Technology Digest

Monthly bulletin of telecom technology

Issue 14, August 2012

For limited circulation

Telecom Regulatory Authority of India

Location Based Services

In this issue

In the era of significant telecommunications competition, operators constantly seek new and innovative means to create differentiation, generate new revenue streams and increase profits. One of the ways to accomplish this is through the delivery of highly personalized services to the consumers such as location based services.

Location based services (LBS) refer to a broad range of services that utilize the knowledge of the geographical position of a mobile device, in order to provide services based on that information. It allows consumers to receive services and advertising based on their geographic location. Such services can be provided in response to a consumer's manual input of his or her location information into the handset or by using a technology to track the location of the consumer automatically. Through LBS information about traffic, restaurants, retail stores, travel arrangements, routes, vehicle tracking etc. can be provided. In addition, LBS can also help in law enforcement and emergency services.

Location based services can be defined as to the provision of geographically-orientated data and information services to users, across mobile telecommunication networks. LBS can be seen as the convergence of mobile telecommunication system, location aware technologies and handheld devices with the Internet, Geographic Information Systems (GIS) and spatial databases(1). GIS provides the tools to provision and administer manmade structures (such as streets, buildings, etc.) and to manage data of interest such as location of petrol stations, stores, restaurants, etc. It also includes information about the radio frequency characteristics of the mobile network. This allows the system to determine the serving cell site of the user. Numerous context based services are possible based on the location of the customer.

As per Pyramid's research report (market forecast: 2011-2015) [2] the global location based services market is experiencing strong growth. Revenue is expected to reach US$10.3bn in 2015, up from $2.8bn in 2010. As per ABI research LBS revenues will cross $4 billion mark in 2012.Some of the key factors in the recent fast uptake of the LBS are the simplicity of the service, increasing GPS enabled handsets and smartphone adoption, success of new business models, continued growth of mobile advertising, wider coverage and higher speeds of mobile networks, availability of the application on multiple bearers including Unstructured Supplementary Service Data (USSD) and the service reaching subscribers even with the most basic mobile handsets. Although operators are continuing to lose control over location information with the growth of Global Positioning System (GPS), this is also creating important growth opportunities for them. In 2008 operators gained around 80% of all location-based service revenue. This has fallen to around half, but the total market has grown more than fivefold. Navigation, local search, people-locating services and targeted advertising are the key areas for operators to target. Navigation applications are the largest location-based service revenue generators.

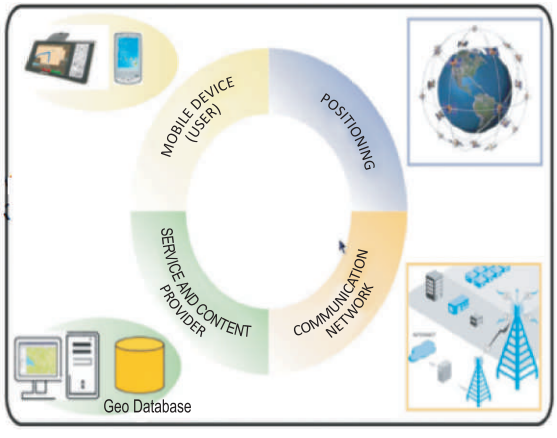

Figure 1: Basic components of LBS

Components of LBS

Network of the Location based services is a combination of the following four components as shown in Figure 1.

Mobile Devices : It is a medium to pull or push the desired information to the users through Mobile Phones, etc.

Communication Network : Mobile network transfers the user data and service request from the mobile terminal to the service provider and then the requested information back to the user or sends information targeted towards user from the service provider.

Positioning Component : It determines the location of the user for provision of location based service.

Service and Content Provider : Service and content providers are responsible for the service request processing and provide a number of different services such as finding a route, friend, store or location to a specified place, etc.

How Does LBS work

When a user requests the desired information such as location or route to a particular place through the mobile device, the location of user is known either by GPS or by a network positioning services. Thereafter, the user's request is sent to gateway via communication network. The Gateway is responsible for exchange of messages between communication networks and internet. The desired request is sent to service and content provider for processing through internet. After processing, the desired information is sent to user via internet, gateway and mobile network (3).

Positioning Technologies for LBS

Various types of positioning technologies are available which include GPS-based, Mobile network based and Wi-Fi-based location technologies.

