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Mobile Positioning in Cellular Networks

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Abstract- Over the past few decades, Mobile Communication have become important in humans life. The use of mobiles is increased and access to information has become requirement. The increased demand for the information access has created a huge potential for opportunities and it has promoted the innovation towards the development of new technologies. Furthermore, with the fast development of mobile communication networks, positioning information becomes the great interest, because positioning information can be used in emergencies, rescues and navigation. In this paper, a comparative analysis of positioning techniques is presented. Some of the technologies that are used commonly are discussed in this paper.

Keywords: *Angle of Arrival, Time of Arrival, Time Difference of Arrival, Assisted GPS, Global Positioning System, Cell Identity, Location, Positioning.*

I. INTRODUCTION

Wireless communication is among technologies biggest contribution to mankind. Wireless communication involves the transmission of information over a distance without any wires or cables. Now a days Position estimation with communication technologies is hot topic to research. In mobile communication networks the area is covered by having respective base stations. Base stations are responsible to provide frequency of range between 450 MHz to 900 MHz. An MTSO controls these base stations. So that subscriber can continue his call without interruption while moving between different cells. In case of emergency like fire or accident the mobile subscriber should be accurately located. Positioning a mobile subscriber within the boundary of cell in mobile telecommunication networks is known as location based services.

A. What is mobile Positioning?

Mobile phone tracking is the ascertaining of the position or location of a mobile phone, whether stationary or moving. Localization may occur either via multilateration of radio signals between several towers of the network and the phone or simply via GPS.

B. Need for mobile positioning

In today's market, the demand for mobile location is growing, both from consumers as well as from authorities. Location is a vital component in consumer services like social media, search, advertising and navigation. For authorities, mobile location is mandatory for emergency-call location and also be used for road-traffic management and machine-to-machine purpose.

C. Classification of Mobile Positioning Techniques

In this paper the techniques are divided in three major types.

1. Handset based Mobile Positioning
2. Remote Mobile positioning
3. Distance based Mobile Positioning

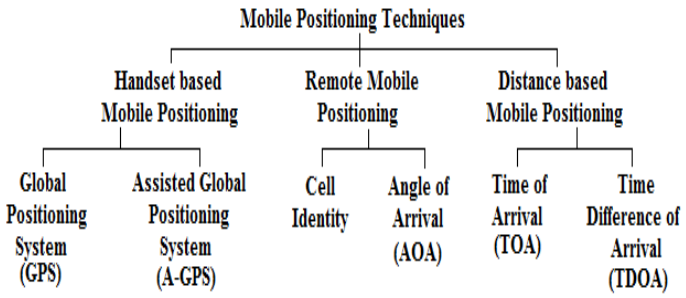

Figure 1 Classification of Mobile Positioning Techniques

II. TECHNOLOGIES

A. Handset based Mobile Positioning

In this technique the handset participates in the position determination. The location of the mobile phone can be determined using client software installed on the handset. This technique determines the location of handset by putting its location by cell identification, signal strength of the home and neighboring cells, which is continuously sent to the carrier. If the handset is also equipped with GPS then significantly more precise location information can be then sent from the handset to the carrier.

B. Global Positioning System

GPS is a wide-area radio positioning system. A mobile telephone can be located by a mobile telephone itself or through a mobile telecommunication network. To locate the mobile telephone by itself, the mobile telephone is provided with a GPS receiver to calculate its location in latitude and longitude coordinates based on the location information received from a satellite through the GPS Receiver[9].There are at least 24 operational GPS satellites at all times plus a number of spares. The satellites, operated by the US DOD, orbit with a period of 12 hours (two orbits per day) at a height of about 11,500 miles traveling at 9,000mph (3.9km/s or 14,000kph). Ground stations are used to precisely track each satellite's orbit [7].

