Mobile E-Commerce and Location-Based Services: Technology and Requirements

Aphrodite Tsalgatidou[1], Jari Veijalainen[2], Jouni Markkula[3], Artem Katasonov[4] and Stathes Hadjiefthymiades[5]

[1,5] University of Athens, Department of Informatics and Telecommunications, TYPA Buildings, Panepistimiopolis, Ilisia, Athens, GR-157 84 Greece
[1]afrodite@di.uoa.gr, [5]shadj@di.uoa.gr

[2] Waseda University, Global Information and Telecommunication Institute, 29-7 Bldg.,1-3-10 Nishi-Waseda Shinjuku-ku, Tokyo, Japan
veijalai@aoni.waseda.jp

[3,4] University of Jyväskylä, Information Technology Research Institute, P.O.Box 35, FIN-40014 University of Jyväskylä, Finland
[4]artem.katasonov@titu.jyu.fi, [3]markkula@jyu.fi

Abstract. Advances in Internet and network technology and the rapidly growing number of mobile personal devices result in the fast growth of Mobile E-Commerce, M-Commerce. In this paper we view M-Commerce as activity of conducting E-commerce transactions using mobile terminals over a wireless network. A special case of M-commerce are Location Based Services (LBS) where often the actual position of the terminal is used in the service provision. In this paper we concentrate on the requirements for the LBS. Because technology is an important facilitator and at the same time a limiting factor, we review shortly the technology aspects relevant for LBS. We then present the most important user, system and infrastructure requirements. Finally we present a design and implementation of an LBS application running on Java handsets and evaluate its properties and review lessons learned with respect to the requirements.

1 Introduction

Nowadays, the development and adoption of mobile technologies have made new services and related commerce more and more available. Some of the factors that contributed to this development are the tremendous development of the Internet and related technologies, the understanding and exploitation of the business potentials that rest behind this development, the boost of E-Commerce frameworks and technologies, and the impressive growth of wireless mobile networks. At the end of 2002, there were 454 GSM operators worldwide in 182 countries, and they served over 730 million users. In 2002, 75 percent of the new mobile customers started to use GSM terminals and services in offered by the GSM networks [15]. The number of mobile customers that use digital mobile networks for voice and data transfer has already exceeded one billion. The market is saturated in some developed countries, such as Japan and many countries belonging to the European Union, but it is still expanding rapidly in developing countries, such as China. If this expanding pace continues, the overall number of mobile telecom subscribers will in a few years exceed two billions. This is a huge customer potential for commercial activities, if the environment supports it properly. Many market survey companies estimate that the global revenues from M-Commerce transactions will range from 3 to 6 billion dollars in 2003 and around 8-9 billion dollars in 2005. The largest estimates go up to 25 billion USD for the year 2005 [2]. For these reasons, M-Commerce is said to "rapidly approach the business forefront" and the general feeling is that it "will soon be a dominant force in business and society" [17].

The high-end mobile terminals have already reached the complexity and performance of the personal computers of mid 1990's, and the development continues at fast pace. The new smart-phones are programmable and can run, in principle, any conceivable application. Wireless communication technologies combined with Internet-enabled terminals constitute an ideal platform for the realization of many new kind of business transactions. The small and light, but powerful, mobile terminals are almost always carried by their owners. Therefore, they are like a wallet, among other things. They can indeed also store electronic cash, credit card information, tickets, etc., and can thus also take the role of an electronic wallet. In addition, the terminals can be located by using satellite navigation systems, within mobile networks, or by some other available means. Recent developments in these areas seamlessly extend the positioning of wireless devices into all the environments where they can be used for voice and data communication. Thus, location-based services become possible.

In the following, we will review the technological infrastructure and its development, which has made M-Commerce gradually available. We concentrate to location-based services (LBS), as the related M-Commerce is probably the best example of the new emerging applications. From this angle, the technological infrastructure consists of mobile networks, mobile terminals and positioning technologies. Requirements considered for the LBS domain refer to all the involved actors i.e., the mobile users, the telecom operators, the service providers, the content providers, etc. In this paper, we mainly focus on the requirements that refer to end-users. For supporting the study, we present a pilot system that fulfils a considerable part of the identified requirements. The requirements neither addressed nor fulfilled by the pilot system are also discussed.

