Electron Commer Res (2011) 11: 5–29
DOI 10.1007/s10660-010-9068-7

Location-based services deployment and demand: a roadmap model

Krassie Petrova · Bin Wang

Published online: 3 November 2010

Abstract The advancements in mobile, wireless and positioning technologies have enabled applications and services such as route guiding and emergency call-out assistance. These and other similar services have become known as 'location-based services' (LBS). The literature on LBS development and deployment addresses technological issues (for example, usability and integration) and issues related to LBS implementation—including LBS business models, adoption and customer concerns and requirements. In the study presented here LBS development and deployment were investigated from a case study perspective and the LBS landscape is explored and analyzed. The study finds that while the regulatory environment has played a critical role as a success factor in the markets investigated some of innovative business approaches may have been equally important as customer demand generators. Economies on the road to deploying LBS should therefore focus on creating a supportive environment encouraging the development of services, which meet the identified needs and requirements of the target customer market.

Keywords Mobile services · Location-based services · Location-aware services · LBS · Case study

1 Introduction

Location-based services (LBS), which integrate wireless technology, positioning technology, and location information management, have a significant potential to improve existing public services such as emergency related ones. LBS can be also used

K. Petrova (✉) · B. Wang
Auckland University of Technology, Private Bag 92006, Auckland, New Zealand
e-mail: Krassie.petrova@aut.ac.nz

B. Wang
e-mail: robinmail@yahoo.com

to offer new commercial services such as tourist guidance, and thus to open new revenue streams for providers of location identification data and location-related information [1–4]. Examples of applications where LBS have been successfully deployed include emergency caller location identification, vehicle fleet management, mobile yellow pages, route finding. Detailed classification of mobile services including examples of LBS can be found in [5]; a comprehensive review of the technological aspects of LBS is provided in [6] where a set of requirements towards the design of LBS are proposed and discussed.

Three important factors influence the development of new LBS applications. First a range of science and technology developments are involved and need to be integrated [7]; second LBS deployment needs to follow a business model meeting the requirements of the potential customer market [8]. Finally, the regulatory environment in the deployment area needs to be taken into account [9]. Subsequently, current academic research in the area of LBS focuses on business models and user related issues (e.g., customer acceptance, personal information privacy, service usability, service attractiveness to customers and other end-users), and on LBS applications and enabling technologies. Based on a literature review of works exploring LBS in the context of a country (the USA, Japan, South Korea, and New Zealand) or a geopolitical entity (the European Union—EU), this article attempts to map the stages of LBS development and deployment and to propose a generic LBS development roadmap model underpinned by an understanding of the factors driving LBS demand and adoption, and the issues related to LBS implementation.

The rest of the article is organized as follows: The next section introduces an LBS reference framework based on a literature review, and is followed by a section describing the research approach. The last two sections present the findings, analyze their implications, outline the limitations of the study, and suggest directions for further research.

2 Background

Contemporary LBS are also known as ‘location-aware services’, ‘wireless location services’, ‘mobile location services’ and can be viewed from different perspectives, including mobile telecommunication systems, location-aware technologies, handheld mobile devices, and software applications [10]. LBS are also related to the use of the Global Positioning System (GPS) (a satellite positioning technology enabling the location of people and objects) and other similar systems, and to information service applications such as Geographic Information Systems (GIS), which include databases populated with spatial location data. Based on [11] for the purposes of this article LBS are broadly defined as applications, which provide an information service related to and dependent on the location of the mobile customer—for example emergency call user location, or location related information to travellers. The scope of LBS considered here excludes indoor technologies such a Bluetooth and RFID and is limited to outdoor LBS where the positioning process uses information provided either by the mobile network or independently by the handheld device (or by a combination of both) in order to determine the location of the mobile device (and of its user).

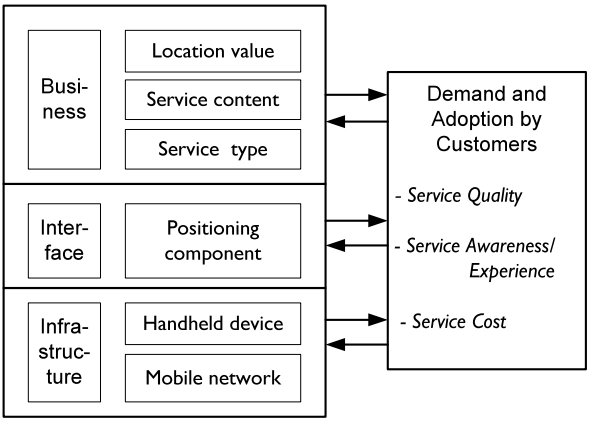

Fig. 1 LBS reference framework

2.1 LBS reference framework

The research adapts and extends an earlier mobile commerce reference model [12] in order to create the data gathering and analysis research framework. The framework links together four major components related to LBS development and deployment: *Infrastructure, interface, business, and customers* (Fig. 1).

