A Review of Location Technologies for Wireless Mobile Location-Based Services

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Abstract: The demand of mobile data services has been increased dramatically with the improvement in wireless mobile technologies from past few years. Wireless mobile network operator provide many different kind of applications to gain attention of their valuable users, some of these are, downloading of ring tone, songs, wallpapers, transmitting of short and multimedia messages and video clips etc. The information about the location of the user is used for the purpose of providing the better kind of services to the user of the wireless mobile network. This type of applications which uses the location of user of the wireless mobile network is termed as Wireless-Location-Bases-Services (WLBS) by the service provider, which will increase the revenue for the wireless mobile network operator and very useful for the customer of these services in near future. But providing these services the wireless mobile network operator must addresses the different issues involved, comprising the development in technology used for, approval of user privacy, standardization and the accessibility of smart services. Various Wireless-Location-Based-Services (WLBS) engage the variety of factors for revenue generated smart services. This paper provides a review of current development and prerequisites for the purpose of providing Wireless-Location-Based-Services (WLBS) and its installation on UMTS, GPRS and GSM wireless mobile networks.
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Introduction

In modern economies, a worldwide and an unceasing spread of novel services and methods of marketization, automation and restructuring of various services prove that services play vital role in existing structural changes (Sirilli and Evangelista, 1998) (Asghar, Khan, Anwar, Ahmad, 2011). In this regard, telecommunication industry like mobile and wireless technologies are considered to perform major role in transforming the techniques for producing, trading and delivering the several services and applications.

The advancement in wireless mobile devices and data communication has changed and modernized the living style of the people and with the increase of the use of wireless mobile devices it become easy to access the data communication sources at anytime and anywhere. The wireless cellular network operator introduced the different kind of services that facilitate the consumers and earned the additional revenue for the cellular industry such like the Wireless-Location-Based-Services (WLBS). Currently, WLBS are getting more and more attention of the researchers as it provides a great platform for a continuously growing number of mobile applications (Mennecke and Strader, 2002) (khan, Asghar, 2009). These applications are of various types; fleet administration, fraud detection, location-sensitive billing and network administration (Zeimpekis, Alvarez, Tafazzoli and Evans, 2002) (Asghar, Ahmad, Ahmad, Saqib, Ahmad, Asghar, 2011).

However, the correct and accurate information about the position of mobile terminal is the main aspect identified so for towards this perspective, as the location of the user of the wireless mobile device is used for the purpose of delivery of the efficient services to their consumers. In order to provide the efficient and attractive mobile application, location awareness is the pre-requisite and the later denotes the ability of mobile hosts to find the present physical position of wireless devices (Tseng, Wu, Liao and Chao, 2001).

This paper provides a review of current development and prerequisites for the purpose of providing Wireless-Location-Based-Services (WLBS) and its installation on UMTS, GPRS and GSM wireless mobile networks. The success of wireless Location-Based-Services (LBS)'s technology is dependent on the positioning accuracy of the wireless mobile device, constraint defined and calculated by the researchers for each services individually with least possible amount of expenditure (investment) and with smallest resource load (efficiency related issues) on the wireless Location-Based-Services (LBS) and its attached working devices.

The rest of the paper is structured as follows. Section 2 discusses some positioning techniques for wireless mobile location-based services; section 3

gives framework for implementation of these positioning techniques and evaluates positioning performance of each technique. Section 4 presents elements of network used for offering the positioning data to the Wireless-Location-Based-Services (WLBS. The paper will conclude by discussing limitations as well as future research challenges that need to be overcome in order to fully exploit the business opportunities provided by mobile positioning techniques.

Positioning Techniques:

For the past few years, positioning technologies have arisen which allows the design of applications to identify a user's location and change their settings, interfaces and functionality accordingly (Pateli, Giaglis, Fouskas, Kourouthanassis and Tsamakos, 2002). In this work we evaluate the positioning technologies for locating wireless mobile devices with. Basic standard Location-Technology is Cell-Id (Cell Identification), and the advanced technologies are EOTD (Enhanced-Observed-Time-difference), OTDOA (Observed Timed difference Of Arrival) and Assisted-Global-Position-Systems (AGPS). Typically these network technologies needed changes in either mobile phones, or networks and in some situations require modification in both.

