Mobile LBS Market

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***Abstract*—This paper presents the mobile LBS market trends by underlying the technology enablers and the positioning techniques roadmap. The LBS applications are classified and an overview of the content requirements is provided. The reasons for the low adoption of LBS during the past years are highlighted while the strong drivers that are expected to push the LBS market in the near future are analyzed revealing the challenges and prospects of this emerging market segment.**

I. INTRODUCTION

Location Based Services (LBS) enable the provisioning of personalized services to the mobile subscribers based on their current position. In this age of significant competition in the telecommunications market, Mobile Network Operators (MNOs) and Service Providers are seeking of innovative value added services that will open new market segments. The successful penetration of LBS in the mobile market is of great importance for the MNOs as they allow the provision of highly demanded services and can boost the data traffic in GPRS and 3G networks, thus leading to an increase of the annual revenues per user. Especially in the area of content services, LBS can provide enhanced customer experience and simplified access to content thus leading to efficient customer retention and provision of an intelligent cross-selling of existing services through specific contents.

The scope of this paper is to provide an overview of the LBS market trends and roadmap, taking into account the current status, the available products and the technology maturity. The paper is structured as follows: Chapter II provides a classification of the positioning techniques and architectures highlighting the technology roadmap. Chapter III provides an overview of the content requirements that will facilitate the deployment of LBS. Chapter IV categorises and groups the LBS based applications. Chapter V focuses on the LBS market trends by contrasting the past expectations along with the updated future trends. Chapter VI identifies the strong drivers that will push the LBS market. Finally, chapter VII concludes the paper and summarizes the results of the study.

II. CHARACTERISTICS AND ROADMAP OF POSITIONING TECHNIQUES

A. Characteristics

The provision of LBS requires information on the terminal position. The calculation of the position can be implemented with multiple methods which can be distinguished based on many different aspects. Distinctive criteria can be the following:

Access technology. The access technology supported by the LBS and its availability influences the grade to and the speed with which the system can be adopted for general use. Technologies mentioned in the literature include the infrared, GSM/GPRS, 3G, WLAN, Bluetooth and RFID. Furthermore, from the terminal point of view, power consumption and price are issues that clearly depend on the access technique: e.g. Bluetooth is nowadays available in many terminals with low cost.

Measurements. Starting point for estimating user location is having the appropriate set of measurements (e.g. timing measurements). Different positioning techniques categories exploit different network parameters measurements.

Terminal or network based. The user location can be measured or calculated completely and independently at the mobile terminal or at the network side. Alternatively, both sides can participate in the process.

Indoor vs. outdoor. Considering the area in which the location estimate should be made, two scenarios can be distinguished: the indoor and the outdoor. Typically, the radio wave propagation environment is more complicated indoors than outdoors. Also, the accuracy requirement for the location estimate is often higher indoors (due to the limited space). Furthermore, some techniques that provide accurate positioning results outdoors (in many places) are far less applicable for indoor positioning (such as GPS).

Software/hardware implications. An issue affecting the usability and deployment costs of a positioning system is

related to the necessary software and hardware implementations. Examples of such adaptations are the requirement for LMUs in OTDOA [6] or installation of client software in the mobile terminal. Also, in positioning implementations where a lot of processing is required at the terminal side, issues related to terminal equipment memory and processing capabilities might turn out to be crucial.

Evaluation criteria. Positioning techniques performance can be evaluated using criteria such as accuracy, latency, availability, reliability and applicability. Many studies focus only on accuracy improvement of the location technique. This issue has been widely addressed in many publications, and a summary of the state-of-the-art techniques that improve accuracy is included in [3]. Further to this, sometimes improvement in the accuracy can be attained only with the trade-off of another performance metric (e.g. higher deployment cost, higher terminal power consumption) as depicted in the following figure. Indicatively, Figure 1 demonstrates that the achieved positioning accuracy is closely related to the implementation costs.