The rest of the paper is organized as follows. Section 2 gives an overview of the mobile network technology, mobile terminals and the location-based services. Section 3 outlines the requirements for location-based services while section 4 describes the LBS pilot system. Finally section 5 concludes this work.

2 Technological infrastructure

In this section we will briefly describe the technology leading to 3rd generation (3G) mobile networks, the technology used in Mobile E-Commerce and the technology for mobile terminals.

2.1 Mobile networks and their development

Our current mobile services infrastructure is mostly based on 2nd generation (2G) digital public mobile networks. The families of standards created to specify these systems include e.g. Global System for Mobile communications (GSM), CDMA standard (Qualcomm, USA) and PDC (Personal Digital Cellular, NTT DoCoMo, Japan). From M-Commerce point of view, Circuit Switched Data (CSD), High Speed Circuit Switched Data (HSCSD), Global Packet Radio Service (GPRS), and Short Message Service (SMS) are important in the GSM standards. They make the wireless data transfer services and applications possible in a wireless telecom network.

The standardization for the third generation of mobile telecom systems (3G) was started at the beginning 1990's. The International Telecommunication Union (ITU) specified a framework standard for the global 3G system, called International Mobile Telecommunications 2000 (IMT-2000). The central idea of IMT-2000 standard is to enable advanced multimedia services on wireless telecom networks (video streams, animations, pictures, etc.), offer a truly global roaming, and the global coverage of the services. Universal Mobile Telecommunications System (UMTS) is the European view on the 3G systems envisioned in IMT-2000. The UMTS standard family was developed by 3G Partnership Project [1] hosted by the European Telecommunications Standard Institute (ETSI). It offers global coverage at different service levels (i.e., satellite, macro, micro and pico-cell environments) and a smooth transition path from the current GSM to 3G networks. In this evolution, there is an intermediate step, often called 2G+ or 2.5G. This covers (CSD) at 14.4 kbps, High Speed Circuit Switched Data (HSCSD), General Packet Radio Service (GPRS) and Enhanced Data Rates for Global Evolution (EDGE). The so-called core networks are common to TDMA-based access network (GSM) and a truly new access network type based on the W-CDMA technology. All the above network generations can support LBS. [8,13]

The work towards 4G networks has also already begun. They should be in operation around 2012. It is no yet clear what 4G systems should and could offer to the users. The hopes for the offerings are: seamless roaming and handoff between various types of technologies such as UMTS/W-CDMA, Bluetooth and Wireless LANs; truly seamless wireless Internet access and; and more bandwidth for wireless data transmission. The main objective as concerns roaming and handovers is to materialize the Always Best Connected (ABC) idea.

One of the main differences between these different network generations is the transmission capacity available to the user (see figure 1). In the current 2G networks the capacity ranges from 9.6 kbps to 14.4 kbps on CSD connections. The 2G+ HSCSD offers in practice 57.6 kbps and GPRS ca. 112 kbps transmission rates. The EDGE system delivers 384 kbps. 3G networks will enable speeds up to 2 Mbps depending on radio conditions as well as the network environment (e.g., satellite, indoor, outdoors). In worse circumstances (e.g., weak signal, or in the move) the wireless link capacity will be only a few hundred kbps.

The Japanese 3G mobile network FOMA, operated by NTT DoCoMo, offers currently in practice max. 384 kbps downlink capacity and 64kbps uplink capacity for packet data. In addition, it offers a connection-oriented full-duplex data transmission service with 64 kbps guaranteed capacity in both directions. Charging for the former service is based on the data volume and the latter on connection time [4].

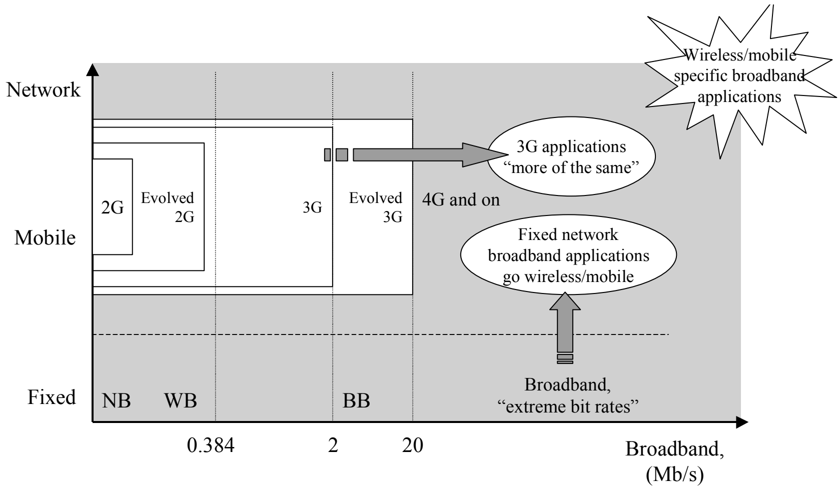

Fig. 1. Network Technology Evolution [5]

