Measuring the Optimal Transmission Power of GSM Cellular Network: A Case Study

Dr. Basil M. Kasasbeh, Applied Science University, Amman, Jordan, b_kasasbeh@asu.edu.jo
Dr. Muzhir S. Al-Ani, Amman Arab University, Amman, Jordan, muzhir@aau.edu.jo
Dr. Rafa E. Al-Qutaish, Applied Science University, Amman, Jordan, rafa@rafa-elayyan.net
Dr. Khalid T. Al-Sarayreh, Applied Science University, Amman, Jordan, khalid_sar@yahoo.com

Abstract

Mobility management is a leading factor in personal communications services networks. Thus, it is important to verify that the mobile unit receives all services whenever moving from one place to another. This paper deals with the study and analysis of the optimal transmission power at a specific zone through a GSM cellular network. The definition of coverage area is constructed by a proper analysis of signal strength measurement. Some problematic tasks appear through the variation of geographical terrain. An accurate coverage area obtained due to an effective cellular positioning method that not requires any significant changes to the network or mobile device.

1. Introduction

The popularity of mobile phones and the number of device users is continuously increasing that leads the manufacturers to introduce new services, features, and technologies. The simplicity, wide distribution, personality, privacy, trusts all these features are important in everyday life to support a huge investment and development in Personal Communications (PCs). Nowadays, an explosive increase in the use of mobile devices exists, such as cell phones, personal digital assistance, global positioning systems etc.

The rapid growth of mobile networks infrastructure leads to activate specific rules to control their huge extension and side effects. Most currently communication networks are able to perform power control measurements for the uplink/downlink. These devices introduce new features to access with Internet and Intranet. The main feature of mobile phone lead customers to access various services any time any location.

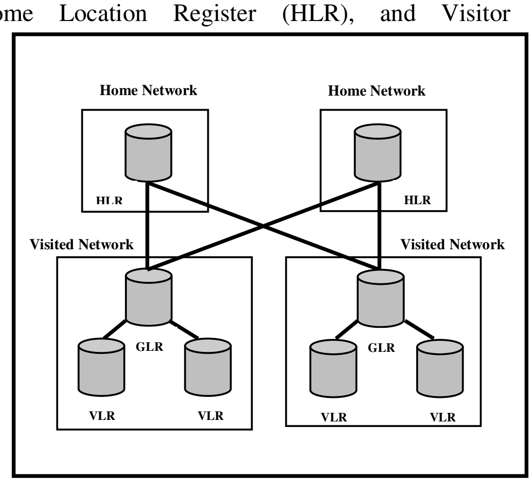
Cellular phones offer elegant features such as, bi-directional information flow, the network to take the mobility of the users; all calls can originate from either the network or the user, and high mobility of user. The basic cellular system allows the mobile user to connect to the Base Station (BS), which is connected to the Mobile Switching Center (MSC) then to the public telephone system. The biggest treasure that seemed to lie in the further development of cellular systems, establishing the third generation (3G), after digital systems (2G), and analog systems (1G) [1].

The successful of wireless systems is occurred due to the development of widely accepted standards especially for cellular communications. These standards ensure that the same type of equipment can be used all over the world, and also for different operations of wireless network within the country.
Digital mobile systems offer a variety of services in addition to regular phone calls. Although providing those services is not a big effort for the network provider, they were a major motivation for customers to switch from analog mobile systems to other digital systems. Different applications of wireless systems have different requirements in terms of data rate, range & number of users, allowed mobility to the users, energy consumption …etc. Location-based services offer a huge number of possibilities for the definition of new services for the digital wireless networks. 3G mobile communication systems are designed to support wideband services of high bit rate and high quality of services [2].

The rest of this paper is organized as follow: section 2 illustrates the mobile phone infrastructure. Section 3 deals with the details of the location management in the 3G mobile communication systems. In section 4, the measurement selection has been discussed. Section 5 presents the measurement analysis and results, and finally, section 6 concludes the paper.

