OUTDOOR PROPAGATION PREDICTION AND MEASUREMENT POINT TO POINT FOR WIRELESS LAN APPLICATION

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ABSTRACT

Wireless Local Area Networks (WLANs) have emerged as a powerful architecture capable of supporting the requirements of broadband wireless communications. In this project, an outdoor propagation prediction is made for a point-to point microwave link (bridging) at Kolej KRP Universiti Teknologi Malaysia (UTM), Johor, Malaysia. The link operates at frequency 5.8 GHz based on IEEE 802.11a standard, the antenna gains was 17 dBi for both transmitter and receiver. The transmitted power was 18 dBm. The measurement of the signal strength was carried out in the site where the link stands. The transmitter antenna mounted on the top of the fellow office G_{01}, while the receiver distance 113m, at the building G_{02}. A simulation of the same microwave link was carried out using a site specific propagation prediction tool provided by Site Ware Technologies. The simulation tool is a three-dimensional (3-D) ray tracing code employing modified shoot and bounce ray (SBR) method know as the Vertical Plane Launch (VPL). Then that presented simulation result into three dimensional using Matlab software. The result From VPL simulation is a path loss about -54 dB, the delay spread equal to 0.068 ns. The measured signal strength on the field was -64 dBm which is less than the predicted from the simulation by 28 dB. Due to many factors influencing the simulation like the data base accuracy, system errors the which they led the differences between the measured and predicted signal strength.

ABSTRAK

Rangkaian Kawasan Tempatan Tanpa Wayar (WLAN) telah menjadi sesuatu alat yang berkuasa untuk menyokong keperluan komunikasi tanpa wayar berjalur lebar. Didalam projek ini, anggaran Perambatan luaran titik-ke-titik jaluran gelombang mikro sebagai penyambung di Kolej Rahman Putra (KRP), Universiti Teknologi Malaysia. Jaluran itu beroperasi di frekuensi 5.8 GHz berasaskan piawaian IEEE 802.11a, antenna adalah 17 dBi bagi kedua-dua transmitter dan penerimanya. Kuasa yang dipancarkan adalah 18 dBm. Pengiraan kekuatan signal dilakukan di tapak dimana jaluran didirikan. Pemancar tersebut dipasang pada atap bangunan pejabat KRP, G_{01}manakala penerimanya terletak pada jarak 113m di bangunan G_{02}. Simulasi gelombang mikro yang sama telah dilaksanakan melalui alat yang disediakan oleh Site Ware Technologies. Alat simulasi ini adalah 3-dimensi (3-D) penjejak kod menggunakan ubahsuaian ‘shoot and bounce ray’ (SBR) yang dikenali sebagai ‘Vertical Plane Launch’ (VPL). Simulasi itu diterjemahkan dalam 3-dimensi menggunakan perisian Matlab. Keputusan simulasi VPL menunjukkan kehilangan signal sebanyak -54 dB, ‘delay spread’ adalah bersamaan dengan 0.068 ns. Signal yang diukur adalah -64 dBm, kurang daripada anggaran simualsi iaitu 28dB. Oleh kerana banyak faktor mempengaruhi simulasi seperti ketepatan pangkalan data, ralat system menyebabkan perbezaan diantara nilai yang diukur dan nilai anggaran kekuatan signal.

LIST OF CONTENTS

L	-	Path loss
D	-	Distance
τ_n	-	Arrival time

CHAPTER 1

INTRODUCTION

1.1 Introduction

With the success of wired local area networks (LANs), the local computing market is moving toward wireless LAN (WLAN) with the same speed of current wired LAN. WLANs are flexible data communication systems that can be used for applications in which mobility is required. In the indoor business environment, although mobility is not an absolute requirement, WLANs provide more flexibility than that achieved by the wired LAN. WLANs are designed to operate in industrial, scientific, and medical (ISM) radio bands and unlicensed-national information infrastructure (U-NII) bands.

In the United States, the Federal Communications Commission (FCC) regulates radio transmissions; however, the FCC does not require the end-user to buy a license to use the ISM or UNII bands. Currently, WLANs can provide data rates up to 11 Mbps, but the industry is making a move toward high-speed WLANs.

Manufacturers are developing WLANs to provide data rates up to 54 Mbps or higher. High speed makes WLANs a promising technology for the future data communications market [1].

The need of an effective mechanism to evaluate radio propagation outside buildings is increasing. It is also critical when we are going to decide where to place the base station in order to give us the best performance.