Another dimension of the access networks is the service capability. In the basic 2G network the services are voice, circuits switched data (CSD) transfer, and short messages (SMS). Especially short messages have been used to support financial services like banking and stock services. CSD can be used as the carrier in a TCP/IP network and it is possible to do Internet banking using e.g., hand-held Communicators over CSD.

At the service level in 2G+ networks the de-facto standard Wireless Application Protocol (WAP) [22] provides an access to higher-level services. These include support for E-commerce. WAP technology brings Internet and wireless technologies together so that contents encoded in a mark-up language at WWW servers can be moved to handsets. In Japan, NTT DoCoMO developed a functionally similar system as WAP environment, but based it on cHTML, instead of WML

WAP 2.0 specification adopted in 2001 the iMode end-to-end HTTP connection model as an alternative to WAP 1.x protocol stack and there is hope that Mobile Internet will converge into XHTML encoded contents and Java as programming language. As such, WAP specifications are independent of the underlying wireless network technology and can be used over GSM, CDMA, and W-CDMA air interfaces.

The popularity of i-Mode largely depends on the business model. i-Mode terminal can be all the time connected to the network, but the user is charged only for the data packets transferred, not for the connection time. The total cost of usage consists of i-Mode usage charge (150 Y/month)+ packet transmission charges + charges for the accessed contents. The packet transmission charge consists of a fixed monthly charge and the charge for the transmitted packets (0.02 Y/packet – 0.3 Y/packet) [4]. Sun Microsystems and DoCoMo have signed an agreement to incorporate Sun's Java, Jini and Java Card technologies into i-Mode cellular phones. The new i-Mode terminals support Java (Micro Edition). The current development phase in Japan is to offer downloadable Java applications and run them at terminals.

Bluetooth is another emerging technology that will evidently have impact on M-Commerce and also on LBS. Using this technology it will be possible to conduct M-Commerce transactions without a heavy network infrastructure. Thus, handheld devices could talk directly e.g. with cash registers. Currently integration of Bluetooth and WAP are under way [22]. Bluetooth can be also used for small LANs, in addition to ad hoc point-to-point links. The maximum rate achieved by Bluetooth1 is 722 kbps, and Blutooth2 2Mbps. Bluetooth advances are that the infrastructure is simple, relatively cheap, and operated in unlicensed frequency bands. From LBS point of view, Bluetooth is able to offer a local positioning method if some of the transceivers is in fixed position and this information can be used by LBS applications.

The UMTS Forum [20] has listed a broad range of services, which should be made available with the advent of UMTS. These services are grouped in six main categories. The required bandwidth, as well as some examples for these categories, are shown in table 1.

Table 1. Categorisation of 3G Services

Category	Service Bandwidth (uplink/downlink) [in kbps]	Sample Services
Voice Services	28.8/28.8	Voice, IVR, Voice Mail
Messaging Services	28.8/28.8	SMS, E-Mail
Switched Data Services	43.2/43.2	Low speed internet/intranet access, fax
Medium Multimedia	20/768	Interactive games, lottery, betting, simple e-commerce.
High Multimedia (MM)	20/1000	m-commerce, m-portals, LAN access, Audio/video on demand
High Interactive MM	256/256	Video telephony, videoconference

2.2 Mobile Terminals

The mobile terminals are developing, getting new features and enhanced hardware, at fast pace. The communicators and PDAs have advanced computing capabilities, and the mobile phones are all the time closing them. The new mobile phones are called smartphones, as their features can be added and modified. Most of the new mobile phones have already support for GPRS, Bluetooth and MMS, inbuilt or attachable camera, as well as sophisticated applications. The smartphones have high-resolution color display (e.g. 176x208 pixels with 4096 colours) and several megabytes of internal memory, which can be supplemented with memory cards.

