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Development of a User-Friendly Application for LOS Link Optimization

Anwar Hassan Ibrahim, Mahamod Ismail, Kasmiran Jumari and Tiong Sieh Kiong
Department of Electrical Engineering, Universiti Kebangsaan Malaysia,
Electrical Electronic and System Engineering, University Tenaga National, Malaysia

Abstract: This study present a windows application for software planning tools for WLAN propagation model visualization. The developed SPWPM Analysis Tool was designed by using the MapInfo Programming concept and MATLAB programming language. The software provides basic functions for propagation analysis such as System operating margin, cost optimization and K-Factor analysis. In particular, the SPWPM provides effective data visualization through wireless link environment condition. Analysis results are expressed realistically and intuitively on geographical display. The Graphic User Interface (GUI) of SPWPM was designed specifically for WLAN link planning analysis. In this paper, the development and implementation of SPWPM is presented. In order to demonstrate the capabilities of SPWPM, it is used to analyze the Bandar Baru Bangi Area in Malaysia for the purpose of intelligent traffic light management system, using LOS wireless LAN link consideration.

Key words: Software Planning Tools for Wireless Propagation Model (SPWPM), K-factor, Graphic User Interfaces (GUI), Bandar Baru Bangi (BBB), MATLAB

INTRODUCTION

The behavior of the environment in wireless communication is one of the most important link optimization problems affecting many links consuming, using sensitive wireless equipments. An effective analysis tool that considers the environment problem between the transmitter and the receiver systems is needed; such as rain drop, humidity, terrain model and trees in the case of Line Of Sight (LOS) condition.

Basically, a SPWPM tool must provide functions, for instance of system operating margin, cost optimization and K-Factor analysis. In wireless LAN system analysis applications, effective visualization of the environment is an important as analytical ability.

The developed software analysis tool has effective visualization schemes for analysis results as well as the above mentioned analytical functions. The GUI windows displays analysis results on a geographical map for realistic and intuitive understanding. It provides visualization by windows Graphics Interface (GDI) and animation of LOS link.

The effective visualization can help engineers to understand analysis results and the state of the system. To achieve an accurate measurement, a highly software monitoring tool is needed. For such environments, ray tracing-type simulation models are adequate and their use is justifiable (Erricolo *et al*., 2002), usually applied to make path loss estimates in complex environments such as those found inside cities. In fact, cities are geometrically and electrically too complex to be analyzed using full wave method. Even with ray-tracing methods, a full Three Dimensional (3D) investigation is very difficult to achieve and there for, a simpler Two-Dimensional (2D) problem is examined (Pohl, 2005). Presently, there are many commercial software monitoring tools available due to the propagation model, which are based on either experiments or ray tracing tools. All these monitoring tools came with communications capabilities for data collection, data processing and results presentations. SPWPM based propagation offer several advantages such as software upgradeable, low cost and simple tools consumption.

SITE PLAN ESTIMATION

A basic consideration is the physical location of the sites at each end of the link, transmit 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 involved collecting information and made decisions that the sights proposed to use line-of-sight connection in all the communication between the traffic lights. Figure 1 show the link of the traffic light proposed in the area of study, the green color is the traffic and the red line represent the LOS link optimization.

Corresponding Author: Anwar Hassan Ibrahim, Department of Electrical Engineering, Universiti Kebangsaan Malaysia, Electrical Electronic and System Engineering, University Tenaga National, Malaysia