The specification design of Global System for Mobile Communication (GSM) and UMTS wireless cellular network indicates two types of process. The one type of process is handset device-based and the other is handset device - Assisted process. In the device-based type, the location is calculated by the handset device and then sent the calculated information back to the wireless cellular network. In this approach, security risk arise since the user's location is stored in the device (wireless mobile device) and could be hacked and traced by the unauthorized user which puts the privacy of the user of wireless Location-Based-Services (LBS) in danger and not compromised in some situation. While in the handset device assisted type the wireless device take the rough data from different direction and these measured data is sent to the wireless cellular network, which contained the special device which serve as a center to calculate the location of the wireless mobile device, called "Serving Mobile Location Centre (SMLC) terminal, which collect and calculates the device position and remains safe because the location data of the user of wireless Location-Based-Services (LBS) does not exist in the device. Device-Assisted technologies are the EOTD and O-TDOA whereas AGPS types can functions in both environments.

***Cell-Id Technique*:**

Cell-Id is the fundamental technique for providing the Location-Based-Services (LBS), since all wireless mobile devices support this technology. In Cell-Identification (Cell-Id) technique the Base Transceiver Station (BTS) to which the signals are going and coming to the wireless device or terminal from the cellular network is used to determine the position of user, which has assign different identification code. Cell-Identification (Cell-Id) positioning technique can provide the wireless Location-Based-Services (LBS) to all the user of wireless mobile device which connected to the wireless cellular network's Base Transceiver Station. However its performance is very low when used in rural areas and high in urban environment (Giaglis, Kourouthanasis and Tsamakos, 2002). Its accuracy can be increased by uniting the Cell-id technique with Timing Advance (T-A) technique. Cell-Identification (Cell-Id) provides location accuracies of wireless mobile device in between 150 meter to 1 Kilometer in metropolitan area and in between 1 kilometer to 35 kilometer in countryside (Kos, Grgic and Sisul, 2006) (Retscher and Kealy, 2006).

Time of Arrival (TOA) Technique:

Time of Arrival (TOA) techniques calculates the time taken by the signal to arrive from the wireless mobile device to the different base station (BS) situated at a very accurately known position (Sage, 2011) (Zhao, 2001). The calculated range, between the points signal takes to travel from Base Station (BS) to the wireless mobile device and from wireless mobile device to BS, determines the position of the user of wireless mobile device. TOA technique needs maximum matches within the network of BS, and in order to calculate the range broadcasted signals must be labeled with the time value. Time-of-Arrival offer the accuracy of 125 m to 200 m (Zhao, 2001), but the cost-benefit is not supported by this technique as it involves large number of special device.

Enhanced-Observed-Time-Difference (E-OTD) Technique:

Enhanced-Observed-Time-Difference (EOTD) is upgraded form of TOA technique and in this type of technique the mobile device calculate the variation of arrival time of broadcasted signals from at least three coordinated Base Station (BS) (Retscher and Kealy, 2006) (Zhao, 2001). Observed-Time-Difference (OTD) is the time period that is measured by mobile device between three responses from two Base-Transceiver-Stations (B-T-S) in wireless mobile network. This type of capability to calculate the time differences is a latest function in the mobile device and this requires special software that can be capable to do EOTD operation. The mobile device calculates and sends the time information to the special network component; "Serving Mobile Location Centre" (S-M-

L-C). The transmitted frames from different Base Transceiver-Station (B-T-S) are not time-marked in the Global System for mobile communication (G-S-M) cellular network. The actual time variation between couple of Base-Transceiver-Station (B-T-S) is calculated by the Location-Measurement-Unit (LMU). This variation of actual time is the difference in the cellular network between two Base-Transceiver-Stations (B-T-S). The calculations returned are the difference from each Base Station (BS) of wireless Cellular Network. When a handset device, equipped with (EOTD and LMU, obtain a signal from minimum three BS then LMU calculates the time variation of arrival of the signal from all BS. The accuracy of EOTD depends on the density of network cell, cell arrangement values, obstruction, noisy environment, and efficacy of LMU. The EOTD can locate a wireless mobile device in the range of 50 m and up to the 150m (Kos, Grgic and Sisul, 2006) (Retscher and Kealy, 2006).