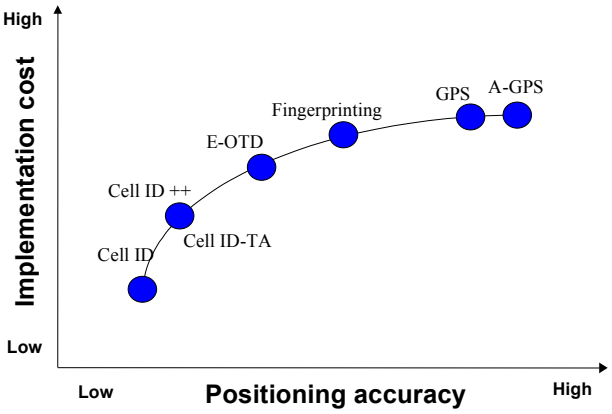

Figure 1: Positioning accuracy vs. Implementation costs

There are different kinds of implementation costs associated with the deployment of a positioning technique, which is difficult to be clearly estimated. For instance, GPS increases significantly the cost of the mobile terminal (does not require network investments), while other positioning techniques require the installation of special hardware network equipment (e.g. Location Measurement Units for the E-OTD technique). Some techniques might require calibration of the propagation model (e.g. for the CGI++ or CPICH technique), which in most cases are already calibrated for network planning tools (owned by operators). Fingerprint-based techniques require no special hardware investment but require extensive and frequent surveys that are costly [10]. On the other hand there is a trade-off between accuracy and fingerprint collection (cost or burden) by collecting fingerprints more sparsely and letting the accuracy degrade.

B. Roadmap of Positioning techniques

An extensive discussion of location techniques is provided in [3]. As mentioned there, many different types of networks and systems have been used for mobile terminal tracking (GSM, WLAN, UMTS, satellites, RFID, acoustic) and proposals for new algorithms are constantly produced. Based on this, some general level conclusions and trends can be identified:

While in its initial phase location studies concentrated on using one access network (e.g. GSM or UMTS) for positioning, with the emergence of new Radio Access Technologies (e.g. WLAN), solutions using multiple networks or techniques (hybrid) have been proposed. Further to this, terminal support for multiple access technologies plays also a key role as terminals supporting GSM/UMTS/WLAN connectivity (multi-homed terminals) have started entering the market.

Statistical processing techniques (such as Kalman filtering) can also be exploited in order to reduce positioning error. As the processing power of terminals is increasing and the size of the memory is being extended, it is possible to gather measurements at the terminal side, pre-process them and upload them to a network server at a later step [4]. On the other hand, communication protocols that facilitate the deployment of LBS, such as the SUPL [5], are currently in the development phase. SUPL enables the usage of the user-plane for the terminal measurements uploading. This protocol requires no hardware updates or modifications to the network while it is supported and adopted by most vendors.

Further to this, emergency call (FCC911 [7] or E-112) and regulations' requirements on the accuracy of location techniques influence the deployment of more accurate positioning systems.

Concerning the satellite-based techniques, they provide high tracking accuracy outdoors (typically less than 10m), but their availability depends on the terminal support (GPS receiver) and they do not normally work indoors. However, they are expected to eventually be adopted in the European market as well (in USA, satellite-based solutions are already more common).

III. CONTENT REQUIREMENTS

Most of the LBS applications require specific content to operate properly. This includes mapping, address information, route models, points of interest and real-time information such as traffic information, road works or weather data. A significant quantity of geographic information must be acquired, aggregated, formatted and quality controlled. This process is not just a once-off effort; it is a constant, cyclical process the objective of which is to improve completeness, conformity, consistency and accuracy. This content is available today in most developed countries from many different sources. However, quality is unequal across different vendors and the content remains relatively expensive to license.

This content can be made available directly on the terminal (on-board mode) or via a server often referred to as a geospatial platform (off-board mode). This work is carried out by companies like Webraska, Geoconcept, PTV, Telmap, Mapinfo, Telcontar, Microsoft, Yahoo, Google and so on. It must be emphasised that the aforementioned companies compile different sources of content and make them accessible via a geotoolbox that performs basic functions such as:

Geocoding; ability to accept partial address information and return the positional information, taking into account the nuances of local address conventions and common human error.

