Location of mobile terminal using Received signal strength & Time of arrival

S. S. Bhandare A. A. Tatugade M.R.Dixit Y. M. Patil

Abstract
Positioning of users or Mobile Station (MS) in cellular systems becomes an interesting topic since the related number of applications for the location information is growing rapidly. Deploying such applications would require a proper method for positioning the MS that are simple and accurate especially in urban area.
This technique is based on hybrid method that uses signal strength to estimate the timing delay and comparing it with the measured time of arrival of the signal. The minimum timing value of the two results would be accepted and averaged for n samples. This will improve the accuracy and reduce the effect of multi-path signaling that both timing signaling and signal strength methods suffer from. In addition, a new calculation method has been presented to find the location of MS based on the BSs coordinates.

Key Words — Mobile Station (MS), multi-path signaling, signal strength, timing delay,

I. INTRODUCTION

There are two basic approaches for locating the mobile phone. The phone can either be located with the help of the cellular system's signals or the phone can be integrated with a GPS (Global Positioning System) receiver, which takes care of the location function. Implementing location methods for cellular phone requires some modifications the network. These modifications create various amounts of costs and new signaling to the network. In addition, the achievable accuracy of location methods varies. Hence, based on the functions of the MS and the network, implementation of a location method can be done at the MS, or the network or at the MS with the assistance of network.

Hybrid method can be developed based on signal strength as well as timing delay for estimating the distance between the MS and base station We can calculate the MS coordinates based on the coordinate of existing base stations

II .DISTANCE BASED ON SIGNAL STRENGTH IN RADIO COMMUNICATION

Accurate calculation of radio transmission range in a communication system is difficult. This is true because of signal might travel in multipath. In addition to moisture, etc., can greatly affect transmission range. Radio propagation involves many mechanisms which factor into the received signal strength, including free space transmission, reflection, refraction, scattering, and diffraction. Transmission loss for free space propagation is determined by the following formula:

$$Lt=Lb-Gt-Gr \quad (1)$$

Where Lt is power loss at the transmitter, Lb is power loss at the receiver, and Gt is the gain of the transmitter, and Gr is the gain of the receiver.
For a given loss, the associated distance is related to the λ wavelength as follow:

$$d = \frac{\lambda}{4\pi}(10)^{\frac{Lb}{20}} \quad (2)$$

Replacing Lb from equation 1 in equation 2 and assuming the power loss at the transmitter equal the transmitter power, and the power loss at the receiver equals the receiver sensitivity, a maximum distance becomes:

$$d = \frac{\lambda}{4\pi}(10)^{\frac{(Ptx-Psen-Gt-Gr)}{20}} \quad (3)$$

Ptx=Transmitter Power (dBm)
Psen = Receiver Sensitivity (dBm)
Gr = Receiver Antenna Gain (dBi)
Gt = Transmitter Antenna Gain (dBi)
d= distance in meters
λ= wavelength in meters = $3x10^8$ / Frequency (Hz)

According to equation (3), the distance of the receiver device (MS) from the transmitter base station can be calculated theoretically using the transmitter power, the gain of transmitter and receiver, the receiver sensitivity, and the signal frequency. Since all these parameters can be measured, the distance can be estimated which depends on the accuracy of the measurement. Accuracy can also be improved using time based signal in addition to signal strength.

III. DISTANCE BASED ON TIME OF ARRIVAL IN RADIO COMMUNICATION

The signal sent by the base station at a particular frequency would arrive at the MS after certain delay [5]. This delay depends on distance d between the MS and the base station according to the velocity of the signal as follow:

$$d = V \times T \qquad (4)$$

Where V is the velocity of the signal ($3x\ 10^8$) and T is the delay in sec.
Assume a number of delay sample have been measured, then the average of the distance:

$$\qquad (5)$$

In order to measure the delay of the signal arrived at the MS, a time stamp can be added to signal when generated at the base station. Then, at the MS the time would be measured to find out the difference with the sending time. However, in order to for this mechanism to work accurately, the base station would send synchronization signal to MS to synchronize both clocks together as shown in the following figure

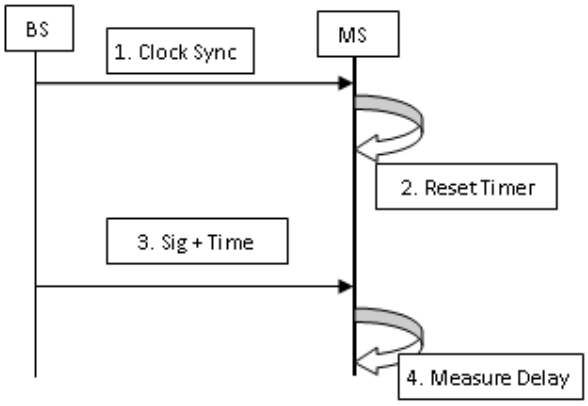


Fig.1. Timing sequence between MS and BS

IV. Distance Based On Signal Strength And Time Of Arrival In Radio Communication

Signal strength method is an easy and low-cost method used to enhance the accuracy of pure cell ID based location [2]. However, in dense urban areas, the accuracy of timing based methods is decreased due to the large possible difference between absolute distance and radio distance for non-line-of-sight paths. Another source of error for both signal-strength and timing based methods, is multipath propagation [8]. The distance between MS and base station can be evaluated using the two techniques that are explained before Since the same distance can be calculated using the 2 equations, dividing the equation 4 and equation 3 yields the new equation that relates time to signal strength as follow:

$$t_a = \qquad (6)$$

Where, S=

Fig.2: Coordinates of MS in relation to Base Station Coordinates

Consider figure 2, d_1 is the distance between MS and base station one, d_2 is the distance between MS and base station two, d_3 is the distance between MS and base station three. xa, ya, xb, yb, xc, yc are the coordinates of base station one, base station two, and base station three respectively. [7] Using geometrical analysis the following three equations can be derived:

$$d_1=(x-xa)^2+(y-ya)^2 \quad (8)$$

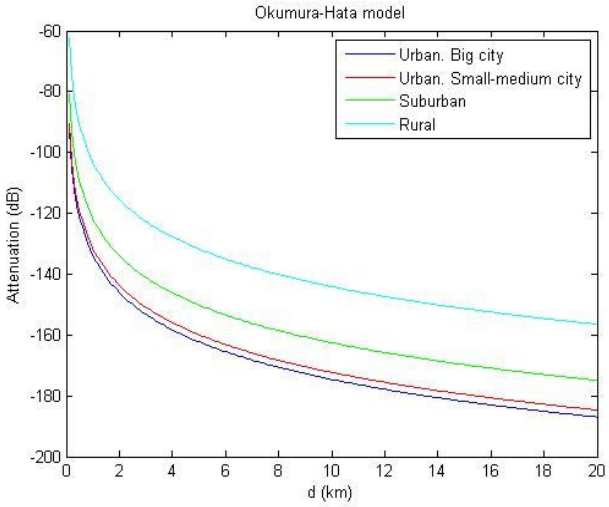
$$d2=(x-xb)^2+(y-yb)^2 \quad (9)$$

$$d3=(x-xc)^2+(y-yc)^2 \quad (10)$$

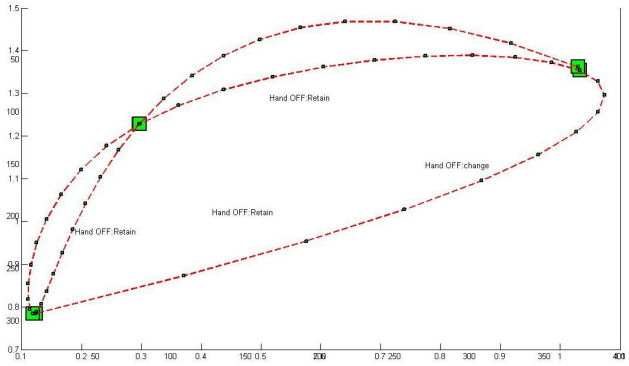
Two possible locations of MS can be calculated by solving equation eight and nine. Similarly two possible locations of the MS can be calculated by solving equations eight and ten.

VII. GRAPHS

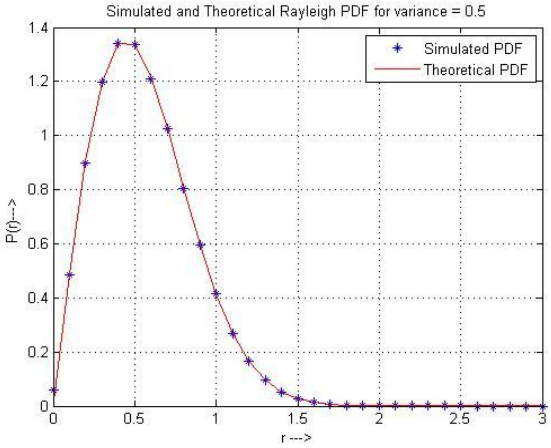
1. For various geographical areas we found received signal strength is as shown in fig.