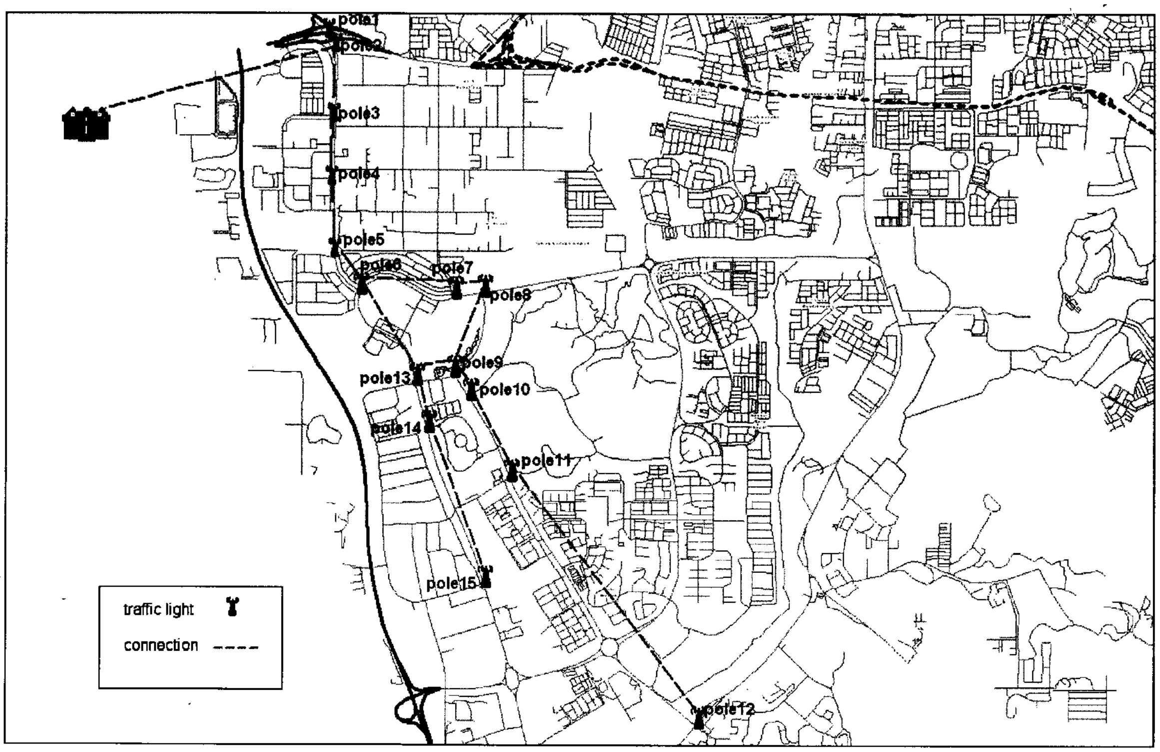

Fig. 1: Study area and site selection

The region under consideration in this study consisted of 14 traffic lights junctions from UKM at (Kajang) Bandar Baru Bangi to Kajang tool in the same area. For each of two traffic lights a set of Digital Terrain Model (DTM) was produced, using site survey (Anwar *et al*., 2006). The counters from theses maps were digitized manually and the heights information was then converted to a DTM in which terrain heights were stored as mean height along straight-line paths between any two given points in the study region were recorded, using MapInfo. In order to calculate the height of antenna at an fixed point in the profile the system automatically calculate the antenna received, depend on the antenna transmit topology which could point-to-point or point-to-multipoint.

DATA COLLECTION

The area is considered to be urban, consisting university and industrial area.

The areas of study involve Bandar Baru Bangi. the data collected includes site location and the meteorological data was collected from UKM, Petaling Jaya Meteorological Stations and site survey.

EFFECTIVE EARTH RADIUS (K-FACTOR)

The effective earth radius factor relates curvature of the ray path to the true earth radius (Rapaport, 2002). This system discussed in this guide operates at frequency 5.8 GHz, any unusual weather conditions that are common to the site location (Ashraf *et al.*, 1995a). It was calculated from the measured refractivity gradient, N, of the air at various altitudes above the earths surface.

$$N = 77.6\frac{AP}{T} + 3.73\times 10^5\frac{H}{T^2} \tag{1}$$

were AP: atmospheric pressure (mbar).
T: absolute temperature (Kelvin).
H: water vapor pressure (mbar). The effective earth's radius (K) is a function of the refractivity gradient or of the mean surface regional difference in average atmospheric conditions is defined as:

$$K = 6370\left[1 - 0.04665\exp\left(0.005577N_S\right)\right]^{-1} \tag{2}$$

The actual radius of the earth was taken to be 6370 kilometer. The refractivity, N_S, represents the surface refractivity reduced to the sea level. Figure 2 shows the