Reverse Geocoding; ability to accept positional information (perhaps from the network) and return an intuitive description of that location in terms of a spread of nearby and relevant landmarks.

Location Refinement; ability to accept positional information (perhaps from the network) and return an intuitive description of that location with an additional refined list of location points, so that users can select their own location precisely.

Spatial Searches; a spatial engine able to support queries for "points of interest" based on geographic proximity, type, name, etc., taking into account the local route network.

Route Directions; the ability to generate step-by-step navigation directions and route mapping, taking into account mode of transport, one-way streets, traffic lighting sequences and other traffic impedances.

Map Rendering; the ability to rapidly compile, render and return geographic information in the form of an optimum map image for a given location, scale, overlay information, number of colours and format.

By combining those modules, complete applications can be developed.

IV. LBS Classification

LBS applications are applicable to nearly every aspect related to human mobility: Navigation, Health/Safety/Security/ Emergency, Convenience, Entertainment, Travel Aids, Productivity Aids, Mobile Work Force Management and many aspects related to human/machine interaction (e.g. Telematics) and even machine to machine (e.g. automatic emergency calling for car breakdowns, medical implant malfunctions, mobile wallet). What is more, LBS applications cover nearly every attractive wireless demographic market, including: parents, teenagers, singles, college students, online communities, business executives, and entrepreneurs. This also includes businesses that significantly depend on mobile voice and/or data communications to operate their business, such as companies with significant field employee organizations, and businesses dependent on information regarding the location of their assets at any moment, such as trucking and even railroads.

LBS applications can be classified according to various categorisations. One is by their class of application: trigger services, tracking & monitoring, location-based information and assistance services. A second is those that are requested by users once their location is determined, and those that are triggered automatically once a certain condition is met (e.g. a boundary is crossed). We might consider the former set to be "pull" services and the latter "push" services [8]. A third categorization is by the market segments (Business to Business, Business to Consumer and vice versa).

In terms of application, the AGILE project [9] identified 18 mass-market applications. Those applications have different needs in terms of required quality of service (accuracy, integrity, indoor coverage, etc.). They also address different groups of users. The grouping proposed by AGILE is presented in the next figure.

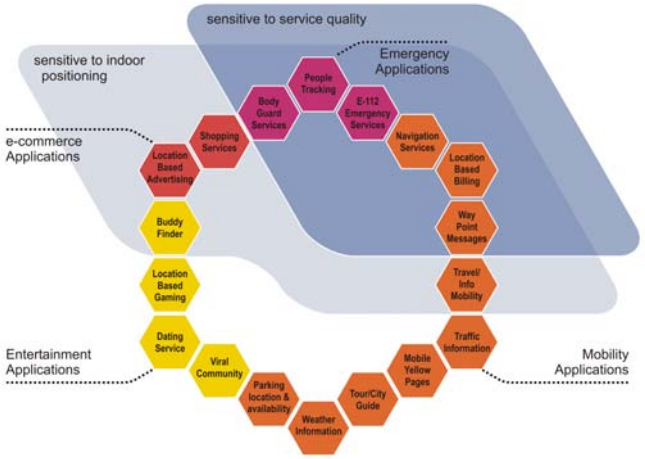

Figure 2: LBS Application Grouping (source: AGILE)

Some of those services have already a certain level of maturity (e.g. navigation, traffic information) and are commercially available. Operators are expected to offer more of those services in the future as part of application bundles to their customer.

Figure 3 depicts a categorization of currently available LBS provided by Network Operators. As shown, the most common services are information services such as yellow pages near you and local weather information. On second and third place come navigation services and tracking [11].