GPS based location technologies

Global Positioning System (GPS)

The Global Positioning System (GPS) is the worldwide radio navigation system based on satellites orbiting the earth that provides location and time information. Each satellite continually transmits messages that include the time the message was transmitted and the satellite position at the time of message transmission. The GPS enabled handset uses the signal it receives to determine the transit time of each signal and computes the distance to each satellite using the speed of light. When the device receives at least four different satellite signals, it can calculate its geographical position (Figure 3).

The disadvantage of GPS is that in urban areas the time required for a GPS enabled handset to acquire satellite signals and calculate the positioning sometimes takes a long time because buildings hinder GPS signals from being received.

Assisted Global Positioning system (A-GPS)

A-GPS is an enhancement to GPS. Here a server called A-GPS server is connected to the telecom network through mobile switching centre (MSC). A-GPS server can obtain handset position through MSC and at the same time monitors signals from GPS satellites seen by the mobile station (MS).

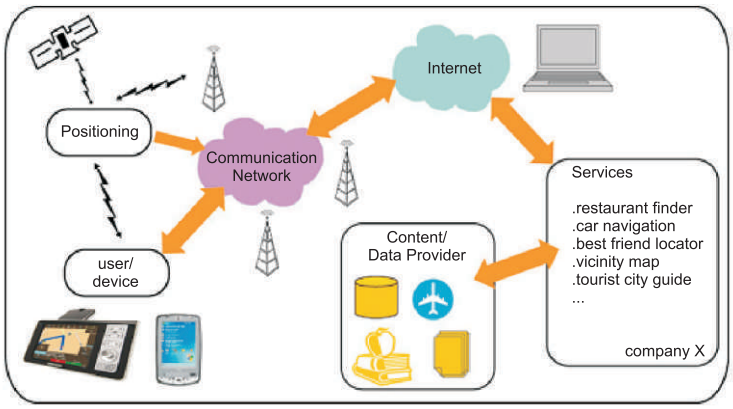

Figure 2: Working of LBS

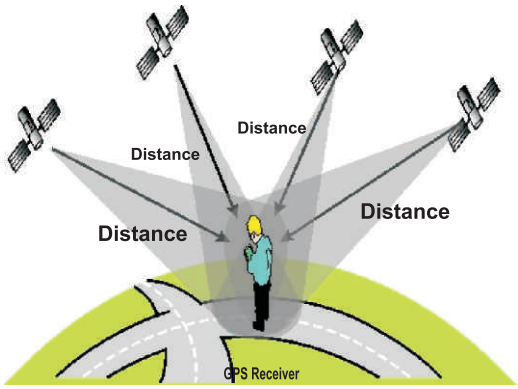

Figure 3: Global Positioning System (GPS)

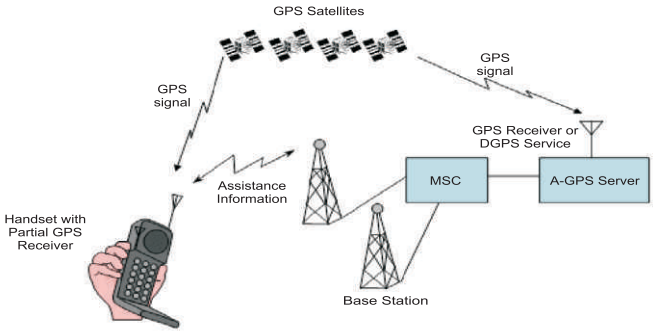

Figure 4: Assisted Global Positioning system

Summary of GPS based location technologies is given in Table-1.

Table-1 GPS-based location collection technologies (9)

	GPS	Assisted GPS
Description	GPS enabled handset's position is calculated based on the signals from at least four GPS satellites with known position of the satellites, the time that messages from the satellites were sent and the time that they were received.	This is an enhanced form of GPS in which a server called A-GPS server is connected to the network through MSC. A-GPS server can obtain handset position through MSC and at the same time monitors signals from GPS satellites seen by the mobile station (MS). This can allow GPS accuracy with initial location information within seconds, thereby making it practical for use in LBSs.
Accuracy	5-10 m	5-10 m
Advantages	Highly accurate. Not dependent on mobile network provider.	Faster and highly accurate. Allows GPS to be used in densely populated areas where clear GPS signals may not be obtainable.
Disadvantages	Relatively high power requirement. Clear satellite signals are required. Depending on the device, it may take a long time (~ 30 sec) to lock onto satellite signals.	Dependent on the mobile network provider; can only operate where mobile network reception is available.