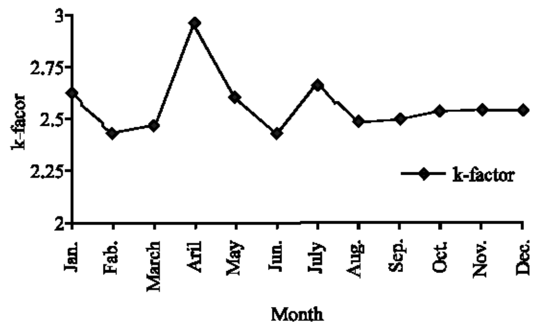

Fig. 2: An example of typical K-factor curve

minimum monthly mean values of radio refractivity, N_0, in BBB. The corresponding surface refractivity N_S is

$$N_S = N_o \exp(-0.1057h_S) \tag{3}$$

Where, h_s is the elevation of the earth's surface in kilometer above the mean sea level (Ashraf *et al*., 1995b).

The antenna tower height depends on two factors. The first factor is related to the geographical condition of the location of the antenna tower while the second factor is related to the quality of the link. The optimization algorithm mainly sets the height of the ellipse to a minimum value and ensures the clearance of the area inside the ellipse.

Figure 2 provides visualization of K-factor due to 2005, on a geographical area of Bander Baru Bangi using data collected from UKM stations.

TOOLS DESIGN AND GRAPHICAL USER INTERFACE (GUI)

The developed SPWPM is designed according to the Geographical area selected using MatLab language.

