Location Based Services in the Mobile Communications Industry

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INTRODUCTION

Advances in wireless communications and information technology have made the *Mobile Web* a reality. The Mobile Web is the response to the need for anytime, anywhere access to information and services. Many wireless applications have already been deployed and are available to customers via their mobile phones and wirelessly connected PDAs. However, developing the "killer" wireless application is still a goal for the industry, rather than a reality. One direction for developing such applications points to **Location Based Services (LBS)**. LBS are services, which are enhanced with and depend on information about a mobile station's position. Location information by itself is not the ultimate service, but if location information is combined with content, useful services may be developed. These services offer the capability to users and machines to locate persons, vehicles, machines, resources, as well as the possibility for users to track their own location (GSM Association 2003). The focus of this chapter is the analysis of the most critical success factors and challenges for LBS.

BACKGROUND

In order to show the domains at which LBS may have an impact, a list with the LBS categories, as defined by the Third Generation Partnership Project (3GPPP 2004) is presented in Table 1. Also, based on the information delivery method, we identify three types of LBS: **pull**, **push** and **tracking** services (GSM Association 2003). In the case of a pull service the user issues a request in order to be automatically positioned and access the LBS he/she wants. A use case scenario demonstrating a pull service used broadly in the LBS literature (Zipf, A. 2002) (Poslad, S. et al 2001) is the following: a tourist roams in a foreign city and wants to receive information about

the nearest restaurants to his current location. Using his mobile device he issues an appropriate request (e.g. via SMS or WAP), the network locates his current position and responds with a list of restaurants located near him. On the contrary, in the case of a push service, the request is issued by the Service Provider and not the user himself. A representative example of push services is location based advertising, which informs users about products of their interest, located at nearby stores. In this service, users submit their shopping preferences profiles to the Service Provider and allow the Provider to locate and contact them with advertisements, discounts and/or e-coupons for products of interest at nearby stores. So, in this case the Service Provider is the one who "pushes" information to the user. Finally, in a tracking service, the basic idea is that someone (user or service) issues a request to locate other mobile stations (users, vehicles, fleet etc.).

Table 1.
Standardized LBS Types and corresponding Application Domains

Application Domain	Standardized LBS Types
Public Safety Services	Emergency Services Emergency Alert Services
Tracking Services	Person Tracking Fleet Management. Asset Management
Traffic Monitoring	Traffic Congestion Reporting
Enhanced Call Routing	Roadside Assistance Routing to Nearest Commercial Enterprise
Location Based Information Services	Traffic and public transportation information City Sightseeing Localized Advertising Mobile Yellow Pages Weather Asset and Service Finding
Entertainment and Community Services	Gaming Find Your Friend Dating Chatting Route Finding Where-am-I
Location Sensitive Charging Service Provider Specific Services	

From a technological point of view LBS are split into two major categories depending on the positioning approach they use to locate mobile stations. There is the handset-based approach and the network-based approach. The former approach requires the mobile device to actively participate in the determination of its position, while the latter relies solely on the positioning capabilities of elements belonging to the mobile network. For both of these approaches several positioning techniques have been developed or are under development. What distinguishes them from one another is the accuracy they provide and the cost of their implementation. The most popular network based **positioning techniques** are Cell Global Identity (CGI) methods, Timing Advance (TA), Up-link Time of Arrival (TOA) and Angle of Arrival (AOA), while the most popular handset based positioning techniques are Observed Time Difference of Arrival (OTDOA), Enhanced Observed Time Difference (E-OTD) and Assisted Global Positioning System (A-GPS) (Christopher Drane et al. 1998) (Goran Swedberg 1999). The accuracy provided by some of these techniques in different coverage areas of the mobile network is presented in Table 2.