2. Mobile Phone Infrastructure

The fixed infrastructure of mobile phone networks includes Base Station (BS) distributed throughout the intended coverage area of the network. Mobility management is very important in Personal Communications Services (PCS) networks. In digital cellular networks, the two-tier mobility databases, Home Location Register (HLR), and Visitor



Location Register (VLR), are utilized to support mobility management for Mobile Terminals (MTs) [3]. Fig. 1 illustrates the mobility database architecture.

Fig 1. Mobility Database Architecture

The services area is partitioned into Location areas (LAs), and within each LA, there are a number of cells. All BSs within on LA are connected to a Mobile Switching Center (MSC). All the MSCs are finally connected to the Public Switching Telephone Network (PSTN). Each LA is associated to a VLR, which is used to store the temporary records of MT's profiles and location information. HLR is used to record mobile user's permanent subscription information. The Gateway Location Register (GLR) is a node between VLR, Serving GPRS Support Node (SGSN), and the HLR [4].

The mobile phone cells are sectored around a common antenna tower. The tower will have several directional antennas, each covering a particular area, this called cell-site or Base Transceiver Station (BTS). All BTSs produce a Broadcast Channel (BCH) that works continuously. All mobile receive the BCH signal in order to: allow mobiles to find the network, allow the network to identify the closet BTS, identify the coded information, and to accept different information. Fig. 2 shows the Architecture of digital mobile system.

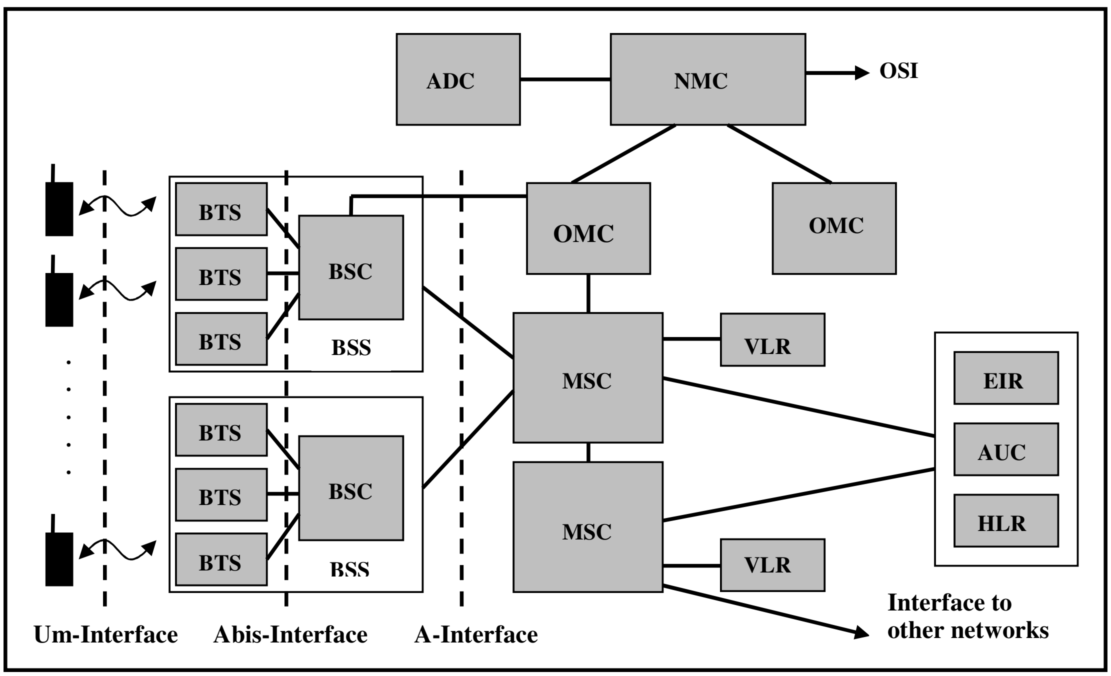


Fig 2. Architecture of the Digital Mobile System

3. Location Management in 3G

There are two basic operations in location management, location update and paging. Location update is a process through which a system keeps track of the location of mobile terminals that are not in conversations. Paging is a search process conducted in the Paging Area (PA) that may include one or more cells. Basically there are two categories of location management, static schemes and dynamic schemes. In a static, location update scheme with two-tier mobility database, the HLR location update are performed when an MT enters an LA on the PA is the same as the LA. PA size is fixed but, there are basically three kinds of dynamic location update schemes in which the PA size is variable: movement-based location update, distance-based location update, and time-base location update [6].