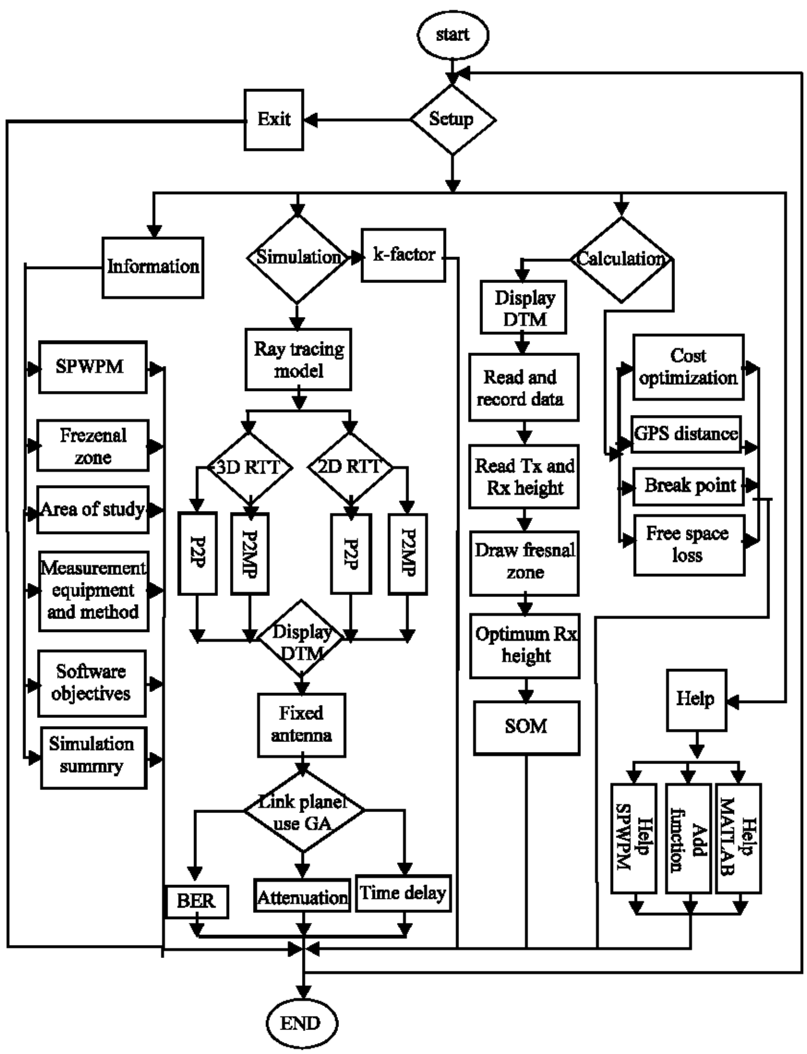

Fig. 3: Flow chart architecture of the prototype SPWPM monitoring tools

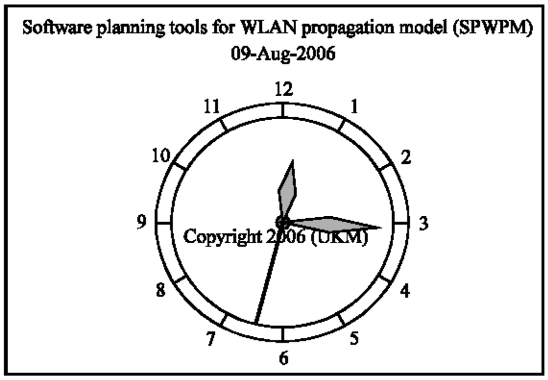

Fig. 4: Graphical User Interface (GUI)

Matlab has been accepted as a viable alternative to traditional procedural programming, to provide convenient GUI. Each element of requirements was designed to obtain specific purpose and All analytical functions were also designed to built the interface of all the calculation consists of attributes and methods. To displays the base attributes and methods of each function and simplified step hierarchy diagram of the software it is shown in Fig. 3.

The developed SPWPM is composed of four main windows such as start, information, simulation, calculation and help, as shown in Fig. 4.

SOFTWARE VISUALIZATION SCHEMES

The main window of SPWPM is composed of the menu, toolbar, dialog bar, status bar, output window and explore window as shown in Fig. 4.

The edit window and select points have base attributes to fill in and select elements for digitize the terrain graph or to import data from excel format. It also has base methods such as Draw (), Delete () and Save () functions. The Draw () function is responsible for digitize the selected data members or reading them from excel file. Typically, Sub functions derived from GUI have their own additional attributes and methods for drawing and analysis.

The help visualization of analysis results can guide users to operators and understand the state of the system. Expressing analysis results easily and exactly for quick understanding is the most important point of data analysis. Visualization schemes for each analysis are as follows.

GUI values are expressed by changes of K-factor according to area level as shown in Fig. 5. the user can select the first antenna height and the software will make decision to display the second antenna height automatically depending on the terrain and k-factor between them.

The terrain distribution in a system can be easily understood from the link LOS of the area displayed. Numerical results such as digital terrain define, antenna transmit, antenna receive and link optimization in the output window.

Line of sight decision of the antenna coordinate depends on GPS data according to the latitude, altitude and longitude to calculate the distance between the points as presented in Fig. 6. Users can also see these numerical results through dialog window after clicking on calculate or reset.

