URSI GASS 2020, Rome, Italy, 29 August - 5 September 2020

A Propagation Model for Mobile Radio Communication in Amara City

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Abstract

Mobile communication technologies are originated to serve people with several utilities. In order to support the planning of such services, there is a need to use models to compensate for the work in real-time. The aim of this paper is to design a propagation model for a mobile communication system in the Amara city. The simulation runs through Matlab environment considering several mathematical and physical concepts to make realistic results that include the ray path characteristics and it can be affected by physical phenomena. Results from the model are maps showing the predicted signal coverage of each base station and different graphs show ray paths. These could provide valuable information for people working in communications sectors of relevance to this paper the mobile network.

1 Introduction

Over a large geographic area, mobile communication systems are designed with a limited bandwidth [1]. Cellular radio is a wireless communication technology used in mobile telephone systems since the first generation (1G). However, there are many updates which improved the service provided by such service. Many promising benefits are expected to be developed in the fifth-generation (5G), such as coverage and data rate. Therefore, the study of requirements is now in demands in the whole world and particularly in the city of Amara (south of Iraq).

The mobile communication services are especially complex in Amara city (Iraq) since it affected by controlled and uncontrolled issues such as type of the infrastructure, city enlargement and population. Recently many people faced a problem of difficulty in connection via the mobile network. Mobile companies are aiming to improve their services by using more advanced technologies and increase the number of instruments. An effective way to predict the job of the system is by introducing a model. The most important part in the process of communication is the path of the signal from the transmitter to the receiver point which is normally called a propagation model. The utilisation of such models results in improvements in real-time systems.

Studies over the past two decades several researchers have introduced various propagation models for mobile communication. They have been divided into main three groups: statistical, deterministic and semi-deterministic models. There are a large number of models that describe the communication process. Notable examples of radio propagation models are Hata and Okumura models (which are applicable for the outdoor environment) and Free space path loss that is used for an indoor environment.

Recent studies have been concerned to design propagation models for mobile communications. This is exemplified in the work undertaken by [2] that carried out using models for GSM. More importantly, researches in [3,4] have examined propagation models for 5G mobile communications. They have discussed the main issues that are necessary to consider in the design of propagation models for 5G. However, a recent study provides an overview of models to be used in 5G mobile communication systems [5].

This paper describes briefly the design and implementation of the propagation model for radio communications in Amara city in the south of Iraq (see Figure 1). This study is part of a project which aims to finally produce software for 5G mobile communication and an earlier study was reported in [6].

Figure 1. Location of Amara city using Google maps

2 Method and Results

The software works by defining the transmitter position in three dimensions (x, y, z). Then, dimensions converted into geographical axes e.g. longitude, latitude and altitude. In the same way, the receiver location is also defined which can be at least two points. In the current version of the software, the number of obstacles can be identified according to different geometries. For example, the obstacle that causes the reflection is different from the other that results in scattering or diffraction. The signal is supposed to have spherical coordinates and it spread out from the transmitter into space. The antenna patterns in this version support the single input- single output and multiple inputs- multiple-output (MIMO) and authors hope to upgrade that to work with Massive MIMO. In the same time of a number of base stations can be identified, through the method that has been already explained above and each station will be assigned a specific height. Thus, rays will be sent in different directions from each base station and each ray has its own power which would be resulted in obtaining various power levels at the receiving points.

Practically, an efficient mobile telephone network was designed using the mathematical formulas described below which were proposed in [1]. This is through defining the basic procedure in the cellular systems. The calculation started with computing the traffic intensity (A_I) for I user is given by the following equation:

$$A_I = \check{C}\, D_T \quad (1)$$

Where $\check{C}$ is the average number of calls per hour and D_T is the hourly average of calls. Furthermore, several other parameters were then also computed, such the carrier traffic, total traffic and total number of users per cluster. Then, the area of each cluster (cell) that has a radius (R_e) can be evaluated using the following equation:

$$A_{cell} = \frac{3\sqrt{3}}{2} * R_e \quad (2)$$

Furthermore, a frequency reuse was also considered though calculating a distance between cells that reuse the same frequency. The transmitted power is evaluated by estimating the threshold power ($P_i\,(dBm)$), the transmission loss (L_m (dB)) and fading margin ($F_M(dB)$) as follows :

$$P_T = P_i + L_m + F_M \quad (3)$$

Then, the power for each ray obtained by multiply the above power by the sphere around which is depend on the several factors, mostly, on the area around the ray. Reflections, refraction, diffraction and diffusion considering the type of surface (e.g. dielectric, conductor. etc.) considered for different terrain (buildings) until the ray reached the received point. There are also other issues that have been considered, such as if the communication is on the Line of sight or not, attenuation due to rain and atmosphere for mm-waves. Finally, received power can be estimated and other parameters, such as angle of arrival may be estimated according to the received rays position.