There are three kinds of location updates in 3G cellular networks: HLR location updates, GLR location updates, and VLR location updates. Location updates and paging procedures will cause a significant amount of cost such as wireless bandwidth and processing power at the MTs, the BSs, and mobility database. In both dynamic and static schemes for 3G, the service area is partitioned into Gateway Location Areas (G-Las), which is further partitioned into LAs. A LA consists of a group of cells. An HLR location update is performed when an MT crosses a boundary of a G-LA. A GLR location update is performed when an MT crosses a boundary of an LA [5].

4. Measurement Selection

It is important to select the perfect measurement to reach a specific goal. Manufacturers and Engineers of mobile phone networks must compensate many other factors with coverage area measurement. It is difficult to refer a certain measurement for a specific point but measures must be chosen for each requirement. Measurements must be chosen corresponding to need in each stage of development, manufacturing, installation and maintenance.

Phase and frequency error measurements are very important in BTS, in order to compensate shifts between transmissions and to avoid interference with other users. This type of measurements can be applied when calibration process performed. Output power is a fundamental transmitter characteristic, and in mobile phone system it is important to maintain sufficient power.

This fact leads to minimize the overall system interference and maximize the battery life. Power measurements are normally performed in every phase of BTS lifecycle, such as accuracy, linearity and repeatability. For some applications it is sufficient to determine roughly the mobile cell terminal, but other services require an accurate system for location measurements.

5. Measurement Analysis and Results

The measurements are applied over the area of the Applied Science University in Jordan. This area is divided into four sections according to the geographical terrain (see Fig. 3, Sections 1, 2, 3 and 4).

The results of the measurement indicate the distributed of power due to the university is mainly covered by the cells 25512 (63A8), 25083 (61FB), 25402 (633A) and 25081 (61F9), see Fig. 3 for the actual cell division.

Section 1

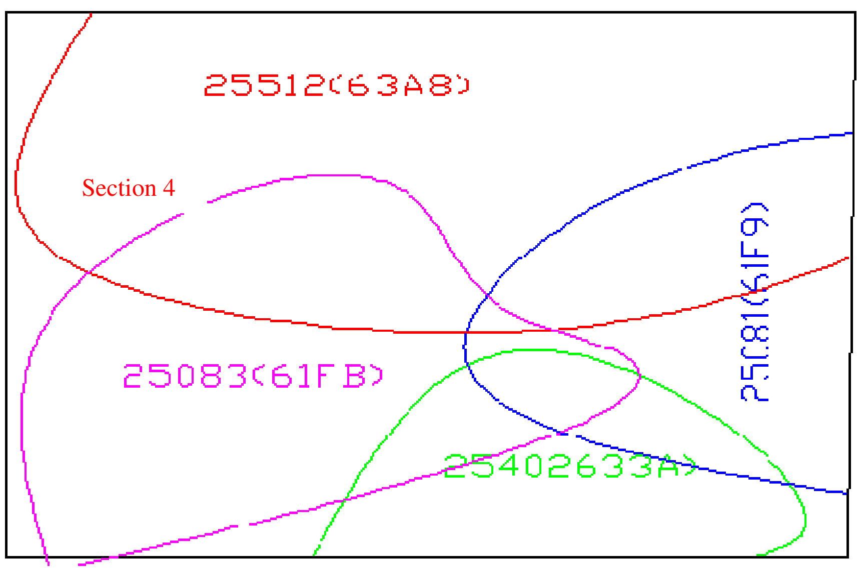


Fig 3. Actual Cell Division

Section1 represents the area from main gate to the registration building and down to the cafeteria. This section distinguishes with flat area and situated near to the BTS. The dominant cell is 25512 (63A8) with some overlapping with cells 25081 (61F8) and 25083 (61FB). The power measurements (see Fig. 4a) demonstrate a smooth distribution of power in this area.