Observed-Time-Difference of Arrival (OTDOA) Technique:

The Observed-Time-Difference of Arrival (OTDOA) only worked on UMTS wireless mobile networks and the weakness and performance strength are alike to the weakness and performance strength of EOTD method. The foundation of UMTS network is on the CDMA technique. The UMTS is optimized for little powered and the effective use of communication bandwidth since it is based on CDMA technology. OTDOA requires an additional investment for installing the instant device, which provides accurate timing for OTDOA calculation. The accuracy of OTDOA differs and varies from area to area within an operator's territory due to the cause of multi-path propagation, which is similar to E-OTD. It is possible for an operator to add more nodes (BS) in some areas to increase the accuracy of the location information. The operator might choose to have fewer nodes (BS) in areas where location information is not needed. The accuracy of OTDOA can be better than 100 m (Searby and Ralph, 2004) and the reply time is very fast and high (approximately 10 seconds) (Siau and Lim, 2003).

Assistant-Global Position Systems Technique:

Assistant-Global Position Systems Assisted-GPS or A-GPS works in all Wireless Cellular network like GPRS, GSM, and CDMA based UMTS networks. A-GPS location technique combines the wireless cellular technologies and navigation system like GPS-system (Searby and Ralph, 2004) (Zhao, 2001). The technology of A-GPS is costly for the user because it requires an additional investment to purchase GPS installed mobile device. New hardware and software are required for high Impact on the handset device for adding GPS functionalities. A-GPS utilizes that type of systems which enables the GPS's receiver to work under the environments like inside a building, inside field area and even in urban valleys. The A-GPS technique provides better precision than Cell-identification (cell-id), E-OTD or OTDOA and the accuracy offers by A-GPS is between 10 m to 100 m. A-GPS operates in synchronous or asynchronous networks mode without the needs for Location Measurement Units (LMU). Accuracy of these positioning techniques in various environments is presented in Table 1.

Table 1: Accuracy of different Positioning technologies

Accuracy of Different Location Technologies					
Full Name	Abbreviations	Rural	Sub urban	Metropolitan	Indoor
Cell Identification	Cell-Id	1 Kilometer to 35 Kilometers	1 Kilometer to 10 Kilometers	150 Meters to 500 Meters	10 Meter to 50 Meters For Pico cell
Enhanced-Observation-Time-Difference	EOTD	-	50 Meters to 150 Meters	50 Meters to 150 Meters	Good
Assisted Global Position System	A-GPS	10 Meters	10 Meters to 20 Meters	10 Meters to 100 Meters	Variable

Implementation Requirements and Positioning Performance

In order to determine the position, location technology should yield a high fraction of well computed locations that satisfy the predefined quality measures to the number of attempts. Different types of environment and variation of networks must not affect the accuracy of location technology Locating technique should generate positioning information rapidly; request time and time taken to fix it. Request time in most networks is usually in the range of 05 seconds to 20 seconds. Up-gradation of hardware and software does not affect the device as well as does not affect the battery power of the device. Location technology must have the facility of roaming through varied geographical zones. Location technique must

be standardized, compatible to upgraded network like second generation to third generation technologies and compatible to existing network with good network efficiency.