Table 2
Positioning Accuracies

	CGI	E-OTD
Rural Area	1km - 35km	100m - 300m
Suburban Area	1km - 10km	50m - 150m
Urban Area	100m - 1km	50m - 150m
Dense Urban Area	100m - 1km	50m - 150m
	CGI-TA	**A-GPS**
Rural Area	550m	50m - 100m
Suburban Area	550m	30m - 100m
Urban Area	100m - 550m	10m - 20m
Dense Urban Area	100m - 550m	10m - 20m
	E-CGI	**TOA**
Rural Area	250m - 8km	85m - 100m
Suburban Area	250m - 2.5km	30m - 75m
Urban Area	50m - 550m	25m - 70m
Indoor Urban Area	50m - 550m	25m - 70m

In order to understand the emergence of LBS, one has to identify the major forces that brought to the surface the need for this kind of services. There exist four major forces, namely: market

forces, competition forces, technology forces and regulatory forces. Each of them is briefly discussed in the following paragraphs.

Market Forces

Market research around the globe has documented the willingness of mobile subscribers to pay for LBS. The LBS subscriber base is forecast to reach 680 million customers globally by 2006. Predictions are that LBS will generate over $32 billion in Europe only, by 2005. Numerous firms have already emerged to tap into this growing opportunity (Bharat Rao&Louis Minakakis 2003).

Competition forces

Having established large customer bases, Cellular Service Providers will seek new ways to ensure customer loyalty by offering new types of services. Location Based Services are the most promising type of these services (called value added services). Some of the advantages for the Cellular Service Provider who offers Location Based Services are:

- Innovative service provision attracts new customers and enhances existing customer's loyalty to the provider.
- Revenues increase due to traffic generated by the use of such services.
- Capability to introduce new revenue streams through deals with third party companies (which specialize in LBS implementation and/or provision), in order to sell to these companies user location information.

Technology forces

The first location based services are expected or are already offered to mobile phone users via Wireless Application Protocol (WAP), Short Messaging Service (SMS) or Multimedia Messaging Service (MMS). Every mobile phone supports the SMS feature and most of them also support WAP and MMS. The cost for such a phone is negligible nowadays. This means that many customers can instantly make use of the location services provided. In addition, the

evolution from GSM to General Packet Radio Service (GPRS), which means a significant increase in the available bandwidth for data communication over mobile phones (from 9.6Kbps to 115+Kbps) also assists the provision of LBS that in many cases can be bandwidth demanding (not to mention the introduction of Universal Mobile Telecommunications System (UMTS) networks in many countries). Finally, new types of phones such as media phones and "communicators" have already entered the market giving greater capabilities for displaying information (e.g. user interfaces enhanced with photos, buttons etc.--not only text-based).

Regulatory forces

In the USA the Federal Communications Commission has issued a directive requiring the identification of the geographical origin of an emergency call made by a mobile phone user. According to this directive, operators should be able to provide location information for every mobile subscriber, who makes an emergency call, with accuracy of 125 meters for 67% of the time (GSM ASERG 2003). A similar directive has been released for the European Union.

SUCCESS FACTORS AND RESEARCH CHALLENGES IN LBS

Despite the appealing idea of using user location information to provide highly personalized and intelligent services, there are certain challenges that should be addressed in order for LBS to succeed. We can divide these challenges into three categories namely: technological challenges, ethical challenges and business challenges.

The main technological challenge for LBS is the capability to create easy-to-use and satisfying services. There is much talk concerning what would be the most suitable user interface and type of service (pull or push) in terms of user satisfaction. For example, in the case of push-based services a user is not required to manually issue queries in order to get the information he seeks. The system automatically informs him, based on his current location and a list of

preferences listed in the user's profile. The problem is that in this way user intent cannot be perfectly captured and the user may be frequently disturbed by 'out-of-context' information. So despite the easiness of usage (no or minimal interface) user satisfaction is not assured. On the other hand in pull-based LBS, where clients have to poll the server for updates, the users may experience difficulties in using these services because cell phones, PDAs and wearable computers are less suitable for browsing and query-based information retrieval due to their limited input device capabilities (Ioana Burcea & Hans-Arno Jacobsen 2003). All these restrictions along with the unpredictability in mobile environments (disconnections, frequent context differentiations etc.) have to be taken very carefully into account when designing LBS. Some of the implied requirements, as identified in (Aphrodite Tsalgatidou, et al., 2003) are:

- Not very intensive use of mobile network and minimal volume of transmitted data.
- Possibility of offline operation.
- Simple and user-friendly interfaces and limited and well specified amount of presented information content.