Currently Symbian OS appears to be the preferred operation system for mobile terminals. However, there are also Microsoft's Smartphone and Linux based solutions available and in development. In addition to operating systems, common platforms are becoming prevalent between the devices. For example Nokia's Series 60 mobile platform has already been licensed by majority of the key players within the mobile phone industry. The common platform over the operation systems provides some common applications and they make application development easier and faster, still allowing required differentiation for markets.

The need for unifying and standardization of application development environments has been seen by the industry. The 3GPP (1) developed the Mobile Execution Environment [18] specification that defines a framework for capabilities of devices. The technologies that are considered by MexE as fundamental for the future, and are covered by the developed specifications, are Java and WAP. Most of the new mobile phones support already Java, which gives a convenient way to download and add new applications to the terminals. MexE also defines security features: security certificates indicating that an application is secure and also where it can be executed.

The Open Mobile Alliance (OMA) has now a central role in standardization with respect to mobile services and applications, and their interoperability. OMA was formed by consolidating several earlier industry fora, among them Open Mobile Architecture initiative, WAP forum and Location Interoperability Forum (LIF). The most important technologies considered by OMA are MMS, Java and XHTML.

The mobile devices are becoming location-independent, widely distributed personal trusted devices (PTDs) that strongly support the realization of financial transactions and other activities related to M-Commerce [23]. To address the need for extra security in the mobile environment, the Wireless Application Protocol Public Key Infrastructure (WPKI) was specified [21]. The WPKI encompasses the necessary cryptographic technology and a set of security management standards that are widely recognized and accepted for meeting the needs of M-Commerce. It is also worth mentioning the Mobile Electronic Transactions (MeT) forum [13] that refers to the application side of mobile commerce. MeT was established to further strengthen the framework for secure mobile transactions. It concentrates on defining a consistent and coherent framework that is based on existing standards and specifications.

2.3 Positioning systems of LBS

Location based services, apart from the already described technology, require specific infrastructure for positioning the mobile terminal. Positioning means determination of the location of the object in a reference system. The reference system can be a coordinate or address system, areal division or route system [16]. Geocoding is a process used for associating the object to general coordinate system, if some other system, like addresses, is used as reference.

The systems offering positioning for mobile terminals in LBS are divided to three main classes [16]: satellite positioning, network-based positioning and, local positioning. Different positioning systems and techniques varies with their features, such as accuracy, reliability and time-to-fix. Each system has its own place, and they complement each other in certain cases. Satellite systems do not work well in deep canyons and indoors where cellular coverage may be denser. Network-based positioning may be more imprecise in rural environments with fewer basestations, where satellite visibility is better.

2.3.1 Satellite Positioning

Satellite positioning systems use an infrastructure of earth-orbiting satellites and receiver terminals. The terminals calculate the position based on the information received through the radio signals from three or more satellites. The terminal-based method provides 10-40 meter accuracy. It renders the user totally independent of the mobile network with respect to positioning, and, in principle, allows access to any location-based services from third-party service providers.

Most well know and widely used satellite positioning system is GPS, operated by US Ministry of Defense. Other currently existing system is Russian GLONASS. European Union has also plans to build a corresponding system called Galileo. Galileo [3] is the European global navigation satellite system providing accurate and guaranteed global positioning service under civilian control. Commercial services availability will be guaranteed through several mechanisms, thus rendering the system ideal for critical applications. According the current schedule, Galileo should be operating in 2008. The intention is to make Galileo interoperable with GPS. For professional use a Differential GPS systems are used, which can potentially provide location accuracy at the meter and sub-meter level. It uses infrastructure-based assistance and different terminals. This method requires that there must be a terrestrial reference station that sends an additional correction signal to the terminal.

In mobile network environment, there exist also a solution called Assisted-GPS solution, where additional data for the GPS receiver is send through mobile network [8]. Assisted-GPS makes the positioning of a mobile terminal including GPS receiver to be positioned faster and more accurately. It even can make possible to use GPS positioning also indoors, in a limited scale. Assisted-GPS is a hybrid solution, using both, satellite and network-based, features. This technology is applied e.g. in KDDI au network in Japan. As a result of a positioning request, the user gets a relevant map delivered to the terminal [32].

2.3.2 Network-based positioning

The network-based positioning systems refer to positioning methods where the mobile telecommunication networks are used for providing or supporting the positioning of mobile terminals. They include several different methods that are standardized in mobile network specifications [1].

