menu

The tools and information need to prepare for the software are presented in the reasonable and brief process; such as a Fresnel zone, an area of study, software description, measurement equipment and method, and the software objectives.

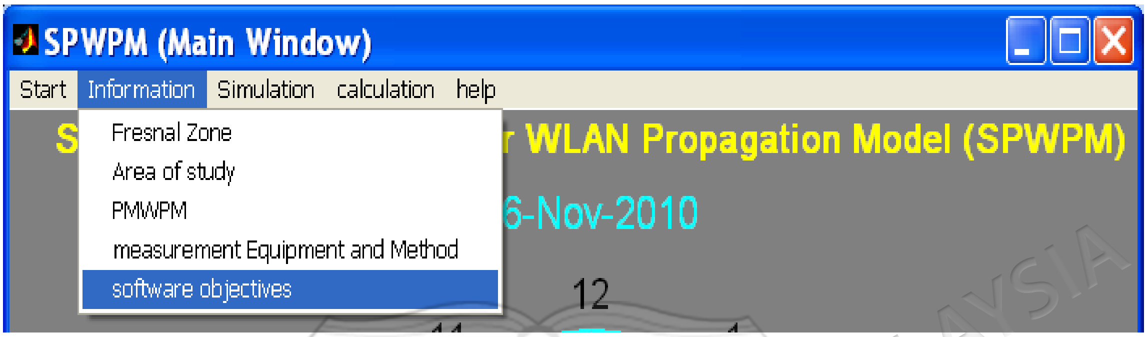

Figure C.4 Informationwindows

C.1.3 Simulation Menu

Simulation is a powerful and intuitive software organization tool that allows arranging frequently used files, folders and applications into their own groups and categories, providing quick access without disrupting the other functional work environment. In order to achieve the above-mentioned objectives, the present development provides Tools and method for ably running an execution function containing instructions for running a simulation program. Windows information, shows a computer system for executing code according to the present creation.

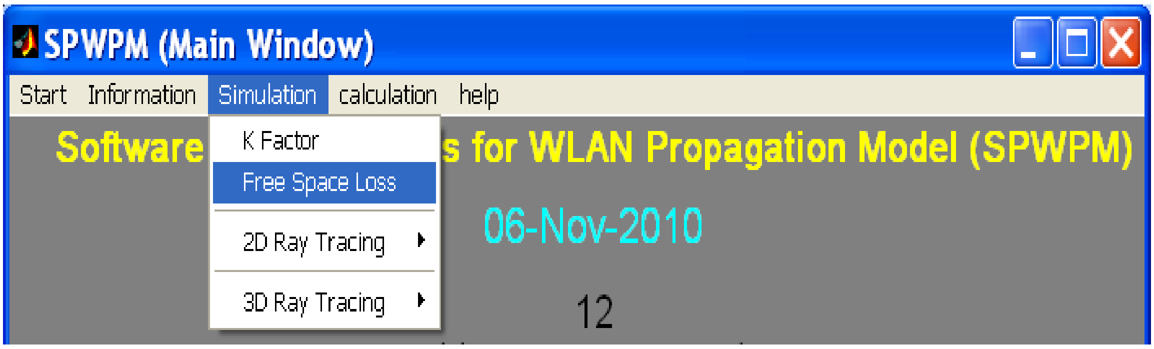

Figure C.5 Simulation window

C.1.4 Calculation Menu

This menu shows a program system for executing code with a mathematical equation according to the current input.