Outdoor propagation is strongly influenced by specific features like the terrain profile which may vary from a simple curved earth profile to highly mountains profile, the construction materials, and the building structure. Due to reflection, diffraction, and refraction of radio waves by objects the signal reaches the receiver from many paths and this causes the multipath fading.

1.2 Development of Wireless Technology

In early 1864 Maxwell comes up with Maxwell equation by unifying the works of Lorentz, Faraday, Ampere and Gauss. He predicted the propagation of electromagnetic waves in free space at the speed of light. He postulated that light was an electromagnetic phenomenon of a particular wavelength and predicted that radiation would occur at other wavelengths as well [2].

His theory was not well accepted until 20 years later, after Hertz validated the electromagnetic wave (wireless) propagation. Hertz demonstrated radio frequency (RF) generation, propagation, and reception in the laboratory. His radio system experiment consisted of an end-loaded dipole transmitter and a resonant square-loop antenna receiver operating at a wavelength of 4 m. For this work, Hertz is known as the father of radio, and frequency is described in units of hertz (Hz) [2]. Hertz's work remained a laboratory curiosity for almost two decades, until a young Italian, Guglielmo Marconi, envisioned a method for transmitting and receiving information. Marconi commercialized the use of electromagnetic wave propagation for wireless communications and allowed the transfer of information from one continent to another without a physical connection.

The telegraph became the means of fast communications. Distress signals from the S.S. Titanic made a great impression on the public regarding the usefulness of wireless communications. Marconi's wireless communications using the telegraph meant that a ship was no longer isolated in the open seas and could have continuous contact to report its positions. Marconi's efforts earned him the Nobel Prize in 1909.

World War II also created an urgent need for radar (standing for radio detection and ranging). The acronym radar has since become a common term describing the use of reflections from objects to detect and determine the distance to and relative speed of a target. Radar’s resolution (i.e., the minimum object size that can be detected) is proportional to wavelength. Therefore, shorter wavelengths or higher frequencies (i.e., microwave frequencies and above) are required to detect smaller objects such as fighter aircraft.

Wireless communications using telegraphs, broadcasting, telephones, and point-to-point radio links were available before World War II. The widespread use of these communication methods was accelerated during and after the war. For long-distance wireless communications, relay systems or troposphere scattering were used. In 1959, J. R. Pierce and R. Kompfner envisioned transoceanic communications by satellites [2]. This opened an era of global communications using satellites.

The satellite uses a broadband high-frequency system that can simultaneously support thousands of telephone users, tens or hundreds of TV channels, and many data links. The operating frequencies are in the gigahertz range. In the 1960s and 1970s, the cellular concept was developed in Bell laboratories; the first generation of wireless mobile communication system appeared in the 1980s and was based on analog technology with FM modulation.

Examples of first-generation cellular sys-terms are the Nordic Mobile Telephone (NMT) and Advanced Mobile Phone System (AMPS). In the early 1990s, the second-generation (2G) digital cellular systems were developed with varying standards [2].

Examples include the Group Special Mobile [(GSM), now Global System for Mobile Communications)] in the U.K., IS-54/136 and IS-95 in the U.S., and the Personal Digital Cellular (PDC) in Japan. In general, the 2G systems have improved spectral efficiency and voice quality.

The third generations (3G) of wireless communications are currently being installed in different regions of the world. The 3G systems provided multimedia services and satisfy more requirements such as applications and communications “anytime and anywhere” To this end, wide-band and broadband radio technologies will be necessary. The examples of 3G standards are International Mobile Telecommunications 2000 (IMT-2000), CDMA-2000, and NTT DoCoMo W-CDMA systems.

The 4G system will provide an all-IP network that integrates several services available at present and provides new ones, including broadcast, cellular, and cordless, WLAN, and short-range communication systems. The general trend in the development of wireless communication is the use of higher data rates (broader frequency band), propagation in more complex environments, employment of smart antennas, and use of multiple-input multiple-output (MIMO) systems [3].

1.3 Problem Statement

Wireless LAN have become widely spread on these day’s and by the fact that wireless LAN can cover the places which they are quite difficult to access by wire line.

Due to the varying of the terrain profile from simple curved earth to highly mountainous profile and the presence of trees, buildings, and other obstacles' is that the signal propagated from transmitter to receiver will experience many signal transformation and paths and this will reduce the signal strength. This study is expected to help in determining the accurate location of both the transmitter and receiver antennas of the microwave link.

1.4 Objective

The main objective of this research is to predict and measure the path loss and delay spread in a point to point microwave link at frequency 5.8 GHz, in order to obtain the best link performance.