Under the consideration of these constraints, various Location technologies are evaluated here below (Kos, Grgic and Kitarovic, 2007) The accuracy of Cell-Id shows discrepancy and very low in different environment but it covers a wide area for providing Wireless-Location-Based-Services (WLBS). Cell-Id can easily be implemented since it does not require the change of End-User device. It does not require changing the infrastructural element of the network. Cell-Id operate in all air medium wireless cellular network including Global System for Mobile communication, GPRS, Universal-MTS. Cell-Id has low initial cost because the Cell-Id resides within the network until it has access to base transceiver station (BTS). Cell-Id does not require much cost for maintenance. Cost required to extend Cell-Id is low as long as extension is implemented within compatible network.

The accuracy became efficient by using Enhanced Observation Time Difference and OTDOA technique as compared to Cell-Id, but is subject to errors due to critical Base Transceiver station configurations and multi-path. As in the countryside areas, there is limited number of BTS, which causes the coverage problems and the implementation of E-OTD and OTDOA becomes hard in such areas. Addition of Location Measurement Units for asynchronous cellular networks and additional software needs to be installed for E-OTD as well as involves the development of Base Transceiver Station for manual improvement and repairs. Roaming in wide areas or into other networks is not supportable for these techniques. Global System for Mobile communication network support E-OTD only and OTDOA operated in Universal-MTS environment only. The initial investment for E-OTD and O-TDOA is high because the special device must be added (imprecisely one Location Measurement Units for every Base Transceiver Station). Repairs rate is high since the huge amount of Location Measurement Units is needed and for expanding the network and coverage area additional Base Transceiver Station is required.

Assisted Global positioning system offer the ideal accuracy as compared to Cell-Id, EOTD and OTDOA techniques, but in large city and inside the large buildings it come across the coverage area problems. It is easy to install and implement the Assisted-GPS technology but it needs modifications of wireless End-User device. This technique does not need to changes the key infrastructure and worked in either type of environment i.e. asynchronous and synchronized cellular mobile networks. Roaming can easily be done in wide area and into the other network. Assisted-GPS can operate in all air medium values with UMTS, Global System for Mobile communication and GPRS cellular network. The cost of A-GPS depends on the cost of end-User device and associated with the number of subscribers that need location. The increasing cost of End-User device is because of semiconductor costs and becomes low when the price of the semiconductor is low. The infrastructural and development rate is minimum, and the maintenance and repairing investment of Assisted-GPS is also small.

Architectural Element For Location System

The elements of network mostly used for offering the positioning data to the Wireless-Location-Based-Services (WLBS) with E-OTD method is represented in figure 1. Single Cellular Network component are described below [8] [6].

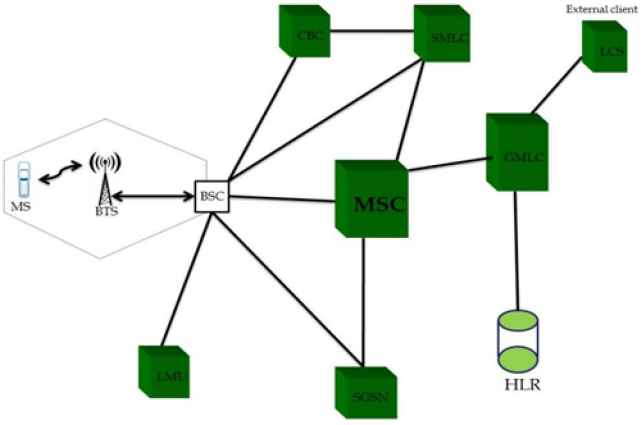

Figure 1: Structural Design Of The Elements Of LCS System

Mobile Station (MS)

The End-User device or mobile device permits the user of that device to connect to the Global System through Cellular mobile Network. The End-User or handset device should contain all the necessary equipment and software for the connection and communication to the cellular network.

Base Transceiver Station (BTS)

BTS of cellular network is responsible to maintain the connection between End-User device and Cellular Network through the radio linkage which allows communication with the mobile station over the medium (AIR).

Mobile Switching Centre (MSC)

The Mobile Switching Centre is responsible for circuit switching connection of End-User device and Cellular network. MSC executes signaling and switching tasks for the users in its coverage area. It performs the authentication process for the correct End-User device.