It has been used the current model to compute the probability of reception failure along the way between the city centre (Amara) and a point at the northern terminal of the city as shown in Figure 2. There were a range of frequencies have been tested in this example from 30 GHz up to 300 GHz.

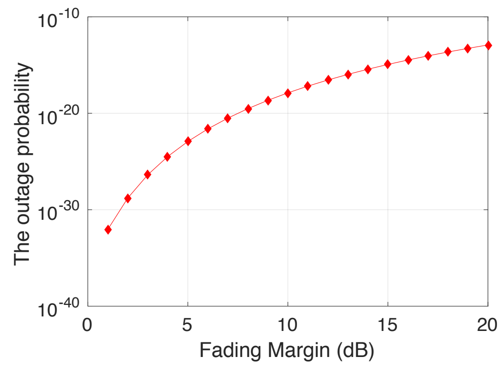

Figure 2. Outage probabilities in terms of fading margins

In order to assess the method, a comparison between measurements and results of simulation has been made. The measurements were developed at Leicester for a link (less than 100 metres) at 35 GHz. For simplicity, only the Line of Sight (LOS) scenario was considered. However, full details of deployments and measurements will be reported elsewhere. A simulation was produced using the measured input parameters including the transmitter power, frequency of operation and the geographic location of both the transmitter and the receiver.

Since there was a discontinuity in the resulted values, fitting curves were used to obtain a continuous line graph as explained in Figure 3.

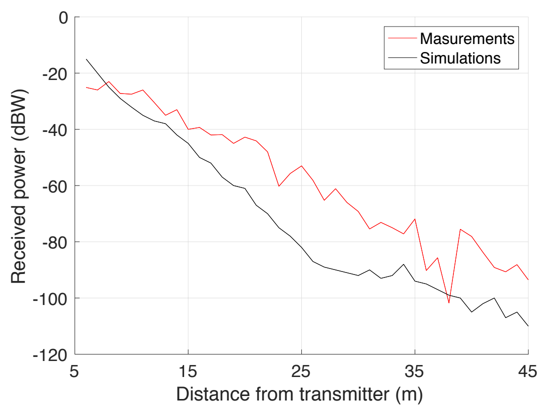

Figure 3. Received signal power

Figure 3 displays the resulted received power obtained from the measurements (red) and simulation (black). From the records in Figure3, it is apparent that both data are agreed in the trend. They started with around -20 dBW and reaching to a range from -110 to -95 when the distance about 45 metres from the transmitter.

Ultimately, the outcome of the model is to display a signal strength map using the procedure described previously. Figure 4 shows a prototype of model's output which is a predicted signal converge map for the region where Amara city located. Signal strength is indicated by the colour scale in dBW. It is evident that geographic locations nearby city centre (around 31.8° N, 41.1° E) have stronger signal than the rest of the other places. Until the time of finishing this paper, it was not possible, to engage the power grid map with the coast geographic map. However, more work on this topic is ongoing to obtain a full system which use ArcGIS software [7] and FalconView [8], in addition to the normal procedure based on Matlab and python.

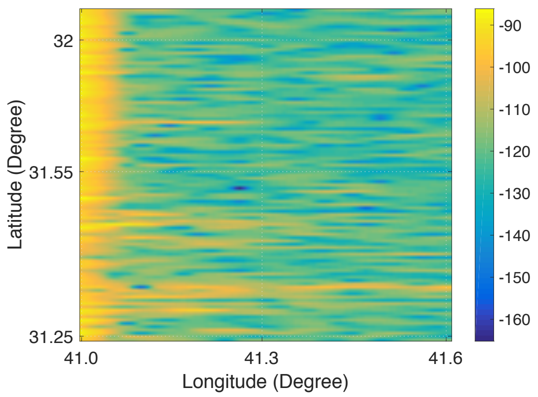

Figure 4. Signal strength predicted map for Amara city.

More developments are under production and need to be tested and compared with a real-time channel measurements to test the reliability of the model which will include coverage maps and angular maps. In future investigations, it might be possible to use an HTML friendly product for improving mobile communication in Amara city.

3 Concluding Remarks

The main goal of the current study was to design a propagation model that yields a prediction for signal propagation in an urban environment. It is also set out to gain a better understanding of the effect of varying the signal parameters. The benefit of this model is to select the best locations for the deployment of base stations. Several aspects have been included in the model such as building heights, type of terrain and time of day in addition to engineering parameters in particular: transmission power and antenna heights. The cellular concept is also considered that applies variable low power levels which allows cells to be sized according to subscriber density and demand of a given area.
Ongoing development in the prediction system is to incorporate weather parameters from specialists and real-time records used by mobile companies in Amara city. The work is hoped to be developed in co-operation with Universities in UK. Further researches is required to better understand how the full mobile coverage can be established in the region of interest.

4 Acknowledgements

The first author is grateful for the consultation early advices provided by Dr. David Siddle, Department of Engineering, University of Leicester.

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