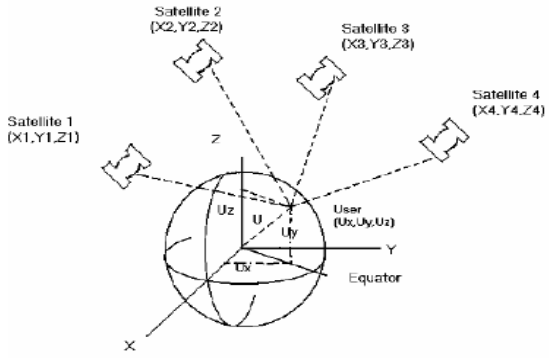

Figure 2 Global Positioning Systems

a. Assisted Global Positioning System

When a GPS system is designed to interoperate with cellular networks, the network assists the receiver to improve the performance with respect to the startup time, sensitivity and power consumption. In order to perform localization, the receiver must first know the orbital elements of the satellites. These data are transmitted with the GPS broadcast signal. The data rate of the GPS broadcast signal is only 50 bits per second. That is why the provision of a first position fix can take up to 12.5 minutes. Alternatively, the satellites' orbital elements can be transmitted via a cellular network connection, thus reducing the startup and acquisition times to a few seconds. A-GPS is considered to be the first A-GNSS. It was initially proposed in the early 1980s. In A-GPS, the GPS receiver is provided with information that helps to reduce the time it takes the receiver to calculate its position. Also, the sensitivity can be improved by using this method when the receiver is unable to demodulate the GPS signals in low-SNR situations. Moreover, the rapid startup time allows the receiver to stay in idle mode when positioning is temporally not needed. This reduces the receiver's power consumption [13].

Figure 3 Assisted GPS

C. Remote Mobile Positioning

Remote mobile positioning, in this case the mobile terminal can be located by measuring the signals traveling to and from a set of receivers. More specifically, the receivers which can be installed at one or more locations measure a signal originating from, or reflecting off, the object to be positioned. These signal measurements are used to determine the length and/or direction of the individual radio paths, and then the mobile terminal position is computed from geometric relationships.

a. Cell Identity

Cell identification, also called cell ID (or CID), is a technique for localization which estimates the location of the MS as the position of the fixed reference points (FRPs) which the MS are connected to. In practice, "cell ID" means an actual measurement obtained in the positioning system. This cell ID is then indexed in a database in order to determine the position and the accuracy range of the FRP. The accuracy of this technique is therefore limited by the physical communication range of the FRPs. simplest method among cellular based localization methods is the Cell-ID method: The position of the mobile terminal is estimated as the position of its currently serving BTS.Its drawback however is the accuracy, which is lower than that of range-, direction- orFingerprint based methods. The accuracy directly depends on the cell size, which may vary depending on the environment from a few hundred meters up to 20−25km.

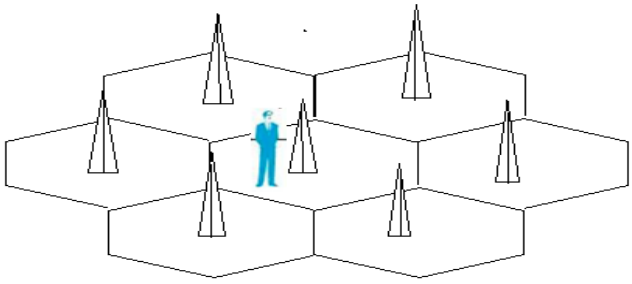

Figure 4 Cell Identity

b. Angle of Arrival

As said earlier there will be transmission and reception of signals between the mobile unit and BSs. This method calculates the angle of arrival of signal receiving at the BS. When a mobile users switches the system ON it receives the signal from different base stations, may be 3 or 4 or more. It measures the direction of signal falling on the base station and measures the angle of incidence with respect to a normal and determines the position of the system[9].

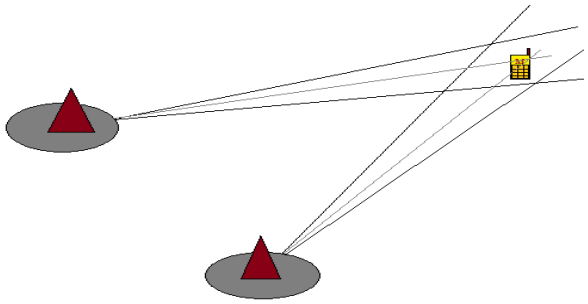

Figure 5 Angle of Arrival

In AOA, the location of the desired target can be found by the intersection of several pairs of angle direction lines, each formed by the circular radius from a base station to the mobile target.

D. Distance based mobile positioning

In this case, the distance between two points can be easily estimated by measuring the time delay of a radio wave transmitted between them. This method is well suited for satellite systems and is used universally by them.

a. Time of Arrival

Time of arrival (TOA) uses the travel time from the transmitter to the receiver, to measure the distance between the two BS. In order to properly localize with TOA, there must be at least three sensors. When the distances from three different sensors are known, the location can be found at the intersection of the three circles created around each sensor with the radius being the distance calculated. Imperfect measurements create a region of uncertainty between each of the sensors in which the transmitter might be contained. Since TOA relies on the difference between the time of arrival and time of departure, all receivers and transmitters must be synchronized so there is no error in the difference due to clock offsets. This may prove to be a problem, especially considering the high speed at which the signals travel.