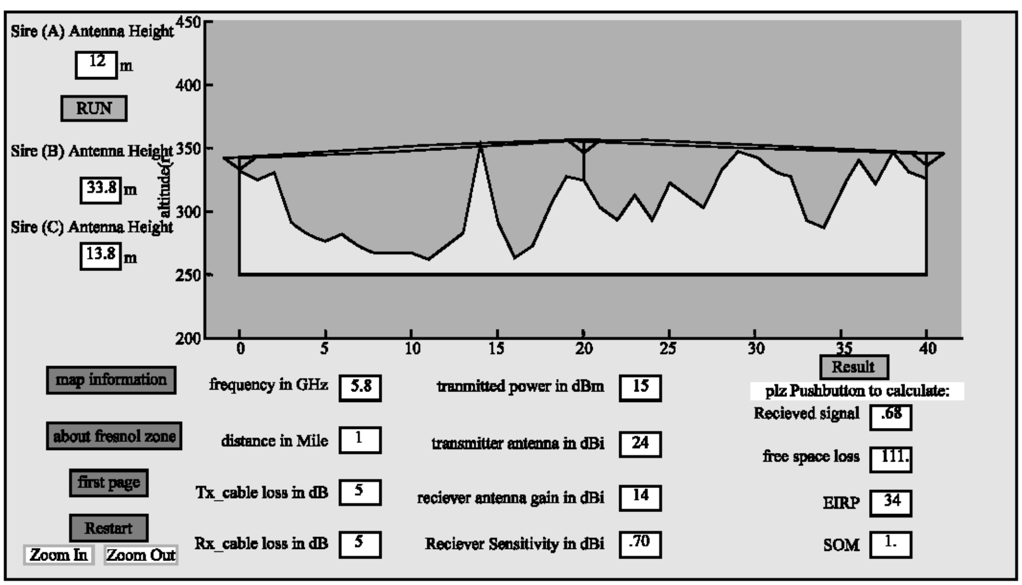

Fig. 5: Terrain distribution and link optimization

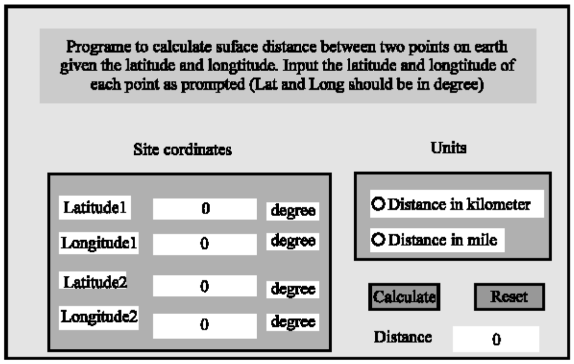

Fig. 6: Dialog box for distance calculation

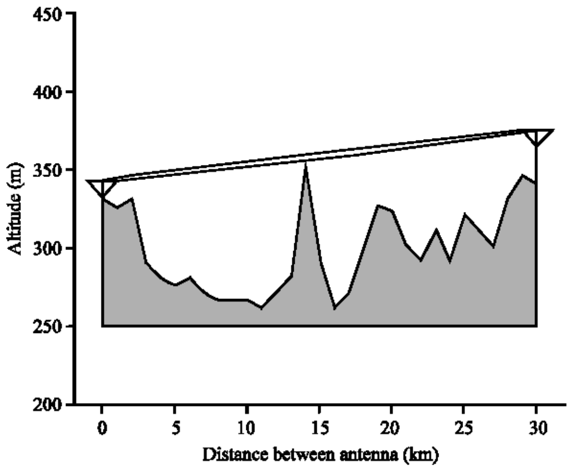

Fig. 7: Point to point LOS link optimization system

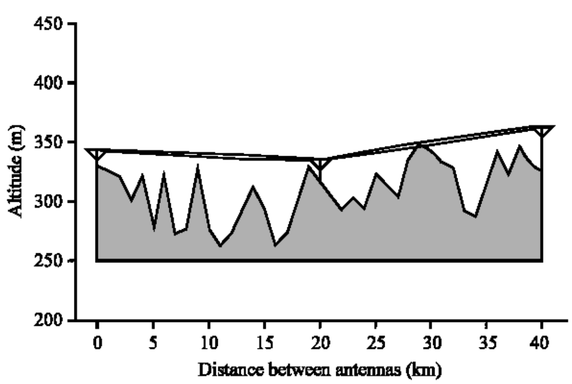

Fig. 8: Point to multi point LOS link optimization

SIMULATIONS

The system studied in this paper is the prototype of easy user friendly (GUI) version for Link line of sight optimization as shown in Fig. 7 and 8. After importing the data of the terrain, the system will transfer it onto the digitize map using the editor function.

