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A Robust Technique for GSM Localisation

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ABSTRACT: Context-aware applications have been gaining huge interest in the last few years. With cell phones becoming ubiquitous computing devices, cell phone positioning has become an important research problem, and numerous localization solutions have been proposed. Effective LBS technology requires accurate location information of the mobile device and demands accurate and reliable mobile positioning technology. Absolute received signal strength values from base station changes with time, but the relative received signal strength values which refer to the relations of the received signal strength values between different base stations are more stable. In this paper we examine the performance of localizing a mobile station in a GSM network based on RSS of practical measurements. The localization method proposed in this paper is based on the fingerprinting method.

KEYWORDS: Received Signal Strength; Relative Received Signal Strength; LBS; GSM

I. INTRODUCTION

An enormous growth of mobile communication gives new challenges for creation of new services. One of the possibilities is to focus attention on the localization and localization based services (LBS). A key requirement to effectively provide a wide range of Location Based Service over mobile networks is to estimate location of a Mobile Station accurately. The need for LBS is increasing everyday with several applications such as monitoring services for customers and helping them find their desired products. Effective LBS technology requires accurate location information of the mobile device and demands accurate and reliable mobile positioning technology.

There are different types of techniques for mobile phone localization. Time based positioning techniques rely on measurements of signal travel times between nodes. Time of Arrival (TOA) is a technique that allows locating a mobile device by calculating the time of arrival of the signal from the mobile to more than one Base Station (BS). For Time Difference of Arrival (TDOA) location methods, the differences of the Mobile Station (MS) to at least three BSs are measured. These methods require new hardware to the network.

An Angle of Arrival (AOA) based positioning technique involves measuring angles of the node seen by reference nodes. AOA can be obtained by using an antenna array at the BS. This makes it expensive to implement in current networks and impractical in microcell sites. Cell ID based technique requires the network to identify the BS to which the cell phone is communicating and the location of that BS. This method provides very low accuracy as it depends on the cell size.

Received Signal Strength (RSS) measurements can also be used in order to determine the Mobile Station's position. An MS permanently measures the RSS from all neighbouring BTSs as a part of its standard functionality to assist in handover process. The distance between two nodes can be estimated by measuring the RSS. At least three reference nodes are required by this technique to determine the two dimensional location of a given node. A triangulation approach is used to determine the location of the mobile unit. Fingerprinting is another approach to localize an MS where it uses a database of measured RSS.

In this paper we examine the performance of localizing a mobile station in a GSM network based on RSS of practical measurements. The localization method proposed in this paper is based on the fingerprinting method. A database is created using radio network measurements collected by mobile station. These measurements include cell_IDs (serving and neighbours), received signal strengths, Location Area Code (LAC), Mobile Country Code (MCC) and location coordinates. In this method we do not require any special equipment. Here we propose a Relative Received Signal Strength (RRSS) based approach where we use RSS in a fingerprinting scheme to reduce the error

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II. Related work

P. Bahl et al (2000) proposed RADAR, an RF-based system for locating and tracking users inside buildings [1]. To triangulate the user's coordinates RADAR uses signal strength information gathered at multiple receiver locations. A Database Correlation Method (DCM) was presented by Heikki Laitinen that can utilize any location-dependent signals available in cellular systems [2]. This method works best in densely built urban areas. Anthony LaMarca et al (2005) demonstrated a radio beacon-based approach to location, called Place Lab. Place Lab addresses both the lack of ubiquity and the high-cost of entry of existing approaches to location [3]. Jon Froehlich et al (2006), argued that localization solution based on cellular phone technology is a sufficient and attractive option in terms of coverage and accuracy for a wide range of indoor, outdoor and place based location-aware applications [4]. It is a variation of the fingerprinting localisation method that aims to determine not the MT geographic position but the MT subarea and to reduce necessary initialisation measurements. Jan Kouba et al (2008) discussed the prototype SS7Tracker platform, an active, non-intrusive, Cell-ID-based solution to network-based location tracking, and two novel applications of this technique: network diagnostics based on inroamer tracking and human activity research [8]. B.D.S.Lakmali et al (2008), presented fingerprinting based positioning techniques suitable for outdoor and indoor positioning [9]. Mohamed Ibrahim et al (2011) proposed a Hidden Markov Model based solution that uses maximum advantage of the signal strength history from only the associated cell tower to achieve accurate GSM localization [12].