Therefore, it becomes apparent that LBS will not succeed in attracting users without implementing sophisticated techniques based on carefully designed interfaces and/or detailed knowledge of customer profiles, needs and preferences. So given existing technical limitations such as device capabilities, access speeds etc. combined with human limitations such as reduced consideration sets and the need for speed and convenience, in order for LBS to succeed they will need to deliver relevant, targeted and timely information to consumers at the time and place of their choice (Bharat Rao & Louis Minakakis 2004).

Also from a database perspective, LBS raise critical challenges, such as spatial and temporal query processing, and because the continuous movement of users or objects leads to the need for fast and frequent or continuous updates to the databases. Some of the most important

database research challenges brought to the surface by LBS, as identified by (Christian S. Jensen et al. 2001) and (Saltenis S. & S.Jensen. 2002) are:

- *Support for Non-Standard Dimension Hierarchies*

In LBS the geographical area may be divided in multidimensional regions following the pattern of network coverage. Until now geographical area representation models used by data warehouses were in the form of completely balanced trees (strict hierarchy), which cannot capture irregularities like these frequently occurred in mobile networks (e.g. the same region covered by more than one base stations)

- *Support for Imprecision and Varying Precision*

Varying precision means that the location of the same user may be pinpointed with different accuracies depending on the positioning technology used while he is roaming from network to network. Imprecision means that the location data for the trace of a specific user may be incomplete (e.g. a user may have gone out of network coverage, or may have switched of his device for some time). So varying precision and imprecision should be carefully handled by employing intelligent query processing techniques, especially for queries on complete user traces.

- *Support for Movement Constraints and Transportation Networks*

Most of the time users move on certain routes as defined by transportation networks (e.g. railways, roads etc.) and their movement is blocked depending on the morphology of the land (e.g. mountains). Incorporation of such constraints in query resolution may offer increased positioning accuracy to LBS despite of the potentially low-accuracy positioning technology used.

- *Support for Spatial Data Mining on Vehicle Movement*
- *Support for Continuous Location Change in Query Processing Techniques*

From an ethical point of view a critical challenge is to protect user privacy. LBS can potentially intrude on customer privacy. The adoption of LBS is highly dependent on the successful confrontation of digital frauds, attempts of intrusion in customer databases with sensitive data/profiles and the threat of unauthorized/uncontrolled resale of location information. As underlined in (Bharat Rao & Louis Minakakis 2003) '*LBS providers must alleviate consumer privacy fears by implementing secure network and encryption technologies to curb illegal activity and by developing clear communication strategies to interact with customers and allay their fears*'. It has been also shown that a privacy-intruding service (for example an always-on tracking service) despite its usability is not desirable by users since it doesn't allow them to switch it off whenever they want (Louise Barkhuus & Anind Dey 2003). So when designing an LBS and in order for the service to be adopted, the provider should take into account very seriously the user's concerns on privacy. From the point of view of the regulator of the telecommunications market, new laws have to be implemented. In order to protect user privacy there are certain laws in the U.S. (Wireless Communications and Public Safety Act –1999) and the E.U (Personal Data Processing and the Protection of Privacy in the Telecommunications Sector – 97/66/EU Directive) with direct references to the way location data should be handled. However, these laws have certain deficiencies and shortcomings and there are ongoing efforts to achieve full legislative coverage of the LBS sector.