Mobile network-based location technologies

In such systems all the measurements and calculations that are needed for position estimation are done by network / user equipment (UE) or both

Cell of Origin

It is the simplest and economical way for position estimation as it requires only minor software changes in the network and no terminal up-gradation is required. Therefore it can be deployed easily. Though Cell ID can be network based or handset based, generally it is implemented as network based. A BTS covers a set of cells, each of them identified by a unique Cell-ID (eg. Area1, Area2 and Area3 in Figure 5). BTS broadcasts the Cell-ID to its cells. The handset which is in the coverage area of cell always receives these broadcast messages. As a result the handset can approximate its actual location using the geographical coordinates of the corresponding BTS (6). The accuracy of this method depends on the size of the serving cell and more precisely on the size of the corresponding sector. Therefore accuracy of location information can be improved by using directional antenna.(7)

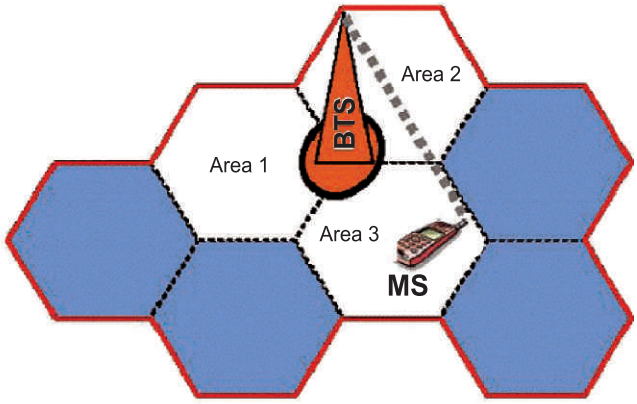

Figure 5: Cell-ID system

Angle of Arrival (AOA)

In Angle of Arrival (AOA) system, a mobile device's signal is received by multiple base stations (Figure 6). In order to locate the position of device, mobile device's signal is received by at least two base stations. Each base station has an array of antennas to measure the angle of the incoming signal and has additional equipment i.e location receiver that determines the direction of the incoming signal. The information from each base station is sent to the mobile Location Calculation and Control

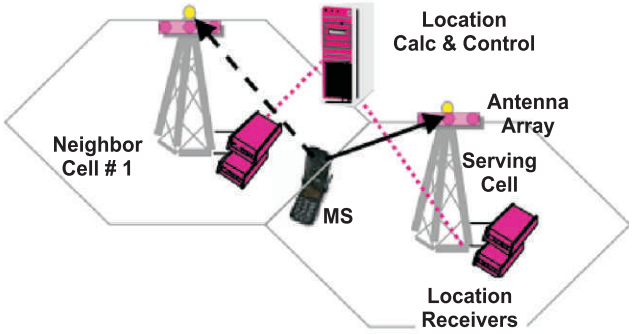

Figure 6: Angle of Arrival system

Center, where it is analyzed and used to generate an approximate latitude and longitude of the mobile device.

Time of Arrival (TOA)

Time of Arrival (TOA) system works by measuring signals sent from the MS to three or more BTSs. BTSs on receiving the signal, hand it over to a Location Measurement Unit (LMU). The LMU measures the time it took for the signal to travel between the MS and the BTSs(TOA). Through these values location of MS can be known.

Time Difference of Arrival (TDOA)

Time Difference of Arrival system is a variation of the TOA, and can be used if the time of the signal was not accurate. Instead of using absolute time measurements, as TOA, this method rather uses difference measurements. The LMU at the BTS marks the time when the signal arrived from the MS (d1) (Figure 8). This value is compared against when the signal arrived to another BTS, d2. The difference between the two arrival times, d1-d2, is called the TDOA value. A curve is calculated along the line where the TDOA value is constant, a hyperbola. By using two pairs of BTSs, at least three BTSs, two hyperbolas can be calculated and an intersection found where the MS is located (8).

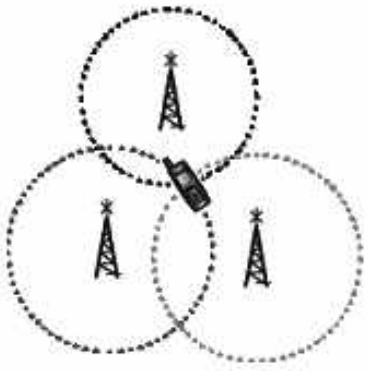

Figure 7: Time of Arrival system

Enhanced Observed Time Difference (E-OTD)

In E-OTD the MS measures the signals from the network. By observing when a signal arrives from a BTS the MS can calculate the difference between the arrival times from two different BTSs, the observed time difference (OTD). As in TDOA the OTD is used to calculate a hyperbola where the OTD is constant to the two BTSs. At least two distinct pairs of BTSs are needed to calculate an intersection, thus minimum of three BTSs. Since the time measurements are done in the MS, just the OTD is not enough to get an accurate value. The real time difference (RTD), the difference between when the two signals were sent, is needed as well. To calculate the hyperbolas the geometric time difference (GTD) is used, where GTD is defines as:

GTD= OTD– RTD.