The basis for the diverse network-based methods is that the coordinates of the base stations are known and that the distance of the terminal from the base stations can be measured or at least approximated. The approximation without any measurements is called Cell Identity (CI). In CI method, the terminal position is approximated by specified coordinates on the cell area, defined based on the cell coverage. The accuracy of the method varies from a few tens of meters (densely populated areas, indoor cells) to several kilometers (in rural areas). The above method can be improved by using Timing Advance (TA) parameter that is readily available in GSM networks at low cost. Using it, methods can be used to increase the accuracy estimate of the CI-method.

The more accurate network-based positioning methods use explicit measurements. In measuring the terminal receives signals from at least three different base stations, or three or more basestations receive signals from the terminal. Based on the measurement the position of the terminal can be calculated at the terminal or in the network. There are different network signal measurement positioning methods, including: Angle of Arrival (AOA), Time of Arrival (TOA), Enhanced Observed Time Difference (E-OTD) and Observed Time Difference of Arrival – Idle Period Down Link (OTDOA- IPDL). The last method is standardized in 3G networks, but all others are present already in 2G GSM network specifications. For a more complete treatment of the network-based positioning methods, the reader is urged to consult for example [8].

The network-based positioning methods differ in many some aspects. The positioning accuracy is method dependent, between 50m to several kilometers; In CI method even up to tens of kilometers. The deployment by the network operators and requirements from users perspective have also significance. Some of the methods require new components and investments to network infrastructure, some other needs mobile terminal software or hardware updates. From the privacy point of view, notable is also where the actual position calculating is done; in the terminal or in the network.

2.3.3 Local positioning

The third main class of positioning systems is local positioning. It refers to positioning that operates only in restricted area and based on short distance signal transmission [16]. It covers specifically location-based services in indoor environments like large buildings, shopping centers, etc., where satellite and mobile network positioning methods are not well applicable or precise enough. Local positioning methods include positioning methods where wireless local area networks (WLAN), Bluetooth technology, radio frequency identification (RFID) or Infrared (IrDA) technology (Active Badges etc.) are utilized. A number of systems/technologies have been proposed for the underlying supporting platforms. An extensive survey of similar platforms can be found in [7].

3 Location-Based Service Requirements

Besides the general requirements for M-Commerce, location-based services are subject to a set of specific requirements. We classify them in the following requirements categories: user (functional), usability, reliability, privacy, location infrastructure and, interoperability. These requirements cover some basic issues in location-based services.

3.1 User Requirements – Functional Requirements

User requirements are formed on mobile user exceptions of an LBS. These requirements are the source for the functional requirements of an LBS application.

Hermann and Heidmann [5] analyzed a specific LBS application, namely location-based fair guide. They conducted interviews with a set of potential users of such a system and a set of visitors of a book fair in order to investigate the user requirements empirically. The list of features the interviewees considered indispensable includes browsing of spatial information (locations of facilities and exhibitors) connected with catalogue data, activity planing and way finding.

The same requirements apply of course to any LBS serving a visitor in unfamiliar environment, whether it is a fair, museum, city or country. Therefore, the main LBS functional requirements are the following:

- Browsing of spatial information, e.g. in the form of a city map.
- Navigation: the user must be able to acquire directions and guidance for reaching a specific point of interest.
- Access to catalogue data, e.g. names of restaurants and their description like menu, range of prices, opening hours, etc. Catalogue data must be spatially referenced, so the facilities in the catalogue can be represented on the map and directions for reaching them can be acquired.
- Location-based access: the user must be able to access map and catalogue data based on his/her present location. If locating the user cannot be resolved automatically by the system, the user must be provided with the option of manually entering his/her location. The system should be able to handle such requests through geocoding procedures.
- Personalized access: the user must be able to specify the type of information s/he needs, e.g. a map depicting just the street network or a map including various points of interest. A profile mechanism should also be provided so that the user does not have to input his preferences every time s/he uses the service.
- Fast access: the user must be able to run various queries, e.g. for nearby restaurants or even for the nearby vegetarian restaurants that are opened after 9pm.