III. Methodology

A key requirement to effectively provide a wide range of Location Based Service over mobile networks is to estimate location of a Mobile Station precisely. Applications requiring positioning in mobile networks gained importance in recent years. This gives rise to various location based services (LBS). Hence developing cellular positioning techniques has been a key research problem, with numerous localization solutions been proposed. There are several methods present to find the location. The main objective is to find the location information more accurately without much modification in existing infrastructure which ensures low cost.

The distance between two nodes can be estimated by measuring the energy of the received signal at one end. This distance-based technique requires at least three reference nodes to determine the two-dimensional location of a given node. This technique uses a triangulation approach to determine the location of the mobile unit. RSS systems are very interesting for urban and indoor geolocation systems, given that this technique is already available for cellular and WLAN networks, without any further changes. But, a direct measurement of the distance from the RSS cannot be reliable, since the value of the RSS mainly depends on the path-loss model that has been considered. Besides, RSS measurements depend on the channel characteristics. Therefore, RSS-based positioning algorithms are sensitive to channel parameters estimation.

Here we evaluate the performance of localizing a mobile station in a GSM network based on RSS of practical measurements. Each mobile station can scan RSS measurements of the downlink control channels transmitted by its surrounding base stations. We measured the received signal strength at the mobile unit and the distance between the mobile terminal and the base station and compared it with the theoretical results to evaluate the performance of location management system through describing the relationship between the practical and calculated received power with respect to the distance. So we have the ability to determine the accuracy of RSS positioning method.

The principle of RSS based mobile positioning is shown in the figure 1. From this figure, we can get;

$$Rx = Tx - L_{LS} \quad (1)$$

Where (Rx) is the received power and (Tx) is the transmitted signal strength, L_{LS} is signal degradation, caused by large-scale propagation (path loss) where all of the three parameters are in [db].

L_{LS} is modeled by extended Hata's model (cost 231). Hata developed model is useful for estimating the path loss in macrocells on the experimental results of Okumura. The model expresses the path loss as a function of BS height, MS height, carrier frequency and the type of environment (urban, suburban or rural) as shown in the following equation;

$$L_{LS} = 46.3 + 33.9 \log f - 13.82 \log h_{BS} - a(h_{MS}) + (44.9 - 6.55 \log h_{BS}) \log d \quad (2)$$

$$a(h_{MS}) = (1.1 \log f - 0.7)\, h_{MS} - (1.56 \log f - 0.8) \quad (3)$$

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Where f is the frequency in MHz, h_{BS} is base station antenna height in meters, h_{MS} is mobile station antenna height in meters, and d is the distance in kilometers. So, by substituting the parameters we mentioned above in the developed Hata model equation we can determine the received signal strength at the MS terminals. Now, we shall use the developed Hata model equation for path loss we mentioned above to calculate the theoretical received signal strength at the MS terminals in [dbm] for many values of distance. The MS antenna height (h_{MS}) will be 1m and BS antenna height (h_{BS}) will be 30 meter while the frequency (f) will be 1800 MHz since the BS is DCS type.

