INTERFACE DEVELOPING FOR HATA MODEL USING MATLAB

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ABSTRACT

Mobile radio communications in cellular radio take place between a fixed base station (bs) and a number of roaming mobile stations (ms). From the research that have been taken place over the years, those involving characterisation an modeling of the radio propagation channel are amongst the most important and fundamental. The propagation channel is the principal contributor to many problems and limitations the best mobile radio systems. One obvious example is multipath propagation which is the major characteristic of mobile radio channels. It is caused by diffraction and scattering from terrain features and buildings, that leads to distortion in analogue communication systems and severely affects the performance of digital systems by reducing the carrier –to-noise and carrier-to-interference ratios. A physical understanding on mathematical modeling of the channel is very important because it facilitates more accurate prediction of system performance and provides the mechanism to test and evaluate methods to see the effects caused by the radio channel. The main objectives of this project is to select one of the propagation prediction model and used this model to develop an interface using Matlab software. With this simulation, hope that this interface can be one of the friendly interface to the user.

ABSTRAK

Perhubungan komunikasi 'handphone' dalam sistem komunikasi radio adalah komunikasi antara satu stesen tetap dengan beberapa lingkaran sel komunikasi 'handphone'. Dari penyelidikan yang telah dilakukan, kajian mengenai faktor-faktor yang mempengaruhi sistem perhubungan radio adalah yang paling penting dan terkini. Saluran yang digunakan dalam sistem perhubungan radio adalah faktor yang penting mempengaruhi kepada kebaikan dan keburukan sesuatu sistem. Salah satu dari masalah yang timbul adalah daripada pelbagai isyarat yang terbentuk daripada pantulan dinding, bangunan dan sebagainya yang membawa kepada perubahan pada isyarat analog dan juga kesan dari sistem digital. Pemahaman yang mendalam mengenai bagaimana isyarat dan saluran perhubungan itu dicipta perlu untuk meramalkan atau memperbaiki lagi sistem perhubungan ke arah sistem yang lebih berkualiti dan mampu mewujudkan satu mekanisma yang boleh dilakukan untuk menguji sistem tersebut. Objektif projek ini dilaksanakan adalah memilih salah satu daripada model yang digunakan dalam system perhubungan dan menggunakan model ini sebagai antaramuka dengan menggunakan program Matlab. Moga antaramuka ini akan menjadi satu antaramuka yang mudah dan senang digunakan.

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CHAPTER 1

INTRODUCTION

1.0 Project Objectives

The objective of this project is related to the study of various prediction models for mobile radio communication system in order to predict the coverage of the base station. It also involves literature review of different prediction models available.

This project will also involve a simulation model based on propagation prediction model which the simulation will be design on Hata - Okumura Model using Matlab software.

At the end of this project, complete reports on designing simulations using Matlab will be produced.

1.1 Problem Statement

Hata Model is the popular model that being used to calculated the losses in urban, sub-urban and open areas. This model can improve the problems that came from rough terrain, buildings, reflection, moving vehicle and shadowing which bring bad accuracy to the radio communication. This model is being extended from Okumura Model which all of the graphical form is described into mathematical form in Hata Model. In order to make sure that all of the calculations is easier to know and accurate, a design on Interface for Hata Model has to be made. This interface can be very useful for the user to make calculations without any doubt and easy.

1.2 Thesis Outline

The first chapter will be focus on basic communication where it describe radio wave propagation , studied the channel and their limitations and some basic problems such as reflection, scattering, diffraction of signal by natural and human-made structures which result to attenuation problems.

Chapter two is focus on various types of radio propagation model which will be covered Indoor and Outdoor Attenuation model. Some overview on Matlab and GUI software will be covered in chapter three. It will describe on GUI basic tools that will be used in this simulation.

The result for this project and outcomes is in chapter four which include the interface development for Hata Model. Lastly, some discussion and summary about this project is covered in the last chapter.

1.3 Wireless Communication

Communication between the sending and receiving is accomplished by the propagation of electromagnetic radio waves through the ground and atmosphere. All communication system operates in the same channel and this will make interference from every other. This interference can be avoided by implementing geographic or frequency separation. Below is depicts of typical wireless communication system.