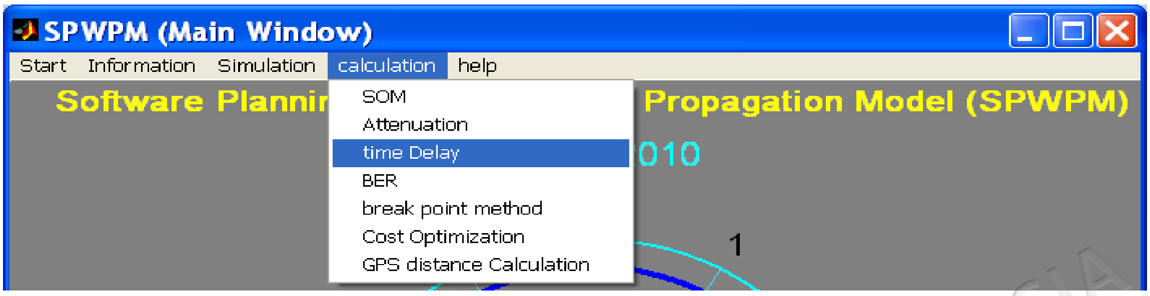

Figure C.6 Calculation procedure

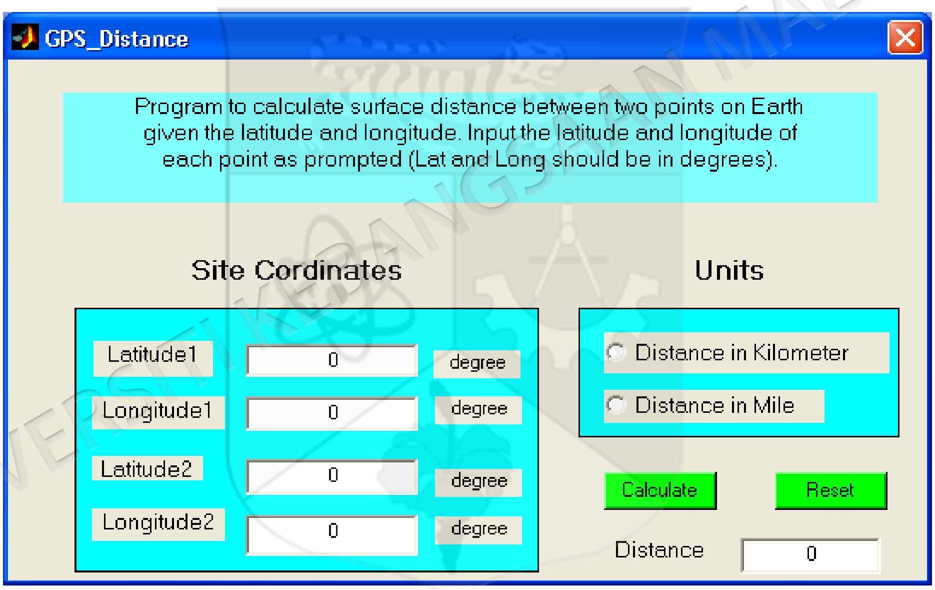

Figure C.7 Dialog box for distance calculation

C.1.5 Help Menu

The help menu is a reference guide to use the software. Referring to the help window for a detailed explanation and the debugging method, a display window will appear and following examples might be different according to the information displayed in the screen.