Finally, capitalizing on the promise of LBS requires developing sustainable and viable business models for offering such services. Unfortunately until today there has been little effort on developing a framework with which to identify the most appropriate business models for the large variety of LBS. The major obstacle for this arises from the fact that there is a multitude of players participating in the provision of such services forming a complex value network. The main categories under which these players are grouped are:

- Application developers and content providers,
- Service providers and network providers,
- Hardware manufacturers.

The roles of all these different actors or players are many times conflicting if not competitive and fairness in revenue sharing is viewed differently buy each actor. In this context it is difficult to determine which activities should be performed by which actor (e.g. should the network operator develop its own services, or out-source them to more focused application providers) or to identify which actor should be the dominant one in the business model (i.e. the operator providing access to its customer base, the content/service provider offering the actual service or the location technology vendor offering the enabling positioning equipment).

FUTURE TRENDS

In the new era of 2.5G, 3G and 4G, Location Based Services have been recognized as one of the fastest growing areas for novel service provision in the telecommunications sector with great revenue potential. What differentiates them from traditional services is their ability to offer highly personalized, context sensitive and timely information to users anytime anywhere. However they have not matured enough yet in order to provide the so much anticipated ‘killer application’, mainly due to technical, business and ethical challenges, that have not yet been adequately addressed. All the participants in the LBS provision market should first understand and fix their roles within the value chain, then provide the essential guarantees for protecting user privacy and finally develop new intelligent ways to manipulate and present location information in order to increase user convenience and satisfaction.

CONCLUSIONS

We have discussed several aspects of the role of LBS in today's wireless industry. We primarily focused on technological, ethical and business challenges imposed by LBS and provided directions for further research. User privacy protection, easy-to-use context-aware service interfaces, sophisticated geospatial data management techniques and flexible business models, have been identified as the most critical issues that the LBS industry should pay particular attention to, in order for LBS to become a success.

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TERMS AND DEFINITIONS

WAP: Wireless application protocol (WAP) is a protocol for providing Internet connectivity-acc ess to thin-client devices, such as mobile phones.

SMS: The Short Messaging Service is a service giving the capability to a mobile phone user to send a text message to another user.

MMS: The Multimedia Messaging Service is a service giving the capability to a mobile phone user to send a message containing any combination of images, video clips, text and audio to another user.

PDA: A Personal Digital Assistant is a small palm-sized mobile device with increased processing and viewing capabilities.

CGI: Each base station in a cellular network has a unique id, which the mobile phone receives when entering the area of the base station. Cell Global Identity uses this unique id in order to pinpoint the base station's area of coverage at which the mobile phone is located.

CGI-TA: Cell Global Identity with Timing Advance is a positioning method, which uses the time needed for a signal to travel from the mobile phone to the base station to compute the distance between the phone and the mobile station. Along with the base station's id, this method provides a rough estimation of the position of the phone in the base station's area of coverage.

AOA: The Angle of Arrival method measures the angle of a signal arrived at the antenna of a base station. The intersection of the projection of two calculated angles (from the antennas of 2 base stations)on the 2-D space reveals the location of the mobile phone.

TOA: The Time of Arrival positioning method is based on measuring the time needed by a signal transmitted by a mobile phone to reach 3 or more Location Measurement Units. From these measurements the distance between the phone and the LMU can be calculated, as the radius of a circle with the LMU as its center. The intersection of 3 or more such circles gives the actual position of the mobile phone.

OTDOA: Observed Time Difference of Arrival is an alternative for the TOA method where the mobile phone measures the time differences between signals from 3 or more Base Stations.

E-OTD: The Enhanced Observed Time Difference method is similar to OTDOA without the need for Base Stations to be synchronized (additional elements are used, which measure the real time differences between Base Stations and correct the measurements).

A-GPS: Assisted Global Positioning System uses measurements from fixed GPS receivers scattered throughout the mobile network, in order to assist a mobile phone to locate the available satellites and calculate its location.