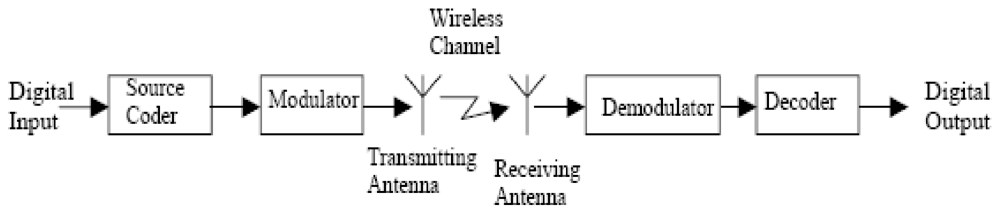

Figure 1.1 Block diagram of a typical Wireless Communication System

1.4 Radio Spectrum Classification

The radio spectrum is divided into sub-bands based on each frequency range's suitability for a given set of applications. Suitability is determined as a function of the atmospheric propagation characteristics of the given frequencies as well as system aspects, such as required antenna size and power limitations.

Based on these considerations, the radio spectrum has been divided into the following sub bands:

a) Extremely Low Frequency (ELF) 300 - 3000 Hz (λ =1000 - 100 km)

Very Low Frequency (VLF) 3 - 30 kHz (λ =100 - 10 km)

Propagation Characteristics: Propagates between the surface of the Earth and the Ionosphere. Can penetrate deep underground and underwater. As the required antenna size is proportional to the wavelength, the large wavelength in this case mandates the use of large antennas.
Applications: mining, underwater communication (submarines), SONAR.

b) Low Frequency (LF) 30 - 300 kHz (λ =10 - 1 km)

Propagation Characteristics: The sky wave can be separated from the ground wave for frequencies above 100 kHz. This enables communication over large distances by reflecting the sky wave off the atmosphere.

Applications: broadcasting, radio navigation.

c) Medium Frequency (MF) 300 - 3000 kHz (λ =1000 - 100 m)

Propagation Characteristics: The sky wave separates from the ground wave in this range. Ground wave gives usable signal strength up to 100 km from transmitter.
Applications: AM radio broadcasting (550 - 1600 kHz).

d) High Frequency (HF) 3 - 30 MHz (λ =100 - 10 m)

Propagation Characteristics: The sky wave is the main propagation mode. The ground wave is used for communication over shorter distances than the sky wave. As propagation loss increases with frequency increases, the use of repeaters is required.
Applications: Broadcasting over large areas, amateur radio (ham), citizens band (CB) radio.

e) Very High Frequency (VHF) 30 - 300 MHz (λ =10 - 1 m)

Propagation Characteristics: Diffraction (bending of waves due to obstruction) and reflection give rise to communication beyond the horizon. Propagation distances are thousands of kilometers. The diffraction and reflection enables reception within buildings.
Applications: broadcast TV, FM radio (88 - 108 MHz), radio beacons for air traffic control.

f) Ultra High Frequency (UHF) 300 - 3000 MHz (λ =1 m - 10 cm)

Propagation Characteristics: Reflections from atmospheric layers are possible. Effects of rain and moisture are negligible.
Applications: broadcasting, satellite (TV) broadcasting, all (1G to 3G) land mobile phones, cordless phones, some air traffic control.

g) Super High Frequency (SHF) 3 - 30 GHz (λ =10 - 1 cm)

Propagation Characteristics: Range becomes limited by obstacles as frequency increases. Propagation is limited by absorption by rain and clouds.
Applications: Satellite service for telephony and TV, mobile services in the future.

h) Extremely High Frequency (EHF) 30 - 300 GHz (λ =10 - 1 mm)

Propagation Characteristics: Very high losses due to water, oxygen, vapor.
Applications: communications at short distances (within line of sight), broadcast satellite for HDTV (for communication between satellites in space, not space to earth).