The ability to provide information about geographic location is a defining feature of LBS therefore the corresponding mobile business service model is built around providing information requested by the mobile customer and dependent on their geographic location at the time of the request. As in other mobile commerce applications, in the case of LBS *infrastructure* comprises supporting technologies. However the handheld device (usually a mobile phone or a PDA—Personal Digital Assistant) may need to have a positioning capability depending on the technology used for positioning. *Interface* includes a 'positioning' component, which is specific for LBS: In LBS a positioning process is needed to obtain and process location data generated by the mobile device or the mobile network, and determine the mobile customer's position. *Business* includes location data provision (i.e., processing the request for location data needed by a specific mobile business service), and location-related content provision (i.e., sourcing and maintaining the location-dependent information needed by the mobile business service).

Demand and adoption by *customers* refer mostly to mobile business service adoption (i.e., to the business component of the framework) as the role of the infrastructure and interface is transparent; still some factors influencing adoption are also related to the infrastructure and interface components, for example the accuracy of the positioning may affected the relevance of the information received by the customer. Some of the issues related to positioning functionality and its significance for the LBS value proposition are discussed below.

2.2 Positioning component

For outdoor environments, the positioning process normally uses either a satellite positioning system such as GPS, or the mobile telecommunication network, to which

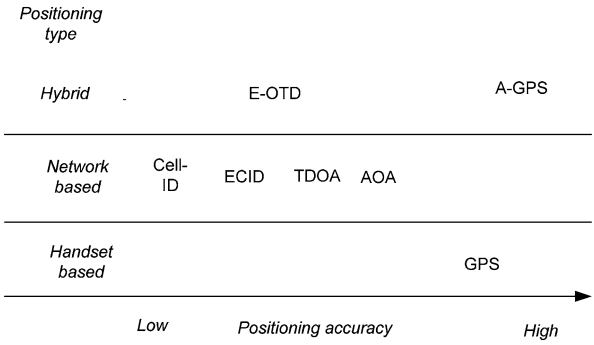

Fig. 2 Outdoor positioning technologies

the mobile customer is connected. [Satellite positioning systems are independent of the mobile telecommunication networks.] Currently, a number of outdoor positioning technologies are used (Fig. 2). The network-based ones such as Cell-ID, Enhanced Cell ID (ECID), Angle of Arrival (AOA), and Time Difference of Arrival (TDOA) use mobile network data to determine the geographic position of the mobile device. The most widely handset based technology is GPS. Hybrid technologies such as Enhanced Observed Time Difference (E-OTD) and Assisted GPS (A-GPS) use both approaches. As seen in Fig. 2, positioning technologies differ in terms of the accuracy of the geographic location data they provide. The more advanced technologies are more expensive to deploy while some may be restricted in their usefulness as they require line–of-sight (e.g., AOA, TDOA). Handset and hybrid technologies (e.g., ECID, GPS, E-OTD, A-GPS) may also require significant handset modification [13].

2.3 Location value

According to their business type and from a customer perspective LBS can be classified as: *emergency, navigation, information or information/entertainment (infotainment), advertising, tracking*, and *billing* [14–16]. These services obtain user location data using one of the methods mentioned above and normally incorporate additional information content relevant to the location of the mobile customer. The service value proposition is based on the expectation that customers will be attracted by an LBS, which is customized to take into account and relate to their geographical location.

Further in the text the term ‘location value’ is used as a reference to the value added to a service by making it location aware as described here. The location value brought to the customer by a specific LBS is created through an appropriate business service model incorporating the use of a positioning technology. Location value contributes to the perceived quality of the particular LBS and to the effectiveness of the respective business model. It is therefore important to be able to measure location value. Two characteristics may be used for the purpose: i) the accuracy of the positioning, and ii) the quality of the location dependent information content of the service.