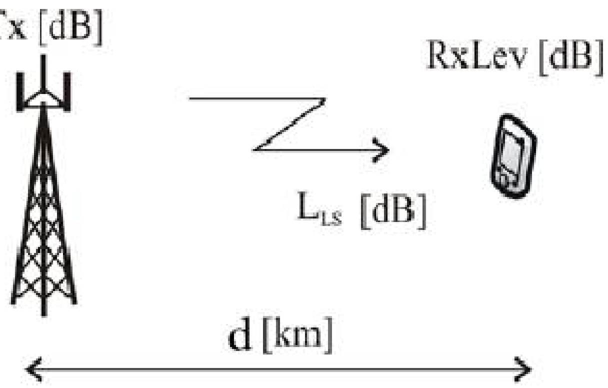

Fig 1: RSS Measurement Model

We measured the BS transmitted power and it was 20 watt which equal 13 db approximately and the BS antenna gain was 17 db therefore, the radiated power from BS will equal 30 db. So, by knowing the transmitted power we can find the received signal strength as a function of distance. By writing the received signal strength equation we can find the theoretical values of the received signal strength for a certain values of distance.
The results obtained in the theoretical calculations and the simulation results were all recorded. From the results we obtained above we can draw the important graphs that describe the relation between the received signal strength and the distance and provide us with information about how the practical results deviate from the theoretical one. It also gives us the ability to determine the accuracy of RSS positioning method. From results we see that the practical values of the received power are deviated from the theoretical ones. This deviation causes a large error while calculating the distance. Therefore, the accuracy of RSS based positioning method is inaccurate. So we go for Relative Received Signal Strength approach. Absolute RSS values received from base station change with time, but the relative RSS values which refer to the relations of the RSS values between different base stations are more stable.

Offline phase and online phase are two phases in Relative Received Signal Strength system. The data base of fingerprint is built during the offline phase. Database contains RRSS for each antenna at a particular position/ sample. The fingerprint is used to calculate the most probable sample during the online or matching phase. This sample has maximum correlation between rules.

A. *Offline Phase*

Aim of the offline phase is to construct the relative signal strength histogram for the received signal strength from each cell tower at each location in the fingerprint. All fingerprints were collected on-the-go as we target a practical technique. Collecting fingerprint at normal speed of roads is more practical than stopping at each training point. Each training point has n(n-1)/2 rules. Here n is number of valid detected cells. This means that maximum number of rules is 15, when five neighbours (plus serving cell) are detected successfully. Rule pattern for GSM is shown below.

$$RSS_1\ (LAC_1, CID_1)\ \{>, <, =\}\ RSS_2\ (LAC_2, CID_2) \quad (4)$$

Here RSS is absolute received signal strength, LAC is Location Area Code and CID is Cell-ID. For example if user equipment detects two cells with cell id 323 and 329, and the two cells have the same LAC which is 51103 and

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received signal strength for them are -79 dBm and -90 dBm respectively. Then, this user equipment has only one rule which can be expressed as following:

(323, 51103) > (329, 51103) (5)

B. *Online Phase*

In the matching phase, a query is submitted to system which contains set of rules generated by mobile user. Sending only rules saves bandwidth. The server will search within the database to find most correlated position with maximum number of matched rules. Which means it is impossible to locate sample with only one cell. In case of multiple sample matched, system will return geometric center of matched samples using Haversine formula.

IV. SIMULATION RESULTS

To examine the performance of locating a mobile station (MS) at a GSM network based on received signal strength (RSS) of practical measurements simulation is done. Simulation tool used is MATLAB.The results obtained in the theoretical calculations and the simulation results were all recorded. Calculated received power is estimated using equations 1, 2 and 3 by substituting measured distance between base station and mobile station.

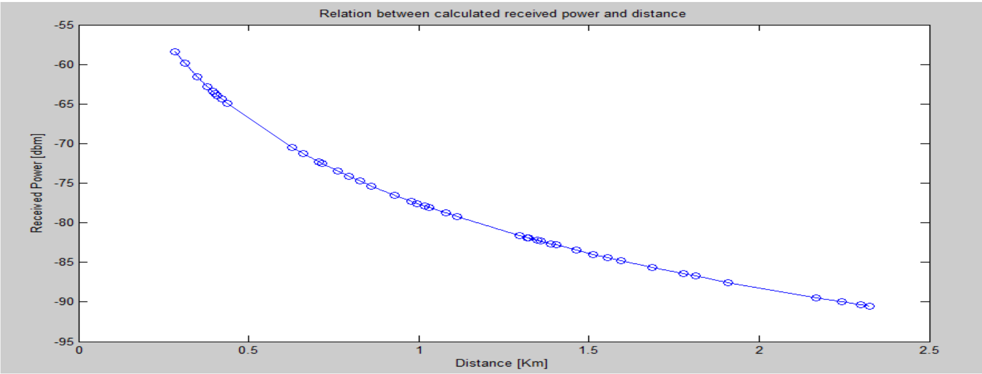

Fig 2: Relation Between Calculated Received Power and Distance

From the results obtained we can plot the important graphs that describe the relation between the received signal strength and the distance and provide us with information about how the practical results deviate from the theoretical one. It also gives us the ability to determine the accuracy of RSS positioning method.