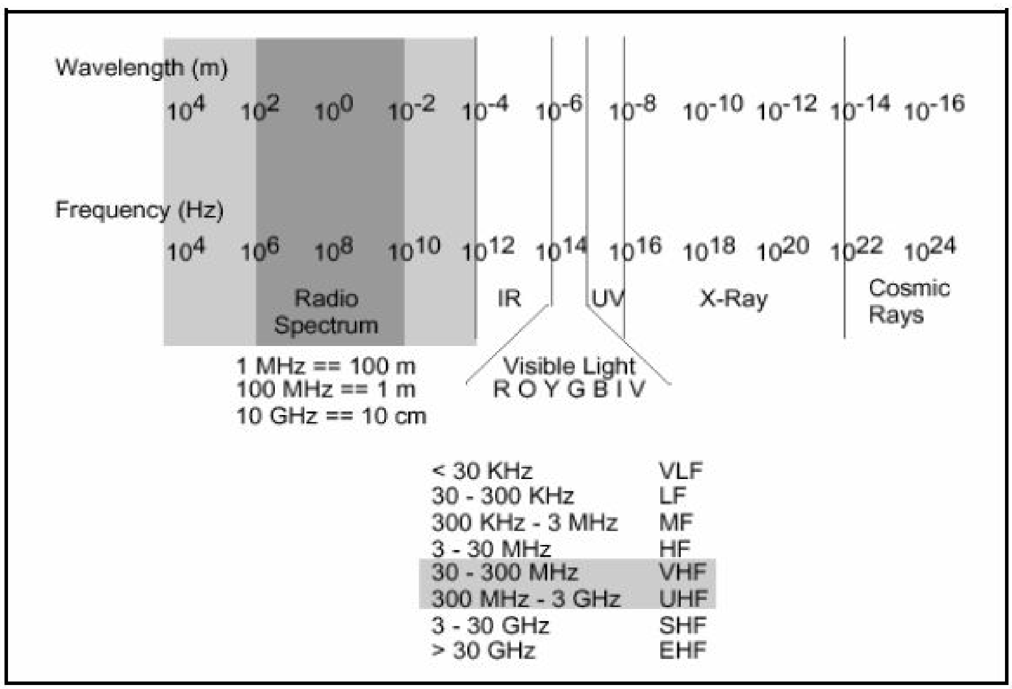

Figure 1.2 Frequencies of radio spectrum is classified into multiple groups

1.5 Propagation in free space loss

Propagation in free space is the ideal. Generally the received power can be expressed as:

$$P_r \propto P_t r^{-2} \quad (1.1)$$

For non-Line of sight received power at any distance d can be expressed as:

$$P_r(d) = 10\log_{10}\left[P_r(d_{ref})\right] + 10v\log_{10}\left(\frac{d_{ref}}{d}\right) \quad (1.2)$$

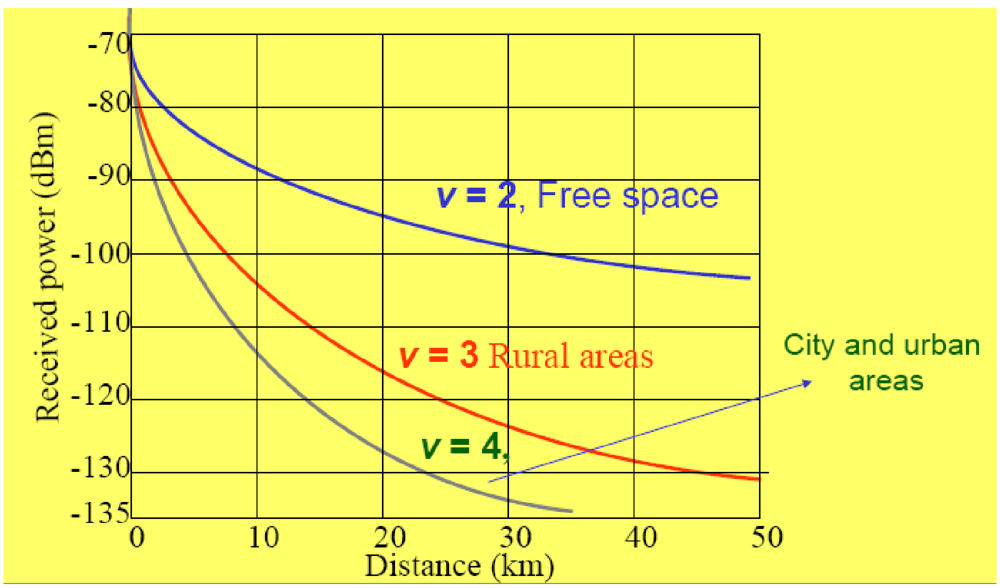

Figure 1.3 Received power for different value of Loss parameter v

Path Loss formula is expressed as:

$$\begin{aligned} L_p \quad (dB) &= 10\log_{10}\left(\frac{P_t G_t G_r}{P_r}\right) \\ &= 10\log_{10}\left(\frac{d^4}{(h_b h_m)^2}\right) \\ &= 40\log_{10}(d) - 20\log_{10}(h_b) - 20\log_{10}(h_m) \quad (1.3) \end{aligned}$$

When propagation takes place close to obstacles, the following propagation mechanisms occur:

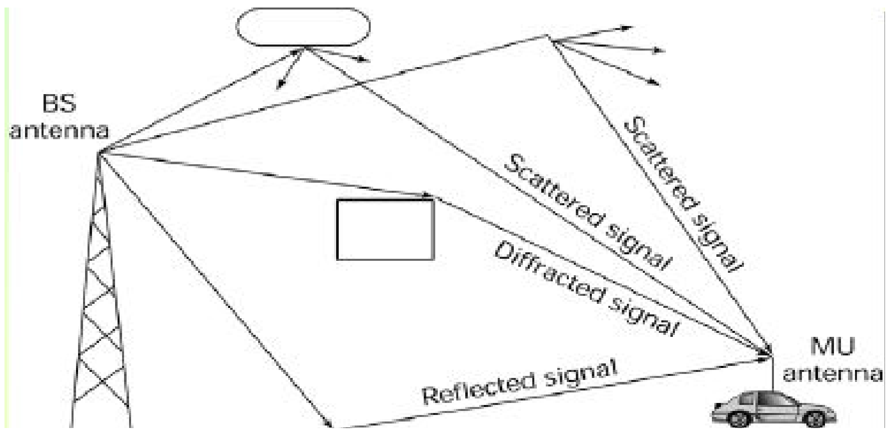

Figure 1.4 Mechanisms of propagation model

a) Reflection will occur when a radio wave strikes an object with dimensions that are large relative to its wavelength, for example buildings. Perfect conductors will reflect with no attenuation. Dielectrics reflect a fraction of incident energy such as "Grazing angles" reflect max and steep angles transmit max. (max -The exact fraction depends on the materials and frequencies involved). The reflection induces 180° phase shift.

When electrical signal propagating through a medium impinges on a different medium with different electrical characteristics, the electrical signal is partly reflected back to the previous media and part of the signal is transmitted through the obstructing medium. If the signal is propagating through a dielectric medium, there is no absorption of the signal due to reflection. Otherwise part of the energy of the signal will be absorbed by the medium. If the reflected media is a perfect conductor, all energy of the signal is reflected back to the first medium.

The intensity of the electric field for the transmitted and reflected signals are related to the incident electrical signal through the Fresnel Reflection Coefficient (G). The Fresnel Reflection Coefficient depends on the properties of the material, like permeability(m), permittivity(e) and conductance(s) of the two media and the frequency of the propagating wave.