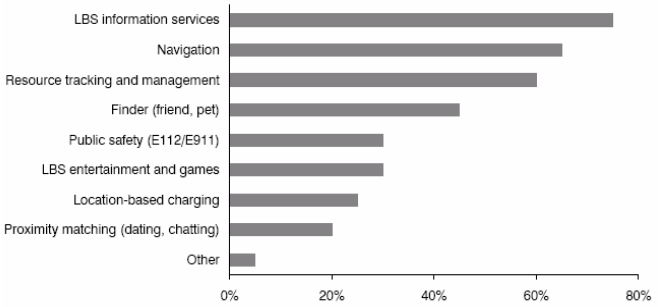

Figure 3: LBS provided today

V. LBS MARKET TRENDS

A. Past expectations not met

At the beginning of the present decade, mobile LBS were widely predicted to be the most promising "killer applications" in wireless communications. Today, most of these expectations are still not met and a significant delay in the market forecast has incurred. The reasons for these amended forecasts are a combination of reduced take-up of mobile data services as a whole, and low take-up specifically of mobile LBS. Both of these have been hampered by the slow introduction of more powerful mobile handsets and in particular mobile LBS have been affected by the wide availability of low quality services – causing end users to make little change in their habits of a lifetime and be reluctant to rely on their mobile phone to perform tasks they have happily performed otherwise.

Some of the most important reasons responsible for this turn are summarized as follows:

Poor tracking performance. Current deployed techniques only allow a few hundred meters to a few kilometers accuracy. For the time of writing, very few handsets with advanced location capabilities (e.g. A-GPS) are available in the market while they are offered at high prices.

Inherent customer perception issues. Privacy concerns arise as users are uncomfortable of feeling being watched. Security and location-aware phobia (both consumer and operator) prevent the users from adopting LBS as their usual habits.

Low throughput mobile networks. The unavailability of high capacity networks (that would enable the transfer of multimedia content) is also considered a preventive factor for the wide adoption of LBS. The 3G networks launch and commercial availability was delayed. Further to this, only recently WLAN have started to take up and provide Internet services to crowded hot spots.

Significant investment required. The initial investment and the high deployment costs (in terms of network equipment and marketing campaigns) imposed to MNOs and service providers did not justify the LBS development and market launch (at most markets).

User adoption requires time. Taking as example other successful services, the market should be well educated in order to adopt a new service concept. Therefore, the initial low take-up phase of LBS was unavoidable.

Not well defined business models. Taking into account that the emerging LBS introduced new service concepts, the business rules that would govern the value chain were not clearly defined among the business entities. This caused confusion in the involved players discouraging thus new initiatives.

Unfriendly User Interfaces. Inherent difficulties of mobile devices e.g. for entering queries and displaying results (images, 3D maps, etc.)**.**

As a result of the above mentioned factors, LBS have remained in the niche domain with few success stories (e.g. fleet management) and in specific markets, while at the same time have not delivered the killer application with wide scale deployments.

B. Future Trends

Now with the required network infrastructure and positioning technologies coming in to place in many parts of the world to deliver functionally richer and more attractive services, there are signs that LBS are about to deliver more of the promised benefits to both MNOs and end users. Based on Juniper Research [8], the estimated total available market for mobile LBS will grow from under $1bn at the end of the current year (2006) to over $8.5bn by the end of year 2010. The largest geographic market will be Asia Pacific, with Europe and North America second and third respectively. More specifically, regarding the European market, LBS could contribute with over 2 billion euros by 2009, based on [11] forecasts.

A major push for this market development, which has already started, is the availability of portable navigation devices (e.g. the Garmin or Tom-Tom). The LBS market is starting to take up with this application launch, which boost the market and technology development (e.g. HDD in current terminals versus CD/DVD readers in cars). The current dynamic is also pushing down prices. Now this is improved with real-time traffic and soon with dynamic Points of Interest related data. Later, people tracking and E112 call will come on the same platforms (terminal devices), which already offer an MP3 player, a hands-free telephone kit, a web browser and more advanced features. This market has exploded over the last 2 years leading to impressive sales in Europe (represented below by the sales of PDA, Personal Navigation Devices (PND), Smart-phones (SP) and Original Equipment Manufacturers (OEM)).