As shown in Fig. 2, GPS and A-GPS are the most accurate. Therefore services based on A-GPS such as providing directions (a navigation service) and routing emergency calls (an emergency service) would be expected to be among the most valuable LBS from a customer perspective. Services based on TDOA/OTD (lower

accuracy technologies) such as traffic management and travel services (navigation), personnel tracking (tracking), and mobile searchable directories (information) may be less valuable as the positioning component is less accurate. Low accuracy services using Cell-ID (e.g., location-sensitive billing, vehicle tracking) are among the least valuable services.

As the quality of the location dependent information content of a service may vary with the deployment environment it is extremely important to understand what customers require and expect in order to identify the most suitable positioning technology and the respective LBS business model [17–19]. While the degree of location data accuracy may contribute to a positive perception about the quality of the service, other factors may also influence customer perceptions. For example, the perceived over value of the service may also depend on its perceived usefulness, its relevance, and the reliability of the location dependent information. Location information content quality may also depend on the service design, and on the quality of the information provided by other systems (e.g., street maps). As contributors to the quality of the location dependent information content all of the factors identified so far may play a critical role in discouraging or persuading customers to adopt and use particular LBS. Some of the issues related to location value and customer demand and adoption identified in prior research are discussed in the next subsection.

2.4 Issues related to location value and customer demand

A number of issues across all components of the LBS framework have been identified in the prior work reviewed. If not addressed these issues may impact negatively on the location value and thus become detrimental factors to LBS adoption and customer demand growth.

Issues related to infrastructure and interface includes reliability, time, and interoperability. As mentioned, positioning accuracy can be used as a measure of location value. Coupled with accuracy is the reliability of the derived location information, which similarly to accuracy is highest for A-GPS based services [20]. An issue related to accuracy and reliability is the time needed to determine the position; another issue is the use of different positioning technologies across the different mobile networks customers may be connected to.

Issues related to business include information currency and customer privacy. Localization is considered as a unique dimension of the value proposition of mobile business [21]; however the information sent to a customer who is using an LBS needs to be up-to-date and relevant to the customer's geographic position. Thus the currency of the location dependent information affects the location value brought to the customer and may play a significant role in making LBS attractive to customers and end users. As location-sensitive information (e.g., travel and routing information) can change very often, keeping the LBS content accurate and up-to-date is essential for the quality of the service [22, 23].

Personalization is another important dimension of LBS [24]. However maintaining location privacy may be essential for users receiving personalized location based information. Customers may have expectations of privacy protection and would also expect assurance that their personal data exposure is controlled, with mechanisms

in place to provide identity protection as well [25–27]. In some countries legislation such as general data protection acts provide a level of customer privacy protection [28]. In addition it is also necessary to prevent customers from being illegally tracked [29]. An issue may arise with the legality of a service using location data tracking (e.g., monitoring a child's or an elderly person's activities) as such use may result in possibly illegal or unethical restriction of the tracked subject's activities [30].

Finally research results in the area of acceptance and adoption of LBS by private customers and business end-users has identified factors positively affecting the motivation to use LBS, which may also lead to increased customer demand. Perceived LBS usefulness may be highly correlated with the level of geographical accuracy however in order to stimulate customer demand advancements in localization techniques need to be informed also by a better understanding of what motivates LBS use and how customer perceptions about the quality of LBS are formed [31, 32].

Usefulness along with useability, efficacy and accessibility can be grouped together as determinants of service quality, while customer experience and customer awareness of the services available (service awareness) constitute a second group [22, 24, 33–41]. Service quality factors depend on the accuracy and relevance of information, and on the ability of the service to address the needs of the customer in a timely and effective manner. However customer and provider perceptions about the quality of a service may differ [42]; therefore fine-tuning a service and the related business model to identify and meet specific customer requirements may take some time before customer become aware of the potential of the service and start to develop positive experiences with it. Thus demand may be expected to grow as users develop an appreciation for the new service [43].

A major detractor to LBS adoption is the privacy factor namely customer concerns about the use of personal data [44]. The ability to control a service (e.g., deactivate it) along with improved regulation providing effective enforcement of laws and regulations protecting privacy and governing the use of personal data including location may be able to address these concerns [22, 26, 27, 33, 35, 36, 45].

Finally, service cost may also become a negative factor [21]; however customer satisfaction with the value added by high quality LBS, which also provide users with means to exercise discretion in revealing location and other personal information to third parties should improve the LBS value proposition and generate demand by customers who are aware of the service potential and/or have experienced it [4, 5].

3 Study approach

The study presented here is based on the premise that an investigation of the current LBS landscape may help understand better what makes LBS attractive to customers, and inform future research and development in the area, The primary study goal is to derive an explanatory model for LBS development and deployment and to provide recommendations to relevant stakeholders including the information and communications technology (ICT) industry, and academic researchers. The following question guides the work: What are the main driving forces behind LBS development and customer demand?