Public Land Mobile Network (P.L.M.N)

A PLMN is a network that is launched and control by an organization for the definite purpose of offering land mobile telecommunications services to the community. It may be considered as an extension of permanent network like a Public Switching Telephone Network. It includes Home Public Land Mobile and Visited Public Switching center Network.

Gateway Mobile Location Centre (GMLC)

GMLC is a GSM public land mobile network center that outer Location Services customers can access, allowing the device to access applications not residing on the operator's own ISP domain. GMLC may request routing information from the Home-Location-Register. It launches the location requests to and receives back the final location calculated from the Mobile Switching Centre, after carry out the registration authorization.

Serving-Mobile-Location-Centre (SMLC)

SMLC gains and manages the measurements from LMUs. The whole scheduling and coordination of network component required for locating the user of wireless device, calculation of the location estimated and accuracy is handled by SMLC. SMLC is also accountable for obtaining measurements results from the target Mobile station in E-OTD.

Home-Location-Register (HLR)

HLR holds Location Services subscription and routing detail and can be accessed through Gateway Mobile Location Centre. It might be in a different Public Land Mobile Network that the existing Serving Mobile Location Centre, for roaming Mobile Stations.

Serving GPRS Support Node (SGSN)

The SGSN is needed in 2.5 generation and 3 generation network to carry information in the whole network.

Location-Measurements-Units (LMUs)

LMU support the location system. It is an additional hardware component in Global System Mobile network used in obtaining the exact Observed Time Difference calculations of the signal coming from different Base Transceiver Stations. LMUs will be able of determine the Relative-Time-Difference between bursts broadcasted from a Base Transceiver Stations on an intervallic and predictable basis. Further this calculated data is used by the system for determining the position of a wireless device.

Cell Broadcast Centre (CBC)

CBC controls the message broadcasted to selected network components. In device based E-OTD, this task is very essential because of the fact that in this process the wireless device calculates a location based on received information. Wireless network sends this information via special broadcast messages. A Serving mobile location center and Assisted-GPS positioning services software at the Serving Mobile location Centre are required to implement the Assisted-GPS on present Global System Mobile network. A Large numbers of the Location measurement Units and additional software at Serving Mobile Location Centers are required for implementation of E-OTD method on existing GSM network to find location of user. The implementation of the E-OTD is difficult then the Assisted-GPS methods if going through infrastructure potential.

Categories of Wireless Location Based Services (WLBS)

In principle there are three basic categories of Wireless-Location-Based-Services (WLBS), i.e. PUSH, PULL and TRACKING presented in Figures 2, 3 and 4 respectively (D'Roza, T and Bilchev, 2003)

Push:

In the case of push based services, the consumer does not made request for the wireless location based service (WLBS) by himself rather the request is made by the service provider. This means that every day at the same time user must be registered in order to get access to certain location based information.

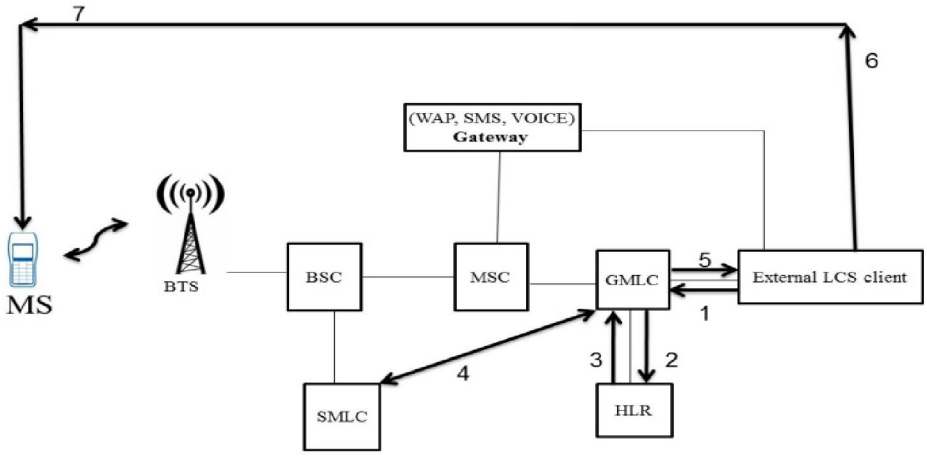

Figure 2: Push Service on Single Network (Mobile Station Is Target)