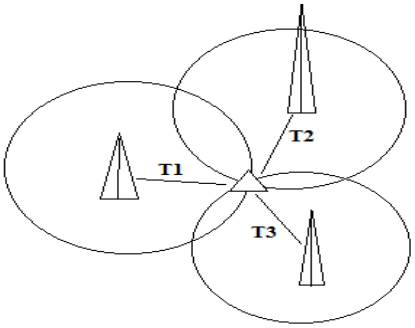

Figure 6 Time of arrival

b. Time Difference of Arrival

The TDOA is the difference between two TOA measurements obtained from two equivalent signals emitted at exactly the same time. This technique was proposed as a solution that allows one to drop the requirement that TOA measurements impose clock synchronization between transmitter and receiver. Since the TDOA is the difference between two equivalent signals sent at the same time, the dependency on the time of transmission of the signal is lost.

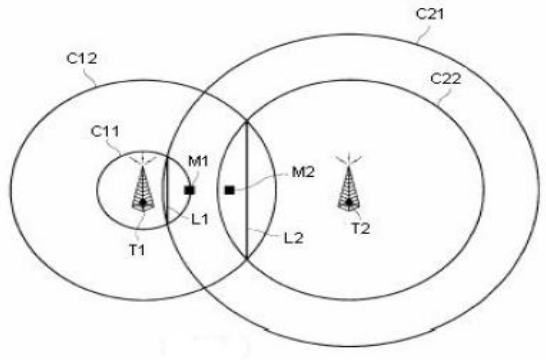

Figure 7 Time Difference of Arrival

III. COMPARISON OF TECHNOLOGIES

In this section the technologies are compared on the basis of common parameters. The comparison is done as per the classification of mobile positioning technologies.

A. Handset based mobile Positioning

Table 1 Comparison of Handset based mobile Positioning

	GPS	A-GPS
Stands for	Global Positioning System	Assisted Global Positioning System
Source of information	Radio signals from GPS satellites	Radio signals from GPS satellites and assistance servers. E.g. Mobile network, cell sites
Speed	GPS devices may take several minutes to determine their location because it takes longer to establish connectivity with 4 satellites	A-GPS devices determine location coordinates faster because they have better connectivity with cell sites than directly with satellites.
Reliability	GPS devices can determine location coordinates to within 100 meter accuracy	Location determined via A-GPS are slightly less accurate than GPS
Cost	GPS devices communicate directly with satellites for free. There is no cost of operation once the device is paid for.	It costs money to use A-GPS devices on an ongoing basis because they use mobile network resources
Usage	Cars, planes, ships/boats	Mobile phones

B. Remote Mobile Positioning

Table 2 Comparison of Remote mobile Positioning

	Cell Identity	Angle of arrival
Stands for	Cell Identity	Angle of arrival
Source of information	knowledge about the location of the BS	Angle of incidence received signal
Speed	Cell Identity may take several seconds to determine their location. It can take 5s or less than 5s to determine position	AOA determine location coordinates slower than the Cell identity Technique. It can take ≈10s To determine the position
Reliability	Cell identity performs Better in range of 200m to 300m and the coverage is moderate	AOA performs better in range of 100m to 200m and accuracy decrease with increasing distance between BS & MS
Cost	Cell identity determines position using the BS location So the cost is Low to implement Cell identity	AOA can cost more than Cell Identity as it requires to determine the angle between MS and BS
Usage	Mobile Phone	Mobile Phone

C. Distance based Mobile positioning

Table 3: Comparison of Distance based mobile Positioning

	TOA	TDOA
Stands for	Time of Arrival	Time Difference of Arrival
Source of Information	TOA of a signal transmitted from the mobile telephone at the BS	Time difference of arrival of received signal
Speed	TOA may take several seconds to determine their location. It can take ≈10s or less than 10s to determine position	TDOA determine location coordinates slower than the Cell identity Technique. It can take ≈10s Or more than 10s
Reliability	TOA performs Better in range of 200m to 550m and the coverage is good.	TDOA performs better in range of 100m to 300m and Coverage is good.
Cost	TOA requires no synchronization between transmitter and receiver. TOA is Expensive to implement.	TDOA requires synchronization between transmitter and receiver. TDOA is Inexpensive to implement
Usage	Mobile Phone	Mobile Phone

CONCLUSIONS

This work discussed different localization techniques and some of their concrete approaches with a focus on accuracy. Due to their high resolution capacity in the time domain, time-based positioning algorithms are usually preferred to those involving AOA measurements. Although these algorithms enable very accurate positioning, they also poses some challenges for practical systems (require installation of dedicated hardware).

In summary it can be said that there is no localization technique that is applicable in every situation and area. Some techniques do not work indoors or have problems in urban areas while other work well in urban areas but give poor results in rural areas. The technology that best fits most situations is A-GPS and will dominate the positioning market in the future.

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