A multiple case study approach was chosen as a research strategy, as especially suitable for the exploration, classification, and hypothesis development stages of the knowledge building process [46]. Data collection was carried through a literature and document survey. The sources include published academic research, industry reports, and miscellaneous publications such as newspaper articles and white papers.

Data collection units were selected from amongst highly industrialized countries/geopolitical entities, and include first the USA, the EU, Japan, and South Korea, which are the subject of a number of comparative studies in the area [31, 47–49]. These units may be considered as cases of global leaders in LBS services deployment and provision. For example, advanced technologies such as GPS have been used for some LBS in the USA where the local legislative environment has contributed significantly to their development. The EU is an active promoter of the GSM technology, which at present is the most popular mobile system standard and accounts for 82% of the global mobile market [50]. Japan is arguably the most advanced country in the world in terms of overall LBS adoption as indicated by the large body of Japan-based or Japan- oriented research. South Korea, which compares to Japan in its strong focus on innovative and emerging technologies has 'leapfrogged' into building superior LBS infrastructure and services [48, 51].

New Zealand is among the 30 OECD member countries and was ranked No 18 in terms of broadband use, i.e. relatively close to that of US (No 15), to Japan (No 17) and also to nine EU countries [52]. However in contrast to these countries, LBS in New Zealand are neither widely available nor popular. Therefore including New Zealand as a fifth data collection unit allows to facilitate a comparison within a group of highly industrialized countries, which have reached different levels of LBS development and spread, and identify directions for future LBS development.

The study first creates a summary of the data collected about each case applying the LBS reference framework and including types of LBS available, service and application scope, mobile technologies used, mobile network market (operators and regulations), and customer acceptance and adoption. Second, the findings are compared and analyzed in order to identify the factors contributing to increased demand for LBS and the LBS development drivers.

4 Case data summaries

To address the stated research question the LBS reference framework is applied to the five data collection units in order to identify the most significant case features relevant to the components of the LBS reference framework: regulatory environment, infrastructure/interface, business, and customer demand (Fig. 1).

4.1 The case of the USA

4.1.1 Regulatory environment

In 1966, new legislation was introduced aimed at improving emergency call services, known as 'Enhanced 911' (E911). Mobile operators are obliged to provide automatically the caller's location information in a 911 emergency call situation. The E911

specifies the required levels of accuracy and reliability: for 67 percent of calls the returned location should be within 50–100 meters of the true location (for handset based and network based positioning respectively), and within 300 meters for 95 percent of all calls. The compliance deadline was extended to 2005; some financial incentives to operators were also provided. The E911 legislation has determined to a significant extent the choice of positioning technology made by mobile network operators as high accuracy is needed to support emergency services [9, 53, 54].

4.1.2 Infrastructure and interface

A relatively small number of wireless carriers/operators dominate the wireless carriers mobile network market place (among them Verizon Wireless, Cingular, Sprint Nextel). The technologies deployed support LBS [55]. Non GPS-compatible handsets are gradually phased out [56]. Third party business partners provide additional location-based services (e.g., the electronic maps service offered by Rand McNally). LBS are reliable and accurate due to the compliance with the E911 legislation. The positioning technologies used are almost without exception A-GPS and U-TDOA (Uplink-Time Difference of Arrival) [54]. The networks are highly interoperable as there are only two dominant positioning technologies.

4.1.3 Business

Services provided include emergency (call location identification), navigation, location information (e.g., about friends, or points of interest), tracking. LBS development and market penetration was positively influenced by the E911 legislation. LBS are used by companies to enhance business processes such as fleet management. In addition the wireless carries offer publicly available commercial LBS (route discovery, navigation, directions, maps, fleet management, people finder, property management). Applications are developed to provide static as well as dynamic (most current) information.

4.1.4 Trends in customer demand

As seen the E911 compliant infrastructure offers a ready platform for implementing commercial and public LBS however the service supply process is considered to be relatively slow [9, 32]. Future growth in LBS is predicted to reach 1.1 million subscribed devices by the end of 2010. New applications continue to emerge, for example the location-enabled enterprise, and public sector LBS [57]. An example of a transportation planning service meeting identified customer needs is reported in [37]. The service targets a specific socio-economic group (low income) and is likely to be in demand even though the service design may raise some personal safety issues. The results of an empirical study also confirm that despite issues related to personalization (privacy concerns) users will be likely to adopt LBS provided that they find the services ‘useful’ [58].