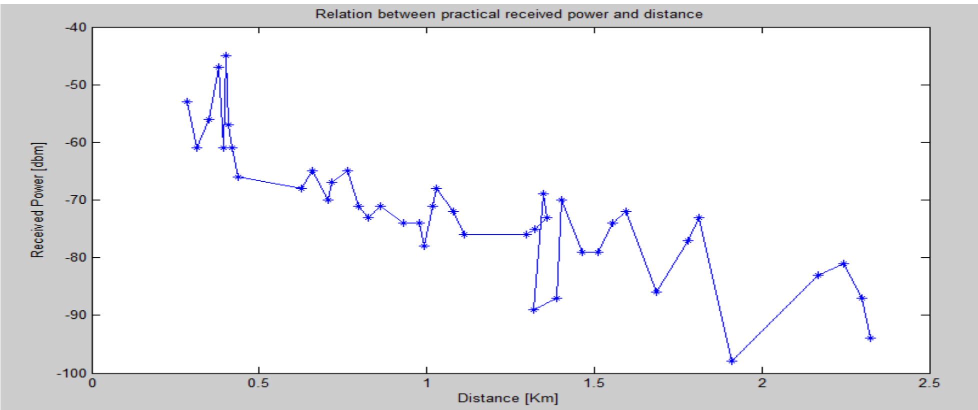

Fig 3: Relation Between Practical Received Power and Distance

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From figure 2 we see that the practical values of the received power are deviated from the theoretical ones in figure 3. This deviation causes a large error while calculating the distance as it's obviously clear on figure 4. Therefore, the accuracy of RSS based positioning method is inaccurate.

Relation between calculated received power and distance is obtained by plotting graph between received powers obtained by substituting the measured distance in extended Hata's model (cost 231). We can see that as distance increases received power decreases. Distance is given in kilometers and received power in dbm.

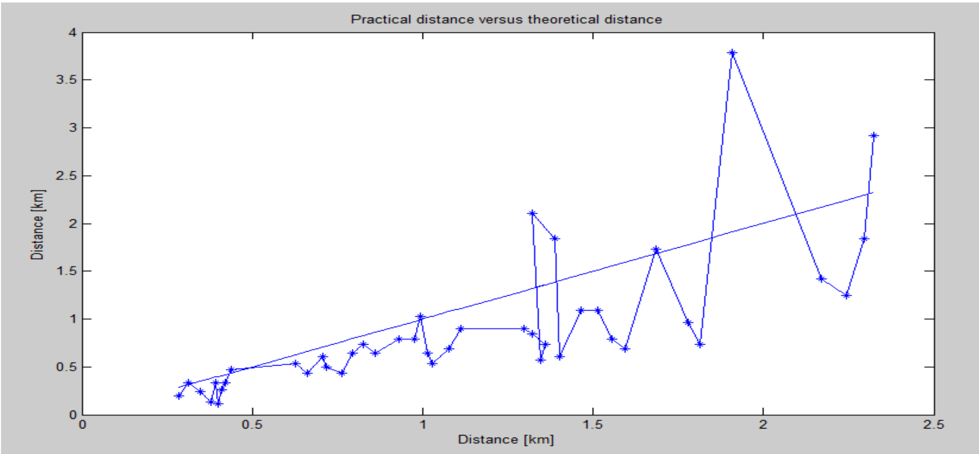

Fig 4: Practical Distance Versus Theoretical Distance

Relation between practical received power and distance is obtained by plotting received power measured and distance between the serving BS and the MS. From this graph we can see that practical values deviate from theoretical values. Figure 6.6 shows graph plotted between theoretical distance and practical distance. It is clearly seen that there is large error in calculating the distance.

V. CONCLUSION

Context-aware applications have been gaining huge interest in the last few years. With cell phones becoming ubiquitous computing devices, cell phone positioning has become an important research problem, and numerous localization solutions have been proposed. The accuracy of the location estimation and the trustworthy localization system are the main factors required. Moreover, the relatively simple and low cost system is also preferable. Absolute received signal strength values from base station changes with time, but the relative RSS values which refer to the relations of the RSS values between different base stations are more stable. The performance of locating a mobile station at a GSM network based on received signal strength of practical measurements is examined. From the simulated results it is observed that practical results deviate from the theoretical one. So we go for location estimation using Relative Received Signal Strength (RRSS). This project proposes a fingerprinting technique for positioning using RRSS.