To measure the RTDs, the signal bursts has to be received not only by the MS but also by a LMU. The LMU has a known position, and therefore have a known distance to all BTSs. When the LMU receives the signal bursts it can calculate the RTD with help of the known distances (8).

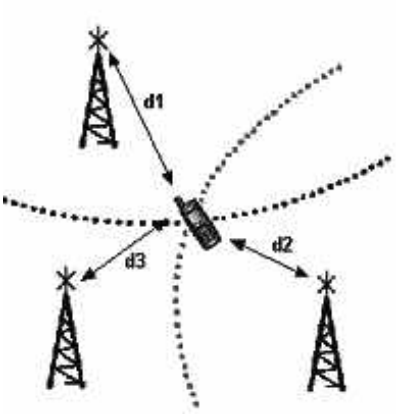

Figure 8: Time Difference of Arrival system

Summary of network based positioning technologies is given in Table-2.

Table-2 Mobile network-based location technologies (9)

	Cell of Origin	**Time of Arrival**	**Angle of Arrival**	**Enhanced Observed Time Difference**
Description	Location is approximated based on the cell servicing a subscriber. It has been superseded by technologies that are more accurate.	Distance to base stations is calculated based on the propagation time of the signal between the mobile device and the station. TOA or TDOA may be used. Calculations are performed by the mobile network systems.	Angle of arrival of the signals received from a mobile device at a number of BTSs is used to determine the device's location.	Similar to TOA system except the calculations are performed on the device.
Accuracy	Depends on cell size. It could be on the order of 150m or more in urban areas, and up to 1km or more in rural areas depending upon the cell size	50-150 m	50-150 m	50-150 m
Advantages	Simplest and economical. No additional functionality required.	Greater accuracy than Cell of Origin. No need for a GPS receiver; standard mobile device hardware is sufficient.	Greater accuracy than Cell of Origin. No need for a GPS receiver; standard mobile device hardware is sufficient.	Greater accuracy than Cell of Origin. Less dependent on mobile network provider
Disadvantages	Poor accuracy.	Requires mobile network provider to perform calculation, which may lead to privacy concerns.	Requires mobile network provider to perform calculation, which may lead to privacy concerns. Multipath can cause issues	Requires more sophisticated mobile devices to perform calculations.

Wi-Fi-based solution

In this technology, the identities and relative signal strengths (which correspond roughly to distance) to public Wi-Fi access points are recorded by the device, thereby allowing triangulation with respect to these access points. Based on a database of known access points and their physical location, an approximate location for the device can be calculated. The accuracy of such systems are claimed to be around 10-20m. This technique involves fast and relatively accurate location collection compared to mobile network techniques. Lower power is required in this case as compared to GPS and there is no need for GPS receiver. The disadvantage of this system is that it relies on access to Wi-Fi access points, which may not be available in certain locations (9).

Services and applications under LBS:

Generally LBS applications can be divided into push and pull services. The pull services are user driven that allow the subscriber to select the LBS application like the location of person or object, Local weather information, city guide, store location, route information etc. Push Services are event driven where the user receives a notification or an alert based on his/her preferences and current location from the service provider. Examples of such services include location based advertising which informs users about products of their interest located at nearby stores.

Some of the examples of Location based services (LBS) are:

- Navigation: These services are used for providing directions to users to travel from an origin to a destination such as finding route to a particular place.
- Emergency services: These services provide information about people during emergencies such as assisting in locating a subscriber who need immediate medical assistance, in case of an accident immediately send alarm to the nearest police and ambulance cars.
- Information services: These services are used to provide information such as finding a particular restaurant, finding the closest train station, Vehicle Assistance, find my friends, Child Finder, Self Guided Tours, etc., to the users.
- Security services: LBS services are used for law enforcement and personnel tracking which allows tracing the location of users
- Traffic monitoring: LBS services may be used to report any congestion on the road, know the number of cars in a specified location, make sure that there are no two aircrafts with nearby paths
- Supply chain management and tracking: LBS services are used for delivery vehicle tracking, Asset Tracking, etc.
- Entertainment: Some of the games and social networking services can also make use of LBS.
- Demographic profile: LBS services can be used to ascertain demographic profiles of the areas for planning and other purposes.
- Advertising: LBS services may be used for advertisement purposes like sending e-coupons to all consumers within 2 km of a store.