4.2 The case of the EU

4.2.1 Regulatory environment

In EU the implementation of policies creating an open internal environment have given a strong position to the few handset manufacturers who dominate the European market; dissimilarly the majority of the network operators tend to focus on national markets with several large companies (e.g., Vodafone and Orange) operating in a number of European countries [48]. In 2002 the EU Commission passed Article 26, a directive on universal service and user rights relating to electronic communication networks and services. Members of the EU were asked to develop national regulations to enforce the automatic positioning of emergency calls and the subsequent routing to the single emergency call number 112 (E112). No positioning accuracy level and no implementation deadline were specified [59].

4.2.2 Infrastructure and interface

There are a large number of mobile and wireless operators across EU member countries, which may have different preferences in the choice of positioning technology although GSM seems to be dominant. While E112 requirements can be met by several different positioning technologies (Cell-ID, U-TDOA, A-GPS, E-OTD), the hybrid A-GPS approach has emerged as the most preferred technology due to its accuracy and reliability.

4.2.3 Business

A number of LBS are currently represented on the market, including for example location based discount billing. LBS are also available through portals such as i-Mode (operating in Europe through collaborative arrangements between NTT DoCoMo and some European operators), and Vodafone Live! With the major network operators actively promoting LBS, LBS deployment has been relatively successful and has generated customer demand, with a number of applications offering dynamic content [4, 48, 60]. It is expected that the location technology industry will take advantage of the increased investments in the public safety sector [61]. Predicted growth in 2010 is 18 million LBS users, with almost 50 percent of them using navigation services [62].

4.2.4 Trends in customer demand

The still slow pace of mobile services adoption in the EU may be attributed to the fact that mobile services have been developed to take advantage of technology pushed on to the market but not have been necessarily based on an understanding of customer needs and customer adoption behavior [63]. While services such as personal navigation (e.g., the NAVI programme in Finland) still target the mass market [64], studies have started to focus on identifying the needs of specific customer segments. Examples include elderly users [38, 65], the educational sector [33, 66], and the tourist industry [45]. Demand for LBS is predicted to grow but only if the service design

and deployment meet specific quality of service requirements such as usefulness and useability (for the elderly and for people with limited functional capacity), service accessibility across networks (for students), efficacy, or real-time information (for tourists). The factors negatively affecting customer demand may also be specific: For example cost may be an important issue with the elderly limiting LBS affordability while students and tourists may be concerned mostly with security issues and privacy control. Work on identifying the differences between the target customer groups and on studying how location information content adds to the value of mobile services is ongoing [18, 67, 68].

4.3 The case of Japan

4.3.1 Regulatory environment

In 2002 the Japanese government granted the three network operators licenses for 3G mobile communication services [48]. In 2004 Japan's Internal Affairs and Communications Ministry started working towards the "The Emergency Location Reporting System". The system automatically notifies the call's location when a call from a 3G mobile telephone/IP phone is made to one of the emergency numbers. Location data are provided by GPS for GPS-enabled devices. For other types of handsets, the location is derived from base station information [69]. The service was set to start as of April 1, 2007, to be gradually expanded nationwide. There is some legislation in place to protect location information privacy [47].

4.3.2 Infrastructure and interface

In Japan 3G mobile network are spread nation-wide. The two biggest wireless operators are NTT DoCoMo and KDDI and have approximately 80 percent of the subscriber market share (the third company is J-Phone). NTT DoCoMo run both 2G and 3G networks however KDDI has a majority market share (95 percent) in the 3G sector. The positioning technologies are respectively Cell-ID and A-GSM, i.e. location data accuracy is subject to significant variation [48, 70].

4.3.3 Business

LBS on offer cover the whole range of business applications. Customers interact with integrated portals such as i-Mode (DoCoMo) and NaviWalk (KDDI). Even though the initial LBS development driver was technology, the successful business model of i-Mode generated strong customer demand. Distinct business models have been developed for three application deployment categories: carrier-hosted applications, mobile-station hosed applications, and provider hosted applications. The use of dynamic content is relatively high [71].