1.5 Scope of Project

The site related is located on kolej KRP inside Universiti Tekhnologi Malaysia the transmitter placed on the top of G_{01} which is the fellow office and the receiver is on G_{02} which is one of the employer houses.

They are the locations over a terrain and in remote rural areas, this links are already exist and this investigation will help in the future to predict for where to place a link point to point bridging or long rang point to point microwave linking. The physical model is to predict propagation effect in the related site by using ray tracing simulation program based on vertical plane lunch (VPL) then the result visualized by math lab. The empirical model represents by the path loss field measurements.

1.6 Project Methodology

1.6.1 Site Survey and Topographical Map Building

Site survey involved in locating the place which the plan will be held on and its very important to see the actual specification of the field environment like terrain profile the trees, buildings in-between the suggested link and is there any possibilities of line-of-sight.

The most difficulties lays on getting the Topographical Map normally for the specified area which the work will held there are no such Digital Elevation Map ready to use.

From a hard copy of topographical map size (AO) which scanned by special scanner for these size of map the scanner was set to give us 200 dpi Pixel quality, the result was JPG picture which its size 168 M Bytes, and this size is very heavy to normal PC's so the image compressed for more useful process and time accelerating, the picture after a lot of compression reaches only 3 M Bytes.

After that map opened by AutoCAD by insert raster image and by land surveying expert the map set to be on RSO WM Projection with scaling it to real scale as it in the earth and rotate it to be on the true North. , then last step was to digitize the map from raster mode to be on the vector mode now the Contour Map or Digital Elevation Map ready for work. Appendix (C.4) shows the scanned AO size UTM map.

1.6.2 Data Collection of Terrain and Buildings

Firstly for the terrain data base the (DEM) of UTM is transformed to (X, Y, Z) points by a powerful surveying under water licensed program called (Hydro Processing), To get the terrain data base for the specified area, the original image matched with the (.DEM) so as to specify the field which contain all the building included the ones which the transmitter and receiver or placed on them, then by drawing a rectangular shape as the boundary limits Fig (1.1) shows that.

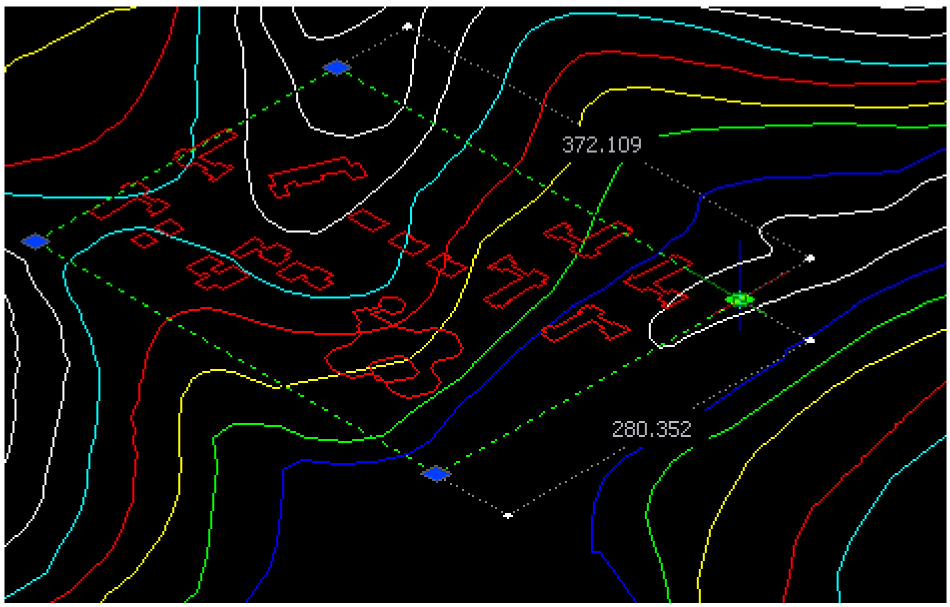

Figure 1.1: Boundary Limits

After that the rectangular coordinate (X, Y) the maximum minimum taken to software called (Surfer) to make a grid for the rectangular shape area with a suitable step for the Y and X and lastly transform the grid to (X,Y,Z) matrix and this is what called the (Terrain Data Base).

The Building Data Base is much easer respectively to the terrain, from the combination of the DEM and the original scanned image the building has been drawn and manually entered the heights, and then we can simply get the building data base. All the data are transferred to an Ms Excel to organize them and on the last stage of all this process save them as the text files to be accepted by the (VPL) Software.