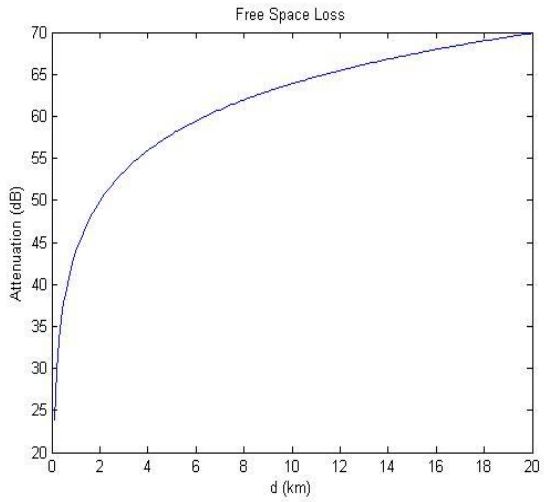
2. Handoff status considering various areas



3. Fading signal applied to channel



4. Free space loss Vs attenuation with distance



VIII. CONCLUSION

In order to meet the requirements for locating the MS, the location method should be based on accurate measurements that are continuously transmitted from the MS back to the network during a connection. Alternatively, a network-based method that uses a base station, could be used to ensure the support for locating the MS in GSM a hybrid method based on signal strength and timing has been proposed .This hybrid method reduce the effect of multipath signaling on timing delay in urban area by taking the minimum of the time based on measured time TOA and estimated time based on signal strength. Then by taking the average of n samples a better accuracy can be achieved.

REFERENCES

01. Marco Ajmone Marsan, Paola Laface and Michela Meo Packet delay analysis in GPRS systems, IEEE INFOCOM2003 - The Conference on Computer Communications, vol.22, no. 1, Mar 2003, pp. 970 – 978

02. M. Hata, T. Nagatsu, "Mobile Location Using Signal Strength Measurements in a Cellular System", IEEE Trans. on Vehicular Tech., Vol. VT-29, No.2, May 1980, pp. 245-251
03. N. Bulusu, J. Heidemann, D. Estrin, "GPS-less Low- Cost Outdoor Localization for Very Small Devices", IEEE Personal Communications Mag., Vol. 7, No. 5, Oct 2000, pp. 28-34.
04. J.J. Caffery, G.L. Stüber, "Overview of Radiolocation in CDMA Cellular Systems", IEEE Communications Mag., Vol. 36, No. 4, April 1998, pp. 38-45.
05. M.A. Spirito, A.G. Mattioli, "Preliminary Experimental Results of a GSM Mobile Phones Positioning System Based on Timing Advance", Proc. IEEE VTC'99 Fall, Vol.4, pp.2072-2076.
06. PERFORMANCE OF MOBILE STATION LOCATION METHODS IN A MANHATTAN MICROCELLULAR ENVIRONMENT Miguel Berg Radio Communication Systems Lab. Dept. of Signals, Sensors and Systems Royal Institute of Technology SE-100 44 Stockholm, Sweden
07. T.S. Rapa port, "Wireless Communications Principles and Practice", Prentice Hall, 2002
08 Proceedings of the International Conference on Mobile Business (ICMB'05) Mobile Station Location based on Hybrid of Signal Strength and Time of Arrival, Dr Ghassan Kbar. Dr Wathiq Mansoor

AUTHOR'S PROFILE

Mr.Bhandare S.S.

Presently working as lecturer in Electronics and Telecommunication Engg. Dept. of Rajendra Mane College of Engg. & Tech, Ambav at the Mumbai University, Maharashtra. He is having 5 years of Teaching experience and 2.5 years of industrial experience.He holds Bachelor of Engineering in Electronics from Pune University. He had presented one paper in National Conference .He is life time member of ISTE.He is pursuing M.E. (EXTC) from Shivaji University Kolhapur.

Mr. Tatugade A. A.

Presently working as Asst. Prof. in Electronics and Telecommunication Engg. Dept. of Rajendra Mane College of Engg. & Tech, Ambav at the Mumbai University, Maharashtra. He holds Bachelor of Engineering in Electronics and Telecommunication from North Maharashtra University. He is having 9 years of Teaching experience and 2 years of industrial experience. He had presented one paper in International Conference and five papers in National Conference. He is life time member of ISTE. He is pursuing M.E. (EXTC) from Shivaji University Kolhapur.

Mrs. Dixit M. R.

Presently working as Associate Prof. in Electronics Dept. of KIT's College of Engg. Kolhapur at the Shivaji University, Maharashtra. She holds Master of Engineering in Electronics from Shivaji University and pursuing her Ph. D from Shivaji University. She is having 26 years of Teaching experience. She had published nine paper in International Journal and fifteen papers in National Journal. She had presented two paper in International Conference and ten papers in National Conference. She is member of IEEE and life time member of ISTE.

Mr. Patil Y. M.

Presently working as Associate Prof. in Electronics Dept. of KIT's College of Engg. Kolhapur at the Shivaji University, Maharashtra. He holds Master of Engineering in Control System from Shivaji University and pursuing his Ph. D from Shivaji University. He is having 23 years of Teaching experience. He had published four papers in International Journal and four papers in National Journal. He had presented six papers in International Conference and eighteen papers in National Conference. He is member of IEEE and International Journal of Computer Sc. And Application. He is life time member of ISTE.