As can be seen, the LBS user interface must deliver to the user various information including a static map image of the desired area, the location of the user and possibly locations of other mobile objects, descriptive information on points of interest, route information, etc. Clearly, all this information cannot be presented at once, so an implied requirement is that LBS must provide a set of alternative views, some or even all from the list presented in [9]:

- Geographical View: graphical representation of a geographical area, usually in the form of a map.
- View corresponding visual perceptions: the view as the user could see it if s/he went to the place of interest. This view can be implemented with photographs or 3D modelling.
- Geographical information view: textual description of points of interest enabling the user to browse through it.
- Status View: description of the current state of the user in the form of picture, text of voice.
- Context View: tied to information representation about close objects and the user possibilities in the current context.
- Route View: graphical representation of a route from one point to another.

- Logistic View: abstract route model, showing only intermediate and final points, but no specific distances and directions
- Guidance View: turn-by-turn instruction for the user, usually in a text form and also possibly as voice.

3.2 Usability requirements

Mobile computing environment has certain features that impose restrictions. The properties of mobile networks are: (relatively) low bandwidth, strong bandwidth variability, long latency, unpredictable disconnections and communication autonomy. The properties of mobile terminals are: small and low-resolution displays, limited input capabilities, limited computing power, limited power and small memory size. The practical conditions, when and where the mobile devices are used, bring also additional restrictions. The using conditions cannot be expected to be constant, as usually is the case in "desktop" conditions. The mobile users are typically in very unstable environment in varying conditions, where their cognitive capacity is demanded for other tasks as well.

All these restrictions have to be taken very carefully into account when designing LBS. Some of the implied requirements are:

- Not very intensive use of mobile network and minimal volume of transmitted data.
- Possibility to offline operation.
- User interface should be very simple and user friendly and the amount of presented information content limited and well specified.

3.3 Reliability requirements

LBS are intended mainly for traveling people as a tool providing support in making decisions about where to go. Therefore, wrong information may mean wrong decisions, lost time and, as a result, anger of the client in the best case and a court examination in a worse case when. You can think, for example, a case where LBS misled the user when he needed an urgent medical assistance.

We split reliability requirements into a few sub-requirements:

- Data reliability: the most important since LBS are built around spatial and catalogue data and incorrect or missed data can easily lead to problems.
- Software reliability: applies to both server and client sides.
- Appropriateness and precision of exploited algorithms and methods: depending on the task in hand, e.g., user positioning precision may be sufficient or insufficient, calculating distances by straight line may be sufficient for some tasks but insufficient for others (the road network thus must be taken into account).

3.4 Privacy Requirements

Privacy handling is a major issue in LBS deployment and provision and a critical success factor to the wide acceptance of this technology framework. The terms privacy handling consolidate issues like ownership of location information, use of location information, disclosure to service providers, etc. Skepticism arises as to where and how privacy handling should take place within the LBS provision chain. Existing proposals from operators and standardization bodies (e.g. OMA [13], 3GPP [1]) specify a priority scheme whereby the core network elements (e.g., Home Location Registers) have master control on location information. The provision/disclosure of such information to other entities (e.g., location servers, LBS serving nodes, ASPs) is subject to subscriber needs (e.g., registration information) and regulatory frameworks.

3.5 Location infrastructure requirements

Location-based service consists of roughly two phases, determining the position of the customer and providing service or contents based on the position. For the location method at least the following requirements can be listed [14]:

- The method should provide good accuracy subject to the requirements of the application and the respective cost.
- The area where the mobile device can be located should be as large as possible; it should be possible to determine in advance where the device can be located; ideally, this should happen within the whole coverage area of mobile networks.
- The method should be fast: also in this respect the applications have different demands, e.g. the emergency applications and car navigation systems have higher demands than "FIND Restaurant" – type applications.
- The location method should not generate too much signaling load within the mobile network.
- The effects of adding location method support to a terminal and using it should be minimal, i.e. it should not increase its size, weight, power consumption, or price.
- The location method should have a minimum impact on the mobile network in terms of complexity and cost.
- It should be possible to locate all mobile devices irrespective of their type and whether they are roaming or not.
- It should be possible to locate a large group of mobile devices at the same time.
- Consumer privacy must be ensured, by, e.g., providing means for the consumer to turn off the locating feature of the terminal.

3.6 Service interoperability requirements

The interoperability should be assured on all levels of the system architecture. The LBS platform should be interoperable with several types of terminals (e.g., PDAs, GSM terminals) and positioning infrastructures (e.g., indoor, GPS). The platform should be able to handle different coordinate reference systems (e.g., WGS-84 and local systems) in order be able to utilize geographic data available in existing GIS databases. The seamless service provision when different infrastructures are visited by the user is also a requirement in the highly diversified modern telecomm landscape.