Section2 represents the area from the registration building to the border of the university. This section is declined slowly and goes far from the BTS. The dominant cells are 25512 (63A8) and 25081 (61F9) with some coverage of cells 25083 (61FB) and 25533 (6291). The power measurements (see Fig. 4b) demonstrate that there is some fluctuation in the power distributed due to the variations of the geographical terrain.

Section3 represents the area occupied by the medical science college to the end of the buses parking. The dominant cell is 25081 (61F9) and some coverage by cell 25211 (627B). The power measurements (see Fig. 4c) demonstrate that this section can be subdivided into three parts. First part includes the area around the medical science building that indicates a good signal level. Second part includes the area around the library building that indicates an accepted level of signal with some effects of far distance from BTS. Third part includes the area bounded by buses parking which indicates a high power level with the effect of flatness area.

Section4 represents the area from the main gate to the secondary gate which is subdivided into two parts depending on the power distributed (see Fig. 4d). First part includes the cars parking area that receive a high level of signal strength due to flatness and near to the BTS. The dominant cell is 25083 (61FB) with small effects of other cells. Second part includes the main gate to the secondary gate which is inclined area, so the signal strength is fluctuated from high level near the main gate and decreases down to the secondary gate. The dominant cell is 25512 (63A8) and some coverage of the cell 25081 (61F9).

6. Conclusion

This work deals with the power measurements through a selected area which is divided into subparts according to the geographical terrain. Through the measurements of signal strength, we can track the coverage area and simulate the boundaries of the effective cell. The signal level through the selected area is measured within the range -38dBm to -100dBm. The signal drop (which indicated in some areas) depends on some factors such as, internal losses, weather, geographical area, distance from BTS, and also there are some effective drop denoted through buildings due to different types of materials.