Steps involved in the PUSH process are as follows

1. Location-Based-Services (LBS) request
2. Authorization request
3. Authorization
4. Positioning
5. Location
6. Location-Based-Service (LBS) response
7. Location-Based-Service (LBS) response

Pull:

In pull-types service, the consumer makes request for the Wireless-Location-Based Services (WLBS) by himself. A good example of the pull service is the visiting of the website through internet because when we entered the exact address of the website then the same pages are delivered to us by the internet service provider. Some other examples include booking of the taxi, request for an ambulance by only pressing a wireless mobile device button and search for closest petrol or CNG station, Chinese hotels etc.

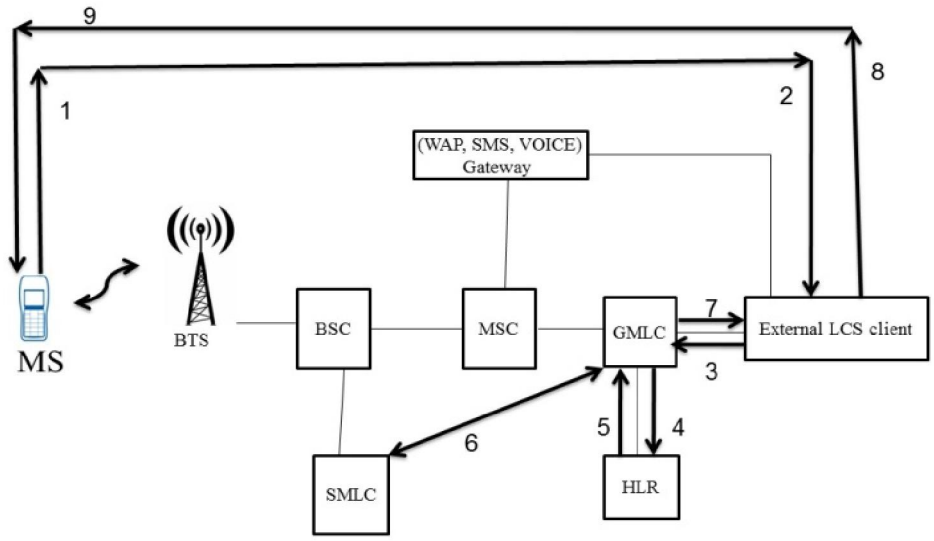

Figure 3: Pull Service on Single Network (Mobile Station Is Target and Requestor Both)

Steps involved in the PULL process are as follows

1. Location-Based-Service (LBS) request
2. Location-Based-Service (LBS) request
3. Location request
4. Authorization request
5. Authorization
6. Positioning
7. Location
8. Location-Based-Service (LBS) response
9. Location-Based-Service (LBS) response

Tracking:

The third basic type of Location-Based-Services (LBS) is tracking. The main idea for this kind of service is that somebody (service / person) demand for a position of the wireless mobile node (vehicle, people, fleet and others). Like push and pull services, it also needed the permission of the End-User that the application or person can track his location or not, without permission the location of the End-user device is not transferred to the requester. The best example for tracking application is buddy finder.