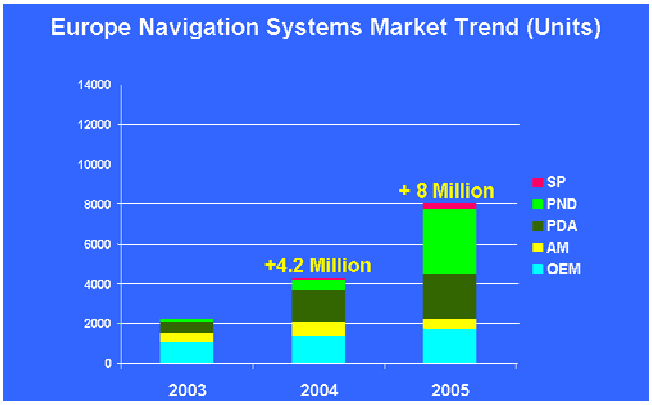

Figure 4: Europe Navigation Systems Market Trend (Units) (Source NAVTEQ)

This trend will continue in 2006 and likely in 2007 with growth levels close to 100%. This development leads to higher familiarity of the end-users with LBS and a higher interest in those applications.

Figure 5 demonstrates the operators' forecast (based on a survey [11]) regarding the most profitable LBS application

for the coming 3 years (by the time of writing). At the first place navigation services (with 28 percent) are considered to be the most successful while resource management and tracking follow at the second place (with 21 percent).

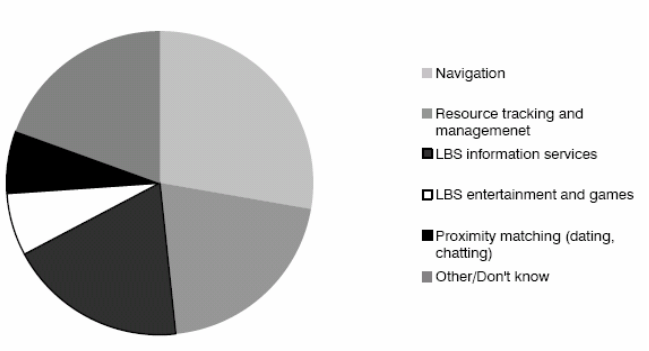

Figure 5: Most successful LBS in three years

VI. STRONG DRIVERS

The following paragraphs identify a number of strong drivers for growth in the LBS field including:

High-end mobile devices. Devices are now better equipped for the provision of LBS. The main enablers are there for many new services to be brought to market; these include better data connections (3G handsets are competitively placed in the market now), improved usability (large colour screens) and larger computing capability and storage for an increasing number of smart-phones. In addition, the developer base for open operating systems such as Symbian, Linux and Microsoft, which offer very good performance, is increasing.

The number of GPS-enabled handsets in Europe is still restricted, but there are handsets in the market that support this feature. Nevertheless, thanks to open application interfaces and easier connections between different devices, it is possible to use most smart-phones with GPS boxes. Some of the early mobile-based navigation solutions are simply based on a combination of a smart-phone and a separate GPS device connected by Bluetooth. New types of mobile devices are also coming to the market, allowing for a new class of positioning devices that use wireless data networks.

Hardware prices are also decreasing. For instance the prices for GPS chipsets or PND/PDAs have been reduced significantly.

Advanced user interfaces, including features such as text to speech and speech to text, 3D maps and multi-lingual support are already in place.

Evolution of the web and the way information is described. The Semantic web, the standardization of ontologies and the taxonomies across services (and industries) will bring significant benefits to the provision of LBS.

High throughput mobile networks. The proliferation of multiple wireless access technologies as service enablers for future offerings (3G, WLAN, WiMAX, Bluetooth, UWB, Wireless Sensor Networks, etc.) will advance the end user experience.

Increased accuracy. Accurate positioning solutions are now more reliable and cheaper to deploy. For instance, hybrid techniques and GPS enabled devices have entered the market. However, operators' trials are still far from declaring a clear success in providing granular locations. Accurate positioning technologies have been deployed mainly in the US, where the FCC mandated a precise positioning of calls to emergency services, and in Japan, where some operators (and in particular KDDI) pushed for handsets with GPS capabilities.