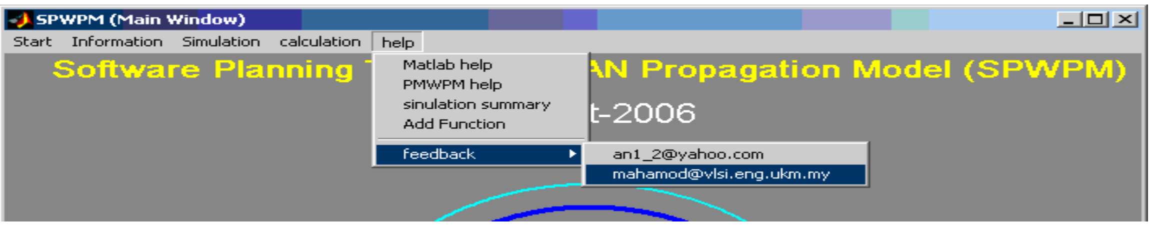

Figure C.8 Feedback windows

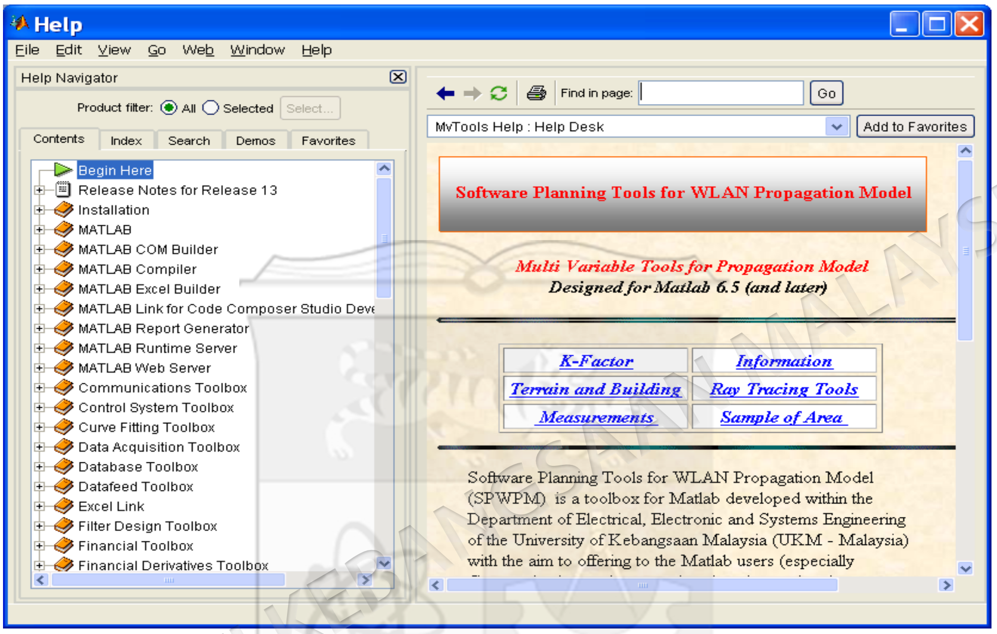

Figure C.9 Help Desk

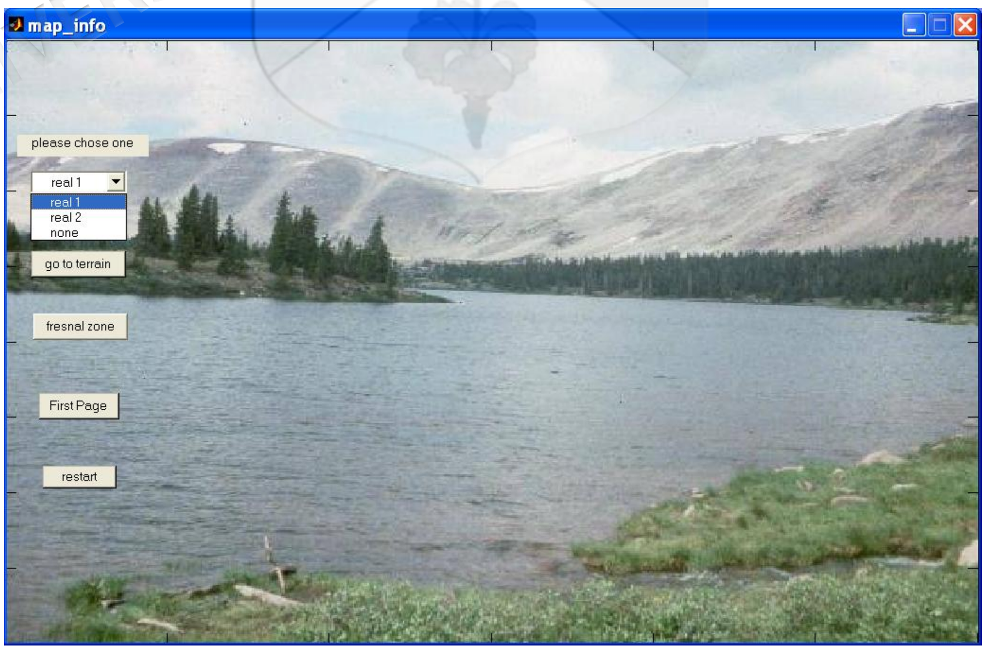

Figure C.10 Mapinfo

C.2 RAY TRACING AND DELAY CALCULATION

Presently, for the planning of wireless cellular networks in urban scenarios either empirical or ray tracing propagation models are reused. In this thesis, the approach was considering the measurements in different urban area in Bandar Baru Bangi. When there is a main stationary signal component, such as a line-of-sight propagation path, in such a situation, random multipath components received from different angles are applied to a stationary dominant signal. The effect of the main signal arriving with much weaker multipath signals gives the increase to the Rican distribution based on system operating margin (SOM).