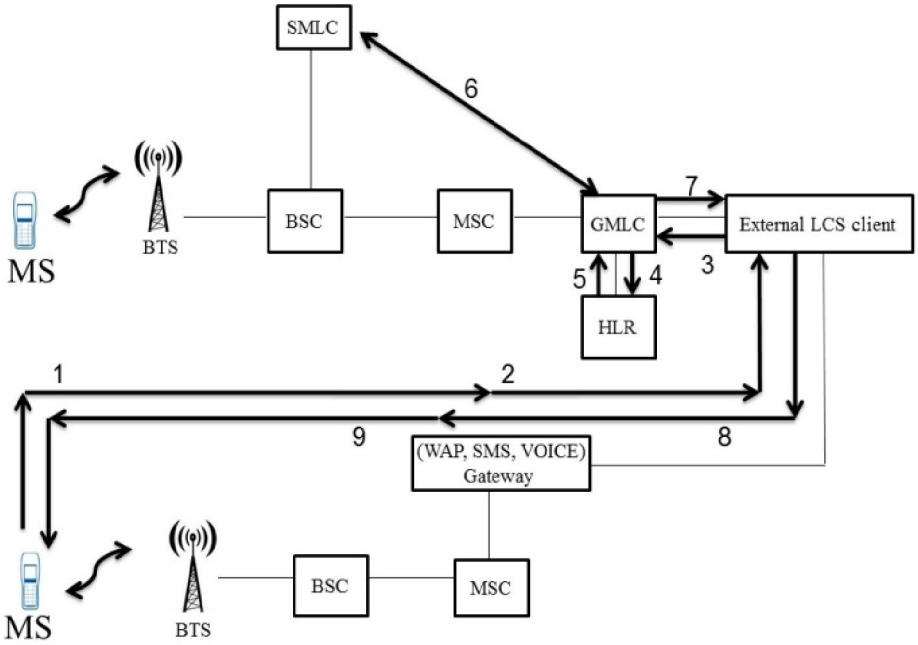

Figure 4. Tracking on single network (top mobile station is target and below mobile station is requestor)

Steps involved in the TRACKING process are as follows

1. Location-Based-Service (LBS) request
2. Location-Based-Service (LBS) request
3. Tracking request
4. Authorization request
5. Authorization
6. Positioning
7. Location
8. Location-Based-Service (LBS) response
9. Location-Based-Service (LBS) response

When the service requestor node (MS) and the target node (MS) are from various H.P.L.M.Ns and different networks are involved, then we consider inter-networking operation. It may be possible that one of the customers is in roaming. The roaming of Wireless-Location-Based-Services (WLBS) is very difficult than the roaming of voice and Short-Message-Service, because there are many components involved for the purpose of providing the Wireless-Location-Based-service (WLBS) process.

Below is the description of the terms used in the above figures (2, 3, 4)

Target Node:

Node whose location is requested is called target node. Examples include vehicle, people, or others. The wireless network operator is responsible to access the location of the target node but target node first asked for the permission from the requestor to access its location or not, then the network operator transmitted the location of the target node to the requestor.

Requestor Node:

The node that requests for the location of the other node and gains the permission from the target node to access the position is called Requestor node. The Requestor and Target node may be the same in Enhanced Emergency Service.

Outer Location Service user:

The Wireless-Location-Based-Service (WLBS) is offered by the services provider to End-User, and uses the external data for the service and allowed to take the charges from the requestor of the service.

Conclusion

Wireless-Location-Based-service (WLBS) provides a good revenue generation opportunity to the mobile network owners. The effective Wireless-Location-Based-service (WLBS), provided to the consumer, must fulfill the prescribed values for that service on wireless cellular network and for implementation of that service it should be considered that low cost will be invested with maximum revenue. The Universal-MTS, Global System for mobile communication and the GPRS cellular networks permit only the two dimension location for the consumer of the Wireless-Location-Based-service (WLBS) applying different methods. The advanced positioning method is Global Positioning System which merges the Cellular technology and the satellite locating method which offered the accuracy from 10 meter to 100 meter. From the above wireless cellular technology, Assisted-GPS and T-DOA technology for providing the Wireless-Location-Based-service (WLBS) are the most prominent methods for the existing communication system which are offering good performance and locating accuracy of the object or End-node. Many of Wireless-Location-Based-service (WLBS) will always generate good profit if they enhanced their technology for the purpose of providing good accuracy, and preference shall be given to locating technique and technology which have good accurate positioning in the future.

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