4.3.4 Trends in customer demand

As reported in the literature both younger and older customers use LBS [49, 72]. The availability and the affordability of the infrastructure are expected to boost further customer demand for LBS. The high level of customer acceptance of existing

services has motivated research into the design of a next generation of personalized and specialized services building upon already popular and accepted LBS. Examples include intelligent map reconstruction enabling users to browse the map screen reflecting their 'inferred intentions' [73], personalized LBS offering a 'place-enhanced' blog integrating a blog with a personal spatial information management system [74], and mobile geographic information services for individual customers [75]. Building upon demand for existing services the new LBS to appear will not be so much focused on meeting already identified requirements but will aim to increase location value by expanding the limits of 'what is possible' with strong context relevance and enhanced personalization [63].

4.4 The case of South Korea

4.4.1 Regulatory environment

The policy development in the telecommunications area encourages integration and collaboration between government and industry with the establishment in 2003 of the LBS Industry Council encompassing all LBS related industries [76]. With the support of government initiatives and public promotion to the public, South Korea became the first country in the world where mobile subscribers outnumbered fixed line subscribers [77]. One of the four services developed by the Korean National Emergency Management Agency (NEMA) under the umbrella name U-119 is emergency caller location identification using GpsOne™—a positioning system built into handsets. A number of acts protect privacy rights and regulate electronic and mobile commerce, including the Protection of Location Act. Work on regulating LBS provision and dealing with issues such as privacy related to third party person tracking services, and to emergency situations such as fire or a medical emergency are in progress [78, 79].

4.4.2 Infrastructure and interface

The South Korea mobile network market is dominated by three major mobile phone operators: SKT (South Korea Telecom) has about 50 percent market share, followed very closely by KTF (Korea Telecom Freetel) and also by the relatively smaller LGT (LG Telecom). The dominant positioning technology is A-GPS, with the widely deployed GpsOne™ providing accuracy in the 50 meter range [80]. Government policies also support network convergence: a service driven approach where operators are licensed to offer services based on connecting existing wired and wireless networks [81, 82].

4.4.3 Business

Typical mass market LBS include friend and point of interest finding, map and directory services, and different types of navigation services. Specialized services include AngelEye—a commercial tracking service for children and the elderly [83]. Another area of development of specialized services is telematics, which provides

drivers with up-to-date information about traffic and security, and with navigation support. Telematics services continue to expand to enable remote vehicle diagnostics, fleet management, wireless Internet access and other services using multiple networks and information systems [84].

4.4.4 Trends in customer demand

As indicated LBS are well developed and actively promoted. Customers have accepted the mobile phone as a vehicle for mobile commerce activities and have experienced and subsequently adopted the services on offer, which are also affordable [85]. Future demand may evolve around highly personalized and specialized services, also taking into account culture related consumer behavior—for example a preference for infotainment services [49, 85]. Future LBS may be also as part of multi-network, multi-system portals such as WiBro, which are available to the user whether on the move or stationary [81]. Portal availability made possible by the cooperation between the actors in the mobile network value chain will motivate further content and service development with a focus on innovativeness, quality of service, and consumer preferences [48, 76, 86].

4.5 The case of New Zealand

4.5.1 Regulatory environment

At present there is no legislation regulating the servicing of emergency calls placed from devices connected to the mobile telecommunication networks, or specific legislation addressing the privacy of location information and the conditions of its use.

4.5.2 Infrastructure and interface

Two operators currently dominate the mobile market—Vodafone New Zealand and Telecom Mobile [87]. Vodafone deploys a primary location technology (Cell-ID) able to support some LBS [88]; Telecom Mobile is expected to acquire positioning capability compliant with the 3GPP standard TS23. 271 by the end of 2010 [89].

4.5.3 Business

At present, only a few location-based services are available. Vodafone provides SmartFind—a subset service of Vodafone Live! for 2. 5G and 3G networks. SmartFind has a well-developed range of searchable locations including community features such as schools, libraries, and businesses [90]. Both Vodafone and Telecom provide fleet management to businesses, using an additional GPS device [91, 92].

4.5.4 Trends in customer demand

A number of studies identify the potential and opportunities offered by LBS services in the New Zealand tourism industry [93–97]; the specific customer needs and opportunities for further development of LBS for tourists were studied in [98]. The use

of mobile services including LBS in the real estate industry has been investigated through a user survey in [99]; the findings indicate that despite the availability of technologies such as smart phones and the possibility of using mapping applications, the respondents were using their mobile phones almost exclusively for voice communication. The authors suggest that the particular culture of the real estate agent profession (with has a strong emphasis on the personality of the agent) may be a barrier to adoption, also coupled with a perception of mobile services being too 'risky'.