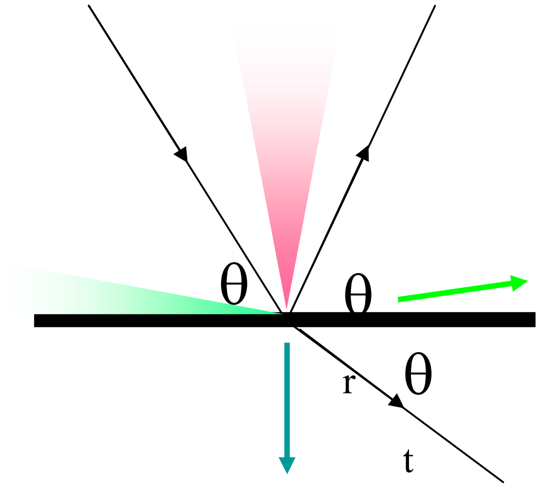

Figure 1.5 Reflection mechanisms

b) Diffraction

Diffraction will occurs when a radio wave is obstructed by surfaces with irregularities. Diffraction allows radio signals to propagate around the curved surface of the earth and that in turn allows the propagation to travel behind a building or obstruction. The received signal drops significantly as the receiver moves deep behind an obstruction. The phenomenon of diffraction is explained by Huygen's principle. It states that all signal points on the signal wave acts as a point source to produce the secondary signal waves that travels in the direction of propagation.

Secondary waves arise from the obstructing surface and give rise to the bending of waves around and behind obstacles. "Secondary" waves propagated into the shadowed region. This make the excess path length results in a phase shift. Fresnel zones relate phase shifts to the positions of obstacles. These secondary waves reaches the shadowed region of the obstruction and the vector sums of all these secondary waves provides the signal to the receiver.

The phase difference between the direct line of sight path and the diffracted path depends upon the height of the obstruction and the locations of the transmitter and receiver.

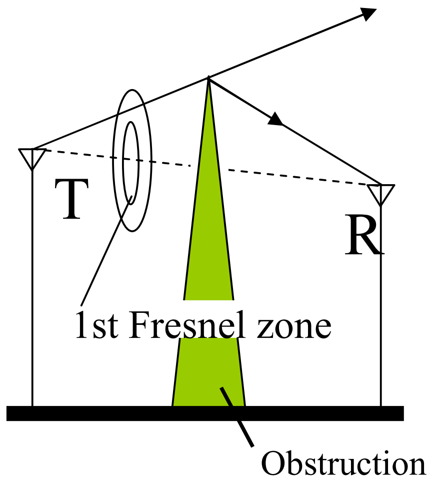

Figure 1.6 Difraction mechanisms.

c) Scattering

Scattering will occurs when a radio wave travels through a medium containing lots of small (compared to wavelength) objects.

The actual signal received at a mobile station, is often stronger than the signal strength estimated by considering reflection and diffraction of signals. The reason for this is the Scattering. When radio waves hits a rough surface, the reflected energy is scattered in different directions. Many natural objects like trees and man-made structures like electrical lamp posts scatter radio energy in all directions. This scattered signal reaches the receiver and increases the signal strength. The scattering depends upon the roughness of the surface. Surface Roughness is stated in terms of the Rayleigh criteria, defined in terms of critical height (hc) of surface protuberances for given incident angle of reflection(θi)

$$hc = 1/8Sin\theta I \quad (1.4)$$

A surface is considered smooth if its minimum to maximum protuberances is less than ***hc.*** and it is considered rough when the minimum to maximum protuberances is more than ***hc*** . On rough surface, the reflected signal energy is reduced due to this scattering effect. For distant objects, where the physical location of the object is known, ***Radar Cross Section Model*** of the object can be used to predict the scattering effect.

1.6 Summary

Radio waves are a form of electromagnetic radiation, which was discovered in the late 19th century. The branch of physics that describes how antennas and radiation behave is called electrodynamics. Many design decisions in layers above wave propagation are affected by the issues mentioned.

There are several factors have to be taken into account in deciding what frequency band should be used for a particular type of radio communication service. Operating frequencies must be chosen in a region of the RF spectrum where it is possible to design efficient antennas of a size suitable for mounting on base station masts, vehicles and on hand portable equipment. Since the mobiles can moved around freely within the area covered by the radio system, their exact location is unknown and the antennas must therefore radiate energy uniformly in all directions.

Based on the fact that each individual telecommunication link has to encounter different terrain, path, obstructions, atmospheric conditions and other phenomena, it is impossible to formulate the exact loss for all telecommunication systems in a single mathematical equation. As a result, different models exist for different types of radio links under different conditions. The models rely on computing the median path loss for a link under a certain probability that the considered conditions will occur.

Finally, mobile systems must efficiently manage the scarce frequency bands. Choosing the correct frequency will leads to a better and sufficient outcomes.

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