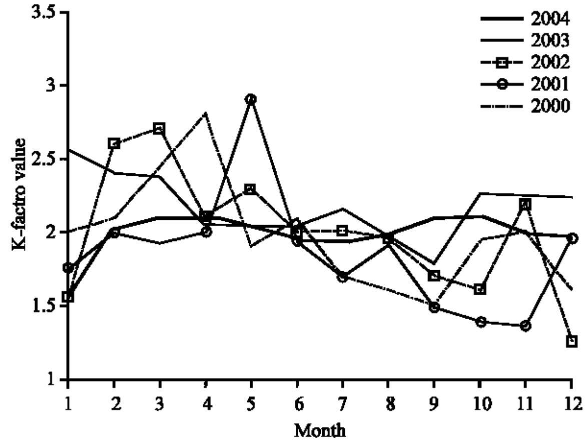

Fig. 9: K-factor in 2004

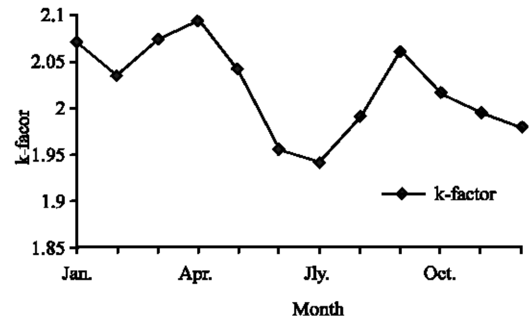

Fig. 10: K-factor for 5 years

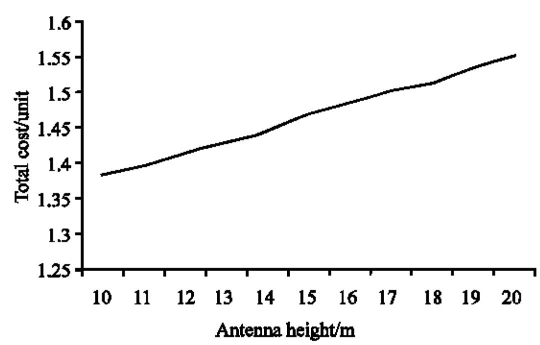

Fig. 11: Total cost optimization due to antenna height

Figure 9 and 10 indicates the k-factor analysis results. We can find by using the SPWPM, additional work is going to carry out to take into account for other propagation mechanisms will in outdoor environments.

The antenna cost optimization program is written in MatLab code. The path profile is generated in an antenna cost optimization program, while the transmitting antenna height is set by the users, the optimal height of the receiver is determined according to first Fresnel Zone ellipse clearance. Figure 11 and 12 show a sample of the cost optimization in the system.

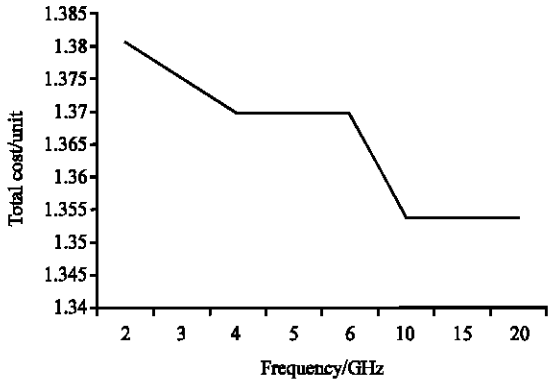

Fig. 12: Total cost optimization due to frequency range

This software used MATLAB language to build system to evaluate the line-of-sigh link calculation regarding to the antenna height using an optimization technique by means of Digital Terrain Model (DTM).

CONCLUSIONS

This study presented a user-friendly windows application for the LOS link optimization analysis. The effective visualization of analysis results is as important as analytical abilities. The developed SPWPM has effective visualization functions for intuitive understanding as well as the environment analysis functions such as terrain, rain, humidity and temperature analysis, depending on a geographical area. The SPWPM provided various convenient GUIs for system edit and simulation analysis.

In order to determine the link setting of any areas for sensitive purposes, especially the link involve LOS curves are used as sensitivity. The simulation of the system clearly indicated that the developed visualization functions are helpful to understand analysis results.

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