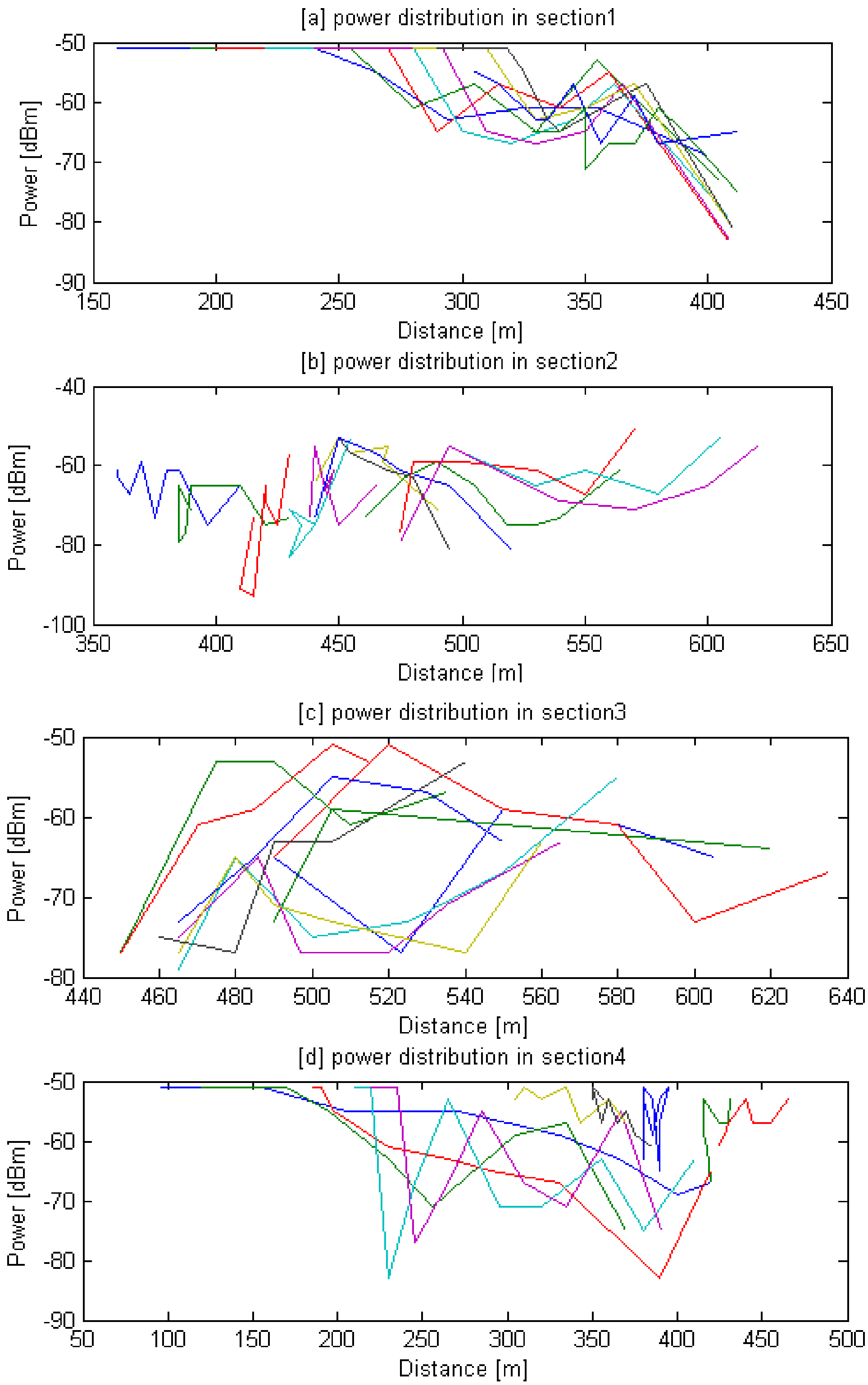


Fig 4. Distribution of Power in all Sections

7. References

[1] Chen, Y.; Sirer, E. G. and Wicker, S. B. "On Selection of Optimal Transmission Power for Ad hoc Networks", in *Proceedings of the 36th Hawaii International Conference on System Sciences (HICSS'36)*, Big Island, Hawaii, USA, 2003.

[2] Molisch, F. *Wireless Communications*, John Wiley & Sons, England, 2005.

[3] Ng, K. and Chan, H. W. "Enhanced Distance-Based Location Management of Mobile Communication Systems Using a Cell Coordinates Approach", *IEEE Transactions on Mobile Computing*, Vol. 4, No.1, 2005, pp. 41-55.

[4] Wu, Jie and Dai, F. "Efficient Broadcasting with Guaranteed Coverage in Mobile Ad-hoc Networks", *IEEE Transactions on Mobile Computing*, Vol.4, No.3, 2005, pp. 259-270.

[5] Xiao, Y.; Pan, Y. and Li, J. "Design and Analysis of Location Management for 3G Cellular Networks", *IEEE Transactions on Parallel and Distributed Systems*, Vol.15, No.4, 2004, pp. 339- 349.

[6] Zaidi, Z. R. and Mark, B. L. "Real-Time Mobility Tracking Algorithms for Cellular Networks Based on Kalman Filtering", *IEEE Transactions on Mobile Computing*, Vol.4, No.2, 2005, pp. 195--208.

Copyright © 2008 by the International Business Information Management Association (IBIMA). All rights reserved. Authors retain copyright for their manuscripts and provide this journal with a publication permission agreement as a part of IBIMA copyright agreement. IBIMA may not necessarily agree with the content of the manuscript. The content and proofreading of this manuscript as well as and any errors are the sole responsibility of its author(s). No part or all of this work should be copied or reproduced in digital, hard, or any other format for commercial use without written permission. To purchase reprints of this article please e-mail: admin@ibima.org.