Low Cost GSM Positioning System Model Tuning

M. Mutajogire, D. Chatelain
French South African Technical Institute in Electronics
Tshwane University of Technology
Private Bag x680 Pretoria 0001 South Africa
Tel: (27)12 318-4191, Fax: (27)12 318-5294
gabymut@yahoo.fr, Damien.chatelain@fsatie.ac.za

Abstract—In 1996 the United States Federal Communications Commission required that operators of mobile communications networks be able to accurately locate mobile callers requesting emergency assistance via 911. This has led to a lot of activity among cellular and PCS providers to examine positioning options. This project aims to design and implement a system capable to compute the position of a GSM user, in a suburban area, every time the mobile station is in active mode. This will be achieved by triangulation using the timing advance, the signal strength and the radio propagation models. The timing advance will give the distance of the mobile station to the serving base transceiver station while the radio propagation model in conjunction with the signal strength will give the distance of the mobile station to six surrounding base transceiver stations. This positioning system will be cost effective and designed for the only use of the operator in order to tune the network. This system must not require changes of the mobile station or changes of the network infrastructures. The accuracy of the system will be tested against a Global Positioning System.

Index Terms—GSM, mobile station, propagation model, signal strength, timing advance.

I. Introduction

Consumer desire for security is one of the main driving factors behind the explosive growth of cellular services [1]. Therefore, this rising use of cellular phones led, the US Federal Communications Commission (FCC) to pass the E-911 regulation that requires that all wireless service operators provide an emergency 911 caller's cellular phone location [2,3].

The Global System for Mobile Communication (GSM) network is divided into cells distinguished by unique cell identifiers. Each cell has its own Base Transceiver Station (BTS) for sending and receiving information [4]. The division of the network into cells reduces the distance from the MS to the BTS and therefore the amount of energy needed by the MS to send information as the power of electromagnetic signals decreases at least quadratically with distance. Any MS in the network is bound to one BTS and more than one BTS may be grouped together under the control of a Base Station Controller (BSC) [5].

Hearability which is the ability of a sufficient number of base stations to simultaneously receive the signal at a sufficient power level is a major concern in network-based location [1]. In this project it will be assumed that there is a dense network coverage which means that the MS is able to detect at least three signals coming from three different BTSs.

One of the most important non-technical issues of positioning systems is privacy. The success of the GSM positioning will be determined by ensuring that consumers do not feel their privacy threatened.

II. Background

Several kind of positioning systems have been already developed. These positioning systems can be classified in three architectures which are:

A. Satellite-based positioning system

The most accurate positioning system is achieved using satellite-based Global Positioning System (GPS) [6]. A GPS is a network of 24 satellites in 6 orbital planes. It uses in general four satellites; three for the position and the fourth one to correct the time error. The basic GPS schemes provide an accuracy of 10m. However, GPS requires a clear view of the sky which makes it hardly usable in urban areas, mountainous terrains and in covered spaces. In order to use this system with the cellular phones, a GPS receiver must be incorporated in the MS. Other satellite-based location systems are GLONASS (Global Navigation Satellite System) from the Russian [6], EGNOS and Galileo from the European Union.

B. Network-based positioning system

The most basic one is the Cell Global Identity (CGI) that indicates the cell in which the MS is currently assigned to [7]. This system is highly inaccurate.

The strength of the signals decreases at least quadratically as the distance increases. Using this information, it is possible to compute the distance between the MS and the BTS.

The MS location can also be done using the Angle of Arrival (AOA) method [2, 7]. In this method, when the BTSs have antennas that are capable of determining directions or have multiple antennas, each of which is responsible for a specific direction, it is possible to determine the part of the cell where the MS is. In this method, each of these sectors has its own CGI.

The TA is function of the distance between the MS and the BTS. Thus this information can be used to determine the MS position. The distance from the communicating BTS to the MS is measured in step of 550 meters.

C. MS-based positioning system

The MS uses the signals from the BTSs to calculate its position. Several methods which accurately measure the time difference such that the time of arrival (TOA) or enhanced observed time difference (EOTD) of wireless radio transmissions have been developed and tested with good results [7]. Unfortunately, the MS-based positioning systems require changes to be done on the GSM equipments [2].

III. Positioning system description

The positioning system to be designed will use a network-based architecture because this architecture does not necessarily require modification to existing mobile phones. This system will be cheaper than the existing positioning systems and will be designed for the operator. The computation of the MS position will be implemented using the timing advance (TA) and the signal strength information.

The slot time advance information is available in the existing GSM system and is used to control the timing of the user's transmission burst. Therefore the TA can be defined as the time that the MS have to advance their burst transmissions to avoid collision or interleaving of the signals from MSs assigned to adjacent time slots [5]. As the TA is function of the distance from the MS to the BTS, the location of the MS can be constrained to a circular locus centered at the BTS.

The MS computes the signal strengths of all the BTSs it can receive signal from. The signal strengths will be function of the distance between the MS and the BTSs and also function of the profile of the terrain where the signal will be propagated. Therefore a propagation model that is adequate to that terrain's profile will be developed. The propagation models vary depending on the terrain's profile because the radio wave propagation is affected by real world conditions [8-12].

IV. Positioning system development

The first step to design and implement the positioning system for GSM will be to develop a propagation model. This propagation model will be developed based on the suburban area terrain's specifications for which the system is designed for. Based on this propagation model, the signal strengths, the TA, and the BTSs positions in the network, a positioning algorithm will be designed.

The simulation of the algorithm will be done using ATOLL software. The network configuration of a suburban area will be simulated in ATOLL environment. Taking points on the ATOLL digital map, the TA and the signal strengths will be extracted from ATOLL environment. The obtained TA and signal strengths will be inputted in the designed algorithm to compute the MS position. This position will then be compared to the position of the corresponding point in ATOLL digital map. This process will help to improve the accuracy of the algorithm.

Field testing of the positioning system will then be undertaken. In this case the signal strengths and the TA of different points in the suburban area will be computed. These signal strengths and TA will be inputted in the designed algorithm to compute the position of the MS. The obtained position will then be compared to the position given by a GPS for accuracy purpose.

V. Future work and Conclusion

The propagation model that will best suit the suburban area for which the system is designed is currently being developed. On completion of this stage, an algorithm will be developed, simulated and tested as described above. The GSM positioning system that will be designed will be accurate and cheaper than the existing ones.

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Mukono Mutajogire obtained his BSc in Electrical Engineering from the University of the Witwatersrand in 2004. He is currently completing his MSc in Telecommunication Technology at FSATIE, a department of Tshwane University of Technology.