Lower deployment costs for MNOs. Positioning technologies are also more mature, and the emergence of a new standard for application interface [5] means it is cheaper to develop and implement LBS applications.

The two main ways to convey positioning related information are control plane and user plane. Initial LBS implementations used the signalling network for deploying services. This approach, known as control plane, is reliable and secure (particularly appropriate for emergency services), but it is more costly, especially for commercial applications.

Content quality. The content availability has increased and the delivered quality is high. Content is becoming richer every day. 3D content is being added to maps. Rich set of PoIs is added. Coverage is extended (100% of Western European roads are now covered). Pedestrian and truck attributes are coming. Market pressure forces the content prices to go down allowing units to be sold now for 300euros. Moreover, content providers are adapting their offers to the applications by providing a large diversity of licensing terms. Depending on the type of terminal, type of positioning techniques, type of users (end-user or professional), and type of access (on-board/off-board, etc.), content providers can offer a different pricing scheme allowing flexibility for the application providers.

Standards have evolved. The emergence of SUPL protocol [5] is providing new dynamics for LBS applications. By the end of 2005, the SUPL standard was completed and adopted by new LBS implementations. User plane has emerged for both GPRS and UMTS networks as an IP-based protocol that allows MNOs to launch LBS without upgrading their existing SS7 signalling network and mobile switching elements. Hence, the investment level required to launch mobile location services is lowered for operators (user plane requires less network elements and a less complex design). One of the main advantages of user plane is that it allows easier development and hosting of applications by third parties. However, these services require an active data connection, whereas control plane can work on simple SMS services.

Mature market. The framework for location-enriched services is improving. Users are becoming more familiar with data services and the mobile terminal is evolving from a talking device into a powerful tool. Other important factors include more widespread penetration of geo-information and LBS into mainstream use. The widespread acceptance and familiarity of the public with LBS via sites such as MapBlast, Google Earth or Multimap, and the increasing visibility of geo-information in everyday life through news programmes,

government sites, web portals, etc, has to some extent prepared the way for more innovative (mobile) LBS globally.

Government mandate (E112, FCC 911). The US strict legislation mandating MNOs to provide mobile terminal positioning with certain accuracy levels is going to push the deployment of high accuracy tracking techniques. In turn, MNOs having prepared the grounds for mobile terminal tracking (deployment of the necessary infrastructure) will try to exploit this investment by providing Value Added Services on top of it. EU mandate is currently enforcing operators to trace emergence calls with no accuracy requirements.

Galileo. Thanks to its added-value features like improved accuracy, quality of service and integrity, Galileo should impact the integration of advanced positioning solutions in terminal and hence influence the deployment of LBS applications. A first step towards Galileo is made now with the availability of EGNOS offering higher accuracy and integrity information compared to a normal GPS. Galileo is considered to be complementary to GPS allowing the extended satellite tracking coverage.

VII. CONCLUSIONS

Taking into account all the latest market researches regarding the LBS market trends, there are positive prospects regarding their establishment. However, challenges still exist for the fledgling industry, which include:

- Managing the complex delivery chains,
- Strengthening business cases and converting capability into revenue,
- Network interoperability and international roaming,
- Continuing concerns over privacy,
- Cost reduction for services deployment,
- Competing technologies.

Technology hype and low adoption of the existing model of LBS (first wave of services) lead the market to rationalise and refocus. It is evident that users lacked of interest in the existing offer during the past years. The expectations for the second wave of LBS should thus be more conservative in terms of the market growth.

LBS services can become more attractive with the involvement of users in the service creation. The personalization requires little or no user involvement in order to build up profiles thus making it very easy and appealing to use.

Moreover initial fears about the user being tracked should be relaxed thus making services more acceptable from the user community. Besides that, significant research is required in the areas of semantics, wireless systems interoperability and mediation services for trust management and syndication.

Concluding, the time for LBS is starting to appear. Despite the initial scepticism, another wave of improvements settles a strong ground for LBS to become a success story for mobile operators.

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