4 Pilot Implementation for Location Based Services

When studying the aforementioned requirements for LBS, and for M-Commerce in some extent, and pilot system was designed and implemented.

The general LBS architecture is presented in figure 4. This is a fusion of the visions presented by OpenGIS/OpenLS Initiative and Open Mobile Alliance.

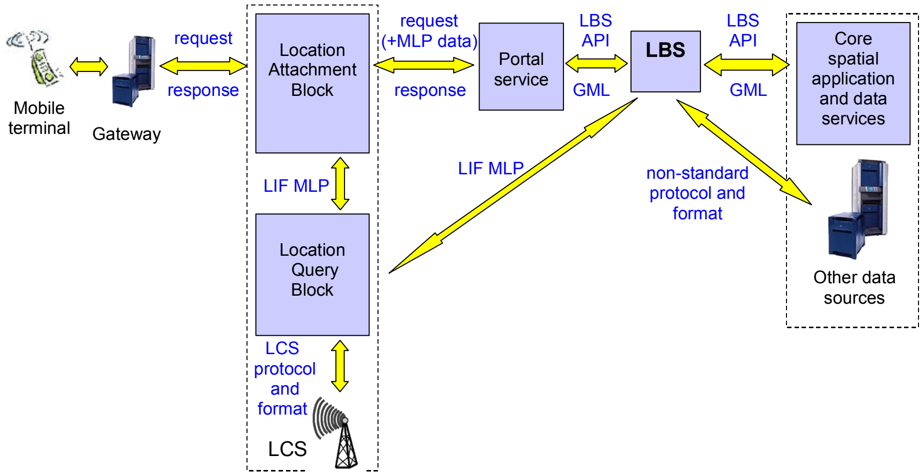

Fig. 2. The general LBS architecture

In the system, a mobile terminal is used for accessing LBS and a gateway provides the conversion between data protocols in mobile network and TCP/IP network, if needed. LCS is a service providing information on the locations of mobile users. Location Query Block is a wrapper of LCS into (formerly LIF) Mobile Location Protocol (MLP). Location Attachment Block, if ordered, queries Location Query Block for the location of the mobile terminal originated the request and attaches this information to this request; transparent for responses. Note that in the case of terminal-based positioning (e.g. GPS) the entire LCS tier would be located inside the mobile device. Portal service provides transformation between data protocols and formats used by in the LBS and those appropriate for specific mobile terminals. Core spatial application and data services are building blocks for LBS, provide geographic data services and standard applications, such as geocoding, geographic queries, route finding and other. The other data sources are sources using some non-standard data protocols and formats, for example, business databases.

Important features of this architecture are utilization of GIS data and algorithms and using of XML for data encoding and all the protocols. Such architecture provides high flexibility in fulfilling of the LBS functional requirements, as well as interoperability requirements. The client application was developed in Java and geographic data is delivered in (compressed) XML-encoded geographical vector form to the client. The client side is responsible for generating alternative views to the data and running simple queries. This allows reducing network load and working offline.

The pilot system includes some additional special features. One special feature is user-centered data selection**.** The system server is capable of selecting geographic data that is relevant for a specific user at a specific time. This again further reduces network load and increases the usability of the service. An other special feature is a transaction monitor**.** In order to protect itself from the unexpected disconnections and crashes, the client application includes the transaction monitor. It keeps track of the history of interaction with the server (what data was sent and received) and stores all the data needed for recovery. This saves the application from information losses and guarantees basic transactional properties.

5 Conclusions

In this paper, we briefly reviewed some of the most important technologies for Mobile E-Commerce and the deployment of LBS. We discussed the emerging telecommunication platforms and positioning systems along with issues related to contemporary mobile computing. We elaborated on this issue of LBS by presenting the requirements posed by users for this evolving family of modern mobile services. Lastly, we presented a built pilot system, which exemplifies how such requirements are reflected in a LBS implementation.