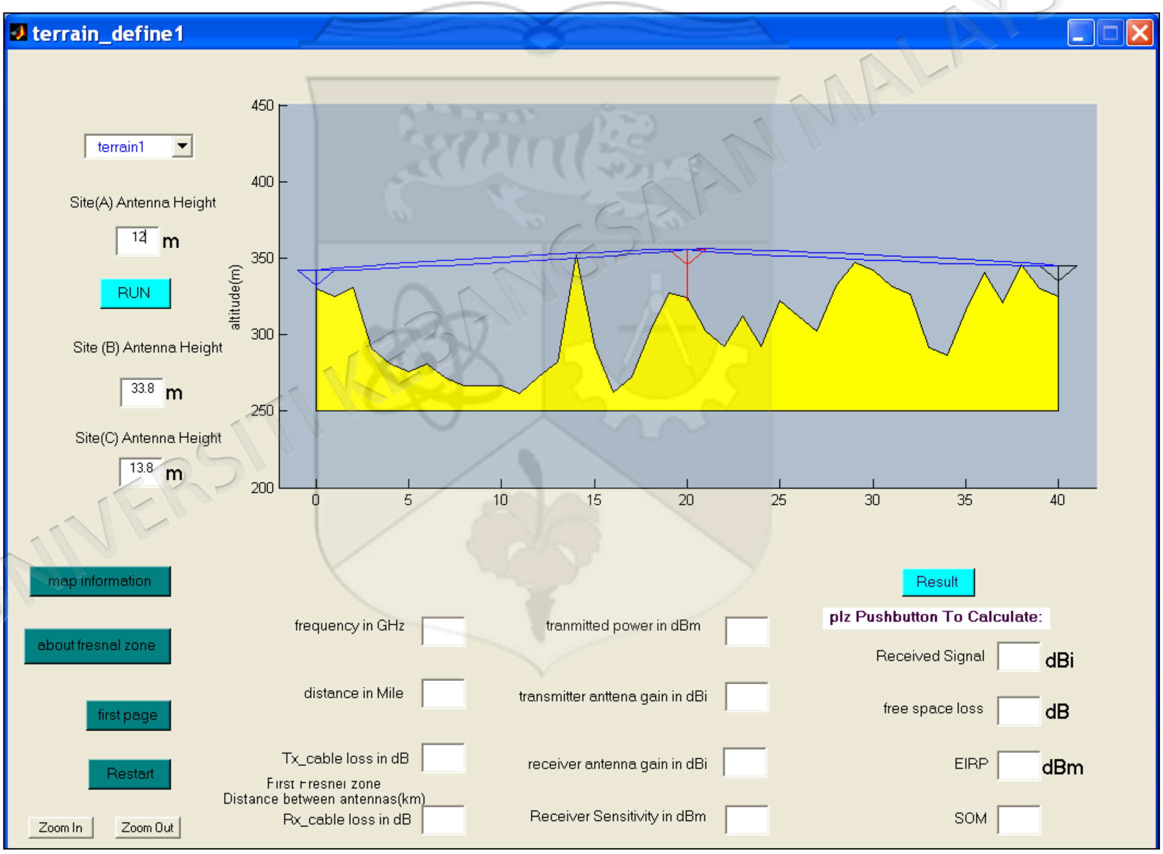

Figure C.11 System operating margin calculations

The transmitting and identical receiving antennas were mounted on two separate identical areas, of heights adjustable in the range 5 to 5m. Both antennas were conducted as a directional antenna, which was applied to certain parameters as shown in (3D), (2D). Furthermore, the software has the flexibility to extend the area for giving train information. The result found that by increasing the umber of rays the error will further be reduced as mentioned in the abstract. In addition, the SPT-ITLMS could estimate other parameters such as RMS delay spread and data throughput in the LOS and NLOS conditions based on giving parameters.