REFERENCES

1. P. Bahl and V. N. Padmanabhan, "RADAR: An In-Building RF-Based User Location and Tracking System", in Nineteenth Annual Joint Conference of the IEEE Computer and Communications Societies, Vol 2, pp 775-784, April 2000.
2. H. Laitinen, J. Lahteenmaki, and T. Nordstrom, "Database correlation method for GSM location", in Vehicular Technology Conference, Vol 4, pp 2504-2508, 2001.
3. LaMarca, Y. Chawathe, S. Consolvo, J. Hightower, I. Smith, J. Scott, T. Sohn, J. Howard, J. Hughes, and F. Potter, "Place lab: Device positioning using radio beacons in the wild", in Pervasive Computing, pp 116-133, 2005.
4. Varshavsky, M. Chen, E. de Lara, J. Froehlich, D. Haehnel, J. Hightower, A. LaMarca, F. Potter, T. Sohn, and K. Tang, "Are GSM Phones THE Solution for Localization?", in Proceedings of the Seventh IEEE Workshop on Mobile Computing Systems & Applications, pp 34-42, 2006.

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5. M. Chen, T. Sohn, D. Chmelev, D. Haehnel, J. Hightower, J. Hughes, A. LaMarca, F. Potter, I. Smith, and A. Varshavsky, "Practical metropolitan- scale positioning for gsm phones", UbiComp 2006: Ubiquitous Computing, pp 225-242, 2006.
6. Nikoletta Mavrogeorgi, Konstantina Xenou, Dimitris Nikitopoulos, Ileana Popescu and Philip Constantinou, "Mobile Terminal Subarea Localisation Method In GSM Networks", in 18th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), pp 1-5, 2007.
7. Q. Chen, D. L. Lee, and W. C. Lee, "Rule-based WiFi localization methods", in International Conference on Embedded and Ubiquitous Computing", Vol 1, pp 252-258, 2008.
8. K. Dufková, M. Ficek, L. Kencl, J. Novak, J. Kouba, I. Gregor, and J. Danihelka, "Active GSM cell-id tracking: Where Did You Disappear?", in proceedings of the first ACM international workshop on Mobile entity localization and tracking in GPS-less environments, pp 7-12, 2008.
9. A. Lakmali and D. Dias, "Database Correlation for GSM Location in Outdoor & Indoor Environments", in 4th International Conference on Information and Automation for Sustainability, ICIAFS, pp 42-47, 2008.
10. Kabir, A.L, Saha R, Khan M.A and Sohul M.M, "Locating Mobile Station Using Joint TOA/AOA", in Proceedings of the 4th International Conference on Ubiquitous Information Technologies & Applications, pp 1-6, 2009.
11. M. Ibrahim and M. Youssef, "CellSense: A probabilistic rssi-based gsm positioning system", in Global Telecommunications Conference, pp 1-5, 2010.
12. Mohamed Ibrahim and Moustafa Youssef, "A Hidden Markov Model for Localization Using Low-End GSM Cell Phones", in International Conference on Communications (ICC) on IEEE, pp 1-5, 2011.
13. Alireza Rahmati and Zabihhollah Hasan Shahi, "Passive Localization Scheme Via The Monitoring System In Air Interface Of Cellular Networks", in 13th International Conference on Computer Modelling and Simulation (UKSim), pp 477-481, 2011.
14. Lars Zimmermann Alexander Goetz, Georg Fischer and Robert Weigel, "GSM Mobile phone Localization using Time Difference of Arrival and Angle of Arrival Estimation", in 9th International Multi-Conference on Systems, Signals and Devices, pp 1-7, 2012.
15. Kejiong Li, Bigham J, Tokarchuk L and Bodanese E.L, "A Probabilistic Approach to Outdoor Localization Using Clustering and Principal Component Transformations", in 9th International Conference on Wireless Communications and Mobile Computing Conference (IWCMC), pp 1418 – 1423, 2013.

BIOGRAPHY

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