Although the LBS adoption potential is significant offerings are limited, with customers/end-users reluctant to accept the value proposition and may be even unaware of it. However as technology gradually transforms people' lifestyles [100] it may be expected that LBS with relevant content and an acceptable delivery method may gain popularity and generate demand for innovative services such as providing seamless information access across mobile information systems based on the location and the information needs of the mobile user [95].

The LBS occurrences identified in each of the five cases discussed above are summarized and classified in Table 1 including the type of location technology used, the type of the service (commercial, private, emergency), the type of the location information used (static or dynamic), and the level of presence of LBS relevant legislation.

5 Findings

A comparison of the findings across the case studies allows addressing the research question and identifying some of the driving forces behind LBS development and customer demand. It is evident that in Japan, South Korea, the EU and the USA LBS have already achieved initial market penetration. There is also evidence to suggest that LBS demand may have become sufficient to motivate further development and deployment. However there are noticeable differences in the spectra and type of LBS offered, in customer awareness and customer demand, and in the degree of personalization and specialization of LBS. South Korea emerges as a leader in LBS deployment, with services targeting both mass and specialized markets and with an established customer base. In contrast New Zealand lags behind in LBS development. The section provides further analysis following the framework used to present the case data and proposes an LBS development roadmap model.

5.1 Regulatory Environment

Generally LBS related legislation focuses on two issues—the use of LBS for public safety and protection (e.g., emergency caller location), and the protection of personal privacy and rights. The USA, Japan and the EU have already legislated for mobile emergency services and thus given a 'push' to the development of applications using location information. South Korea has made a similar move relatively recently, after LBS have been already established on the market.

With regard to legislation regarding location information privacy, there is some already in place in the EU, Japan and South Korea. In New Zealand there are no regulatory requirements with respect to providing location information in case of

Table 1 LBS services summary

Case	Location technology	Location-based services			Location information		Legislation about location data privacy
		Commercial	Private	Emergency	Static	Dynamic	
USA	A-GPS; U-TDOA	Fleet management; Work force management; Property tracking; Traffic information	Navigation; Friend finder; Points of interest; Directions; Tracking; Traffic; Route finder	Yes (E911)	Yes	Yes	Some
EU	Cell-ID; U-TDOA; A-GPS; E-OTD	Fleet management, Work force management; Property tracking	Yellow pages; Tracking; Navigation; Directions; Traffic finder	Yes; also ongoing (E 112)	Yes	Yes	Some
Japan	A-GPS; Cell-ID	Fleet management; Force management; Property tracking	Navigation; Friend finder; Points of interest; Directions; Tracking; Route finder; Weather information	Some only; also ongoing	Yes	Yes	Some
South Korea	A-GPS (majority)	Telematics; Fleet management; Remote vehicle diagnostics and control; Navigation	Finding information about the locality; Online location based dating; Kid tracking; Navigation; Friend finder; Traffic and routing services	Ongoing (U-119)	Yes	Yes	Some
New Zealand	Cell-ID	Fleet management tracking	Tracking; Finding information about the locality	None	Yes	None	None

emergency calls, and no specific LBS related privacy protection legislation. Finally, the governments in the USA, Japan and South Korea have actively supported the development of the mobile telecommunication industry with incentives to encourage investment. This has happened to somewhat lesser extent in the EU and even less in New Zealand.

5.2 Positioning technology

While in the USA, Japan, South Korea and the EU highly accurate and reliable positioning technologies such as A-GPS have been already adopted by all major operators, and most customers are likely to own GPS enabled handsets, until recently in New Zealand only one of the big mobile network operators had had some positioning capacity at the lower end of the scale in terms of accuracy and reliability (Cell-ID). Cell-ID is still used also in the EU.

5.3 Business

The spectra of LBS offerings in New Zealand is relatively limited. A prohibitive factor may be the inadequate provisioning of location information by the networks, which may mean that all services requiring positioning would need an additional third party device and thus be costly and inconvenient to customers. In contrast in the rest of the cases and especially in Japan and in South Korea LBS are available in many different areas and also include business customers and employees; additionally LBS are relatively inexpensive. However the EU is different from the rest as it is composed of different states with different local languages, which may be a barrier to the provision of services integrated across boundaries. The current trend in the EU, the USA and in Japan is to develop new services targeting the requirements of specific customer segments, and to aim to offer superior quality of both service and user experience. In South Korea LBS are innovatively offered on converged platforms.

5.4 Trends in customer demand

While LBS applications such as directory services and fleet management based on static GIS information are common there is no evidence that these services generate sufficient customer demand, and revenue to providers. When services start adding dynamic content such as real-time traffic information (used for navigation), their value to customers increases and may start to generate demand (such services are offered in all cases except in New Zealand).