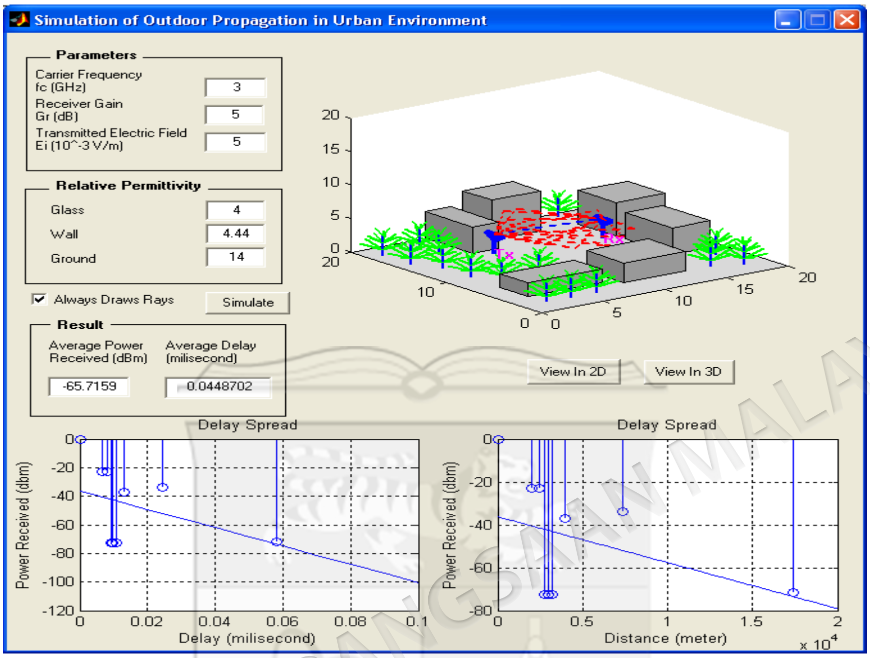

Figure C.12 GUI for 3D ray tracing tools

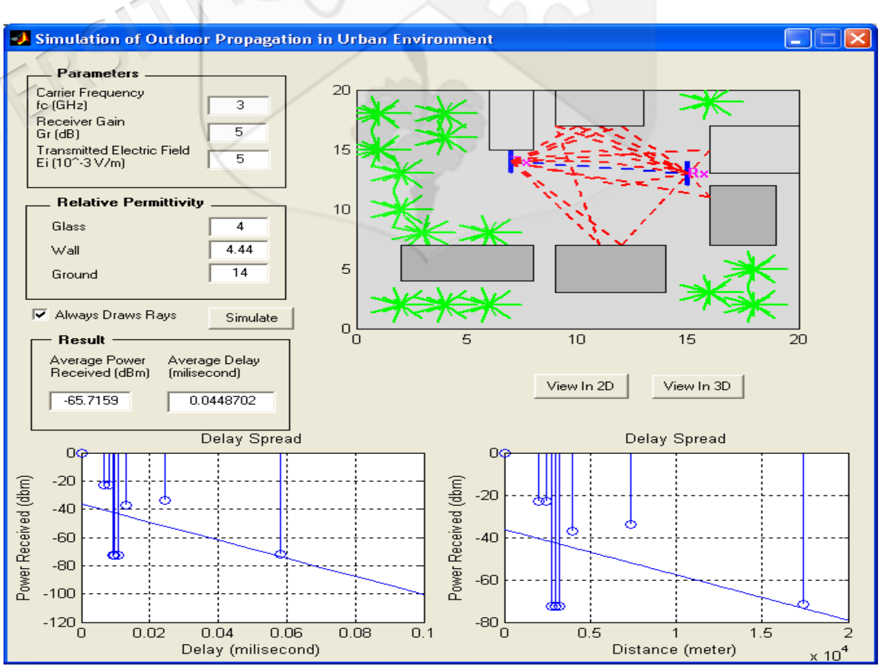

Figure C.13 2D ray tracing model