1.6.3 VPL Simulation

Firstly selecting up the parameters for VPL like the number of reflections of the rays from the objects which will considered, operating frequency, Antenna type which is (directional antenna in our case), and simulation is carried out and the outcome of the simulation is tested if no errors, the result can be plotted by the MATHLAP program. If errors occur, then simulation must be repeated by changing either the parameters of the VPL itself or the inputs text files.

1.6.4 Real time measurements

The measurements of the signal strength for the bridging link can be read directly from the bridge which connected the receiver end. Once the real time measurement done a comparison will be done with the predicted results, this results shows that the prediction are efficient ant can be done at any similar environment to find the best places where to place the transmitter and receiver for the microwave link.

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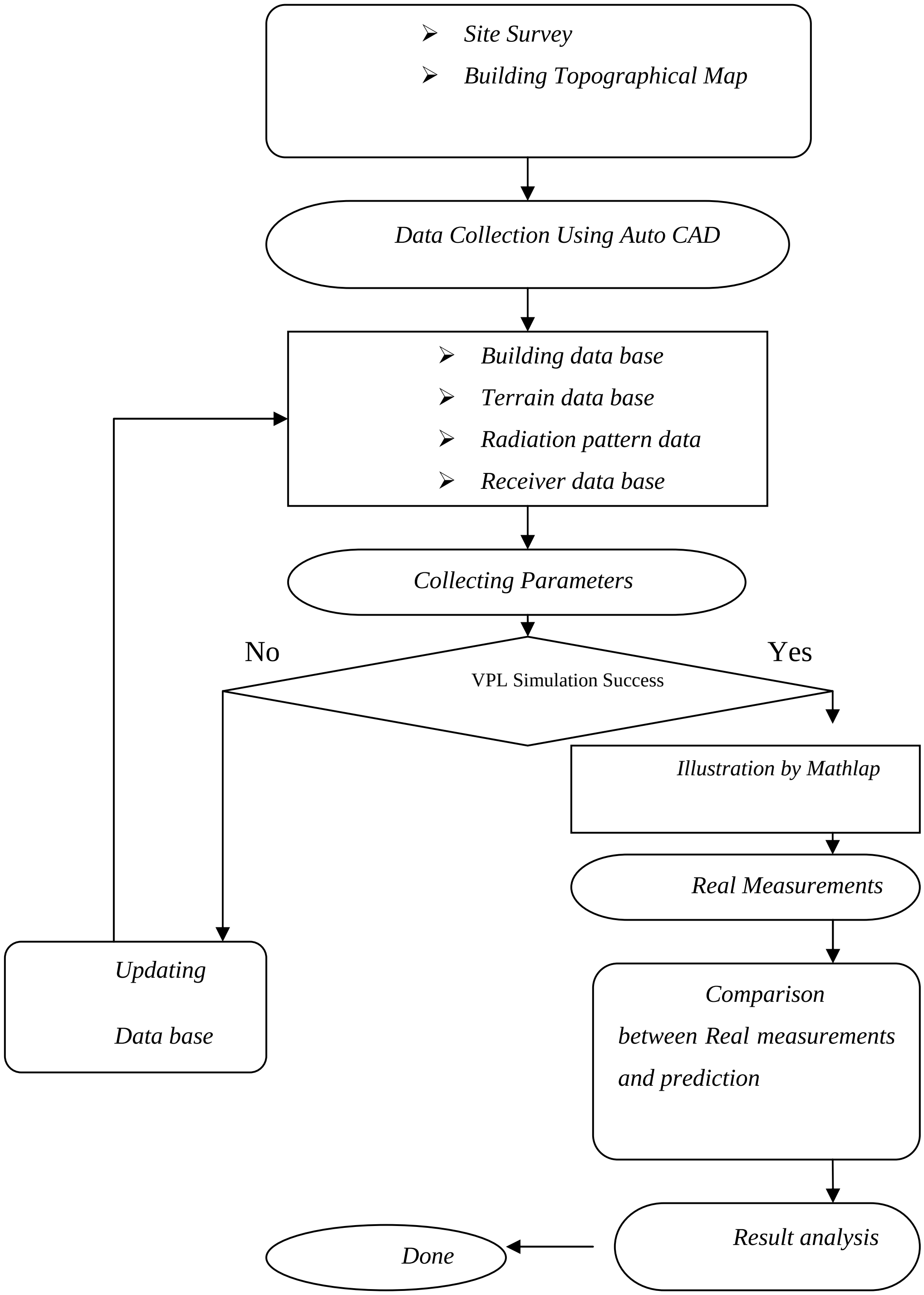

Figure 1.2: Flow chart of the methodology

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