Further specialization and differentiation combined with the affordability of the service has made LBS profitable in Japan and South Korea, with demand predicted to be stable or to grow. However future growth may not occur if services do not meet the increased expectations of customers such as being seamlessly integrated with other systems as shown by the case of South Korea.

Quality of service and customer experience (e.g., usefulness, useability, efficacy and the ability to open new possibilities) and also awareness emerge as factors positively influencing customer adoption and as possible drivers of user demand. LBS

based on accurate and reliable location data, and on up-to-date location related information (the EU, the USA, Japan, South Korea) are likely to be perceived as services of higher quality compared to static services such as 'yellow pages' type of directory services (the EU, New Zealand). In South Korea LBS development and deployment is aimed at meeting future customer demand for integrated, personalized and lifestyle oriented services made possible on portals.

Privacy concerns are the major detractor to LBS adoption and subsequent use; however means to control the use of a service and the protective environment may mitigate the effect of this negative factor.

5.5 A roadmap model for LBS development

Five determinants of LBS development and deployment emerge from the analysis above: i) mobile market infrastructure, ii) positioning technology, iii) LBS type and content, iv) regulatory environment, and v) customer demand. Applying these determinants in order to identify the phases in LBS development in the cases studied allows deriving a general roadmap for LBS development (Table 2).

The roadmap model consists of four phases. In faze one, LBS are possible. Mobile networks lack good positioning ability, location accuracy is within the 300 metre range, and the infrastructure cannot provide positioning independently of the handheld device. Services are based on static location information; there is a lack of dynamic content. Customers are not likely to use LBS unless these are well promoted. LBS development and deployment may need to be supported by government initiatives such as legislation (e.g., emergency services), and/or incentives to operators to encourage investment (e.g., reduced cost of bandwidth licensing).

When phase two is reached, LBS become feasible. Accuracy improves to a range of 20–200 metres, with the infrastructure capable of providing independent positioning. Services include applications, which return mostly static but also some dynamic (GIS-based) information, with significant location value to customers. Legislation is in place to drive the improvement of LBS. Customer demand for quality LBS starts to emerge however the regulatory environment still may play an important role in encouraging long term investment in the infrastructure and in research supported LBS development.

In phase three, LBS become viable. The well-established positioning network infrastructure has a very high accuracy (within 20–50 metres) and provides transparent interoperability and positioning. Applications can handle dynamic content and capable to offer precise location dependent information in real time. The location value proposition made to customers is very strong and appropriate legislation exists both to drive improvement, and to protect customers. Customer demand gradually becomes an LBS development driver.

In phase four, LBS are widely used and therefore may become significant revenue generators. With 3G and above networks and satellite systems provide position information of high accuracy. Services are based on dynamically updated content, and are highly personalized. A number of services are aimed at meeting specific customer requirements and at enhancing customer lifestyle experiences. Customers can exercise control over the service they use and can actively protect the privacy of their location information. Customer demand drives further development.

Table 2 LBS development: A roadmap model

Determinant	Phase 1 *LBS "possible"*	Phase 2 *LBS "feasible"*	Phase 3 *LBS "viable"*	Future *LBS "widely used"*
Infra-structure	Not inter-operable, possibly many operators.	Interoperable, possibly a hierarchy of operators in place.	Interoperable even if many operators.	Convergence of different technologies.
Positioning technology	Limited capability.	Significant capability, high accuracy.	High-end technologies, very high accuracy and reliability.	A-GSM technologies with possible new GPS entrants (e.g., the global navigation satellite system GALILEO in the EU).
LBS type & content	Static content, a few services.	A range of services with a mix of mostly static/dynamic content.	Service range expanding, static and dynamic content offered as required.	Services using both public wireless networks and mobile (subscriber) networks.
Regulatory environment	No specific legislation.	Some specific legislation (emergency services).	Specific legislation to cover all aspects (emergency services, privacy, rights).	Incentives for continuing investment. Ongoing work on regulating security related aspects. Possible cross-border regulation.
Customer demand	Low awareness of existing services on offer. Services not differentiated.	Usefulness and quality of service may start driving demand, issues a about privacy and trust may be a detractor. Services for specific industries may start to be developed.	Users motivated by past experience, ready to adopt. Highly specialized / advanced services for socio-economic groups of customers with identified requirements.	Users will accept new services based on quality and innovativeness; creased demand for differentiated services