LBS is surely an area of modern mobile services where considerable growth is observed. The developments in the Internet domain, wireless/mobile networking as well as the proliferation of positioning technologies expedited such evolution. The impact on nomadic users is tremendous. It is evident that such progress needs to be addressed in a methodological manner and supported, where appropriate by coordinated standardization efforts. Requirements need to be reviewed and studied very carefully by all the involved actors. Their coverage – fulfillment by modern technological platforms is also a very important issue. Our work is mainly moving along these lines. Our analysis, as presented in this paper, shows that the technologies and issues involved in LBS deployment and provision cover a very wide spectrum including operating system capabilities, user interface design, positioning techniques, terminal technologies, network capabilities, etc. The meticulous mapping of these technical aspects to the identified requirements is a critical success factor for LBS.

Acknowledgements

The research was partially supported by the Finnish National Technology Agency under contracts 750/401/99 and 330/401/99 and the Special Account for Research Grants of the National and Kapodistrian University of Athens (ELKE) under contract 70/3/5362. The work of J. Veijalainen was supported by the Telecom Advancement Organisation of Japan (TAO). The work of A. Tsalgatidou has been partially funded by the Special Account of Research of the University of Athens under contract 70/4/5829.

References

1. 3G Partnership Project (3GPP), http://www.3gpp.org .
2. Epay statistics on M-commerce. Accessed 8.2.2003. Accessible at http://www.epaynews.com/statistics/mcommstats.html#9 .
3. European Space Agency, "Navigation – What is Galileo? Satellite Applications, European Space Agency, 2002. Accessible at http://www.esa.int .
4. "FOMA® , The World's First 3G Mobile Service, based on W-CDMA", Service Bulletin, NTT DoCoMo, Autumn 2002.
5. Magnus Frodigh, Stefan Parkvall, Christiaan Roobol, Per Johansson, and Peter Larsson, "Future Generation Wireless Networks", IEEE Personal Communications, Vol. 8, No. 5, 2001.
6. F. Hermann and F. Heidmann, "User Requirement Analysis and Interface Conception for a Mobile, Location-Based Fair Guide", proceedings of Mobile HCI 2002, Lecture Notes in Computer Science, v. 2411, pp.388-392.
7. J. Hightower, and G. Borriello, "Location Systems for Ubiquitous Computing", IEEE Computer, August 2001 (also in IEEE Special Report "Trends Technologies & Applications in Mobile Computing").
8. H. Kaaranen, A. Ahtiainen, L. Laitinen, S. Naghian, V. Niemi, UMTS Networks; Achitecture, Mobility, and Services. John Wiley&Sons, Great Britain, 2001.
9. Eija Kaasinen , Juha Luoma, Merja Penttinen , Tuula Petäkoski-Hult, Rolf Södergård, Basics of Human-Centered Design in Personal Navigation, NAVI programme report, 2001.
10. KDDI au. Accessible at http://www.au.kddi.com/ . Accessed on April 14, 2003.
11. Mobile electronic Transactions forum, www.mobiletransaction.org, 2000
12. F. Muratore (ed.), UMTS; Mobile Communcations for the Future. John Wiley&Sons, Great Britain, 2001.
13. Open Mobile Alliance (OMA), http://www.openmobilealliance.org/ ..
14. Nokia, Mobile Internet Architecture (MITA), Technologies and Standarization. Edita Publishing/IT Press, Helsinki, Finland 2002.
15. Nokia Newsletter. Accessible at http://www.forum.nokia.com/the_year_ahead. Accessed on Jan. 9, 2003.
16. Paikannussanasto, Vocabulary of Positioning (2002). Tekniikan sanastokeskus, TSK 30, Helsinki.
17. James A. Senn, "The Emergence of M-Commerce", IEEE Computer Magazine, Vol. 33, No 12, December 2000.
18. Gavin Stone, "Mobile Execution Environment White Paper", MexE Forum, RONIN Wireless, 2000.
19. A. Tsalgatidou and J. Veijalainen "Requirements for Mobile E-Commerce", in E-Bussiness: Key Issues, Applications, Technologies, B. Stanford-Smith and P. Kidd (eds.), IOS Press, pp. 1037-1043. Proceedings of the E-business and E-work Conference, Madrid, Spain, 18-20 October 2000.
20. UMTS Forum, Report #5, 1998.
21. WAP Forum, Wireless Application Protocol Public Key Infrastructure Definition, WPKI, WAP-217-WPKI, April 2001.
22. WAP Forum, Official WAP 2.0: the Complete Standard, John Wiley & Sons Inc., July 2002.
23. Chan Yeob Yeun, and Tim Farnham, "Secure M-Commerce with WPKI", proceedings of 1st International Workshop for Asian PKI, October 2001, Korea.