Other application/services that may be offered by using location based services include polling booth finder on election day, Equipment inspection log, inspection or maintenance of equipment , etc.

Figure 9: Examples of Location based services (LBS)

Provision in License agreement for security

Due to security related concerns, license terms and conditions of mobile operators were amended on 31.5.2011. As per this amendment, the Licensee shall provide location details of mobile customers in the license service area as per the time frame mentioned in Table-3 from the date of issue of the amendment and accuracy. The amendment mandates the location information to be part of CDR in the form of longitude and latitude, besides the co-ordinate of the cell sites, which is already one of the mandated fields of CDR.

Table-3 Required Location Accuracy by cellular operators

Accuracy in Percentage							
Distance in Meters	Urban (More than 1 million mobiles in a municipal limit)		Sub-Urban & rural			Remote	
	1 year	2 years	1 year*	2 years	3 years	2 years	3 years
50	30	50					
100	60	75		50	60		
300	80	95	50	60	70	50	60
500			60	70	80	60	70

* Applicable for the state of J&K, Assam and NE region.

Challenges in LBS

One of the main challenges in use of LBS technologies is the issue of privacy as the users care about their privacy and are concerned with any intrusions. LBS may be highly beneficial but it can intrude into user's privacy. Technical solutions that may be used to protect the privacy of LBS users include : Anonymisation to ensure that the LBS will not be able to link requests to specific users, Cryptographic techniques (such as encryption & secure hashes are commonly applied to conceal information) and accuracy filtering that can also be used for some applications/services to reduce the possibility that the LBS provider can identify the user. Another challenge is that various positioning technologies require different levels of accuracy for various services. Multiple mobile positioning techniques are available in the market with varying accuracy and the quality of position viz. horizontal accuracy, response time, etc. varies with technologies. Further, in case of emergency services, the timely delivery of accurate emergency locations to the close emergency station needs to be ensured. Interoperability issues also need to be addressed as the requisite databases for provision of Location based services could be maintained by the user's service providers only and may not be shared by other service provider.

Conclusion

This paper focuses on Location Based Services (LBS) which is developing rapidly in the mobile space. Different positioning techniques of LBS, their pros and cons, challenges in LBS are discussed in this paper. LBS services have tremendous potential to provide value and foster innovation to benefit consumers and economy. Analysts have predicted massive growth in the LBS market over the next few years. By using, LBS people can save time (eg. using applications/services such as finding a particular place), money (eg. using applications/services such as finding the shortest route to a particular place), and even lives (by using emergency services). But with that potential comes the need to better inform LBS users about privacy considerations and ensure the confidentiality and protection of their personal information.

References: There are many to be individually acknowledged, the primary ones are cited here:

(1) 'Spatial Ability, Urban Way finding and Location-based services': a review and first results, Centre for Advanced Spatial Analysis University College London, (Lily) Chao Li, March 2004

(2) http://www.pyramidresearch.com/store/Report-Location-Based-Services.htm

(3) 'Foundations of Location Based Services', Stefan Steiniger, Moritz Neun and Alistair Edwardes,

(4) 'WiFi and Cell-ID based positioning: Protocols, Standards and Solutions', Jonas Willaredt, January 2011

(5) 'Geolocation and Assisted-GP',: Bell Laboratories, Lucent Technologies

(6) 'Cell-ID location technique, limits and benefits: an experimental study', EmilianoTrevisani, Andrea Vitaletti, Proceedings of the Sixth IEEE Workshop on Mobile Computing Systems and Applications (WMCSA 2004), IEEE

(7) 'Performance of cell id + RTT Hybrid positioning methods for UTMS', JakubMarekborkowski, Tampere University of technology, Department of Information Technology, December 2003.

(8) 'Positioning of a cellular phone using the SIM', Oskar Mattsson, Stockholm, 2001.

(9) 'Next-generation location-based services for mobile devices', Computer Sciences Corporation, February 2010

Published by: Telecom Regulatory Authority of India
Editorial responsibility: TD Division
Contributions, comments and suggestions: tdra@trai.gov.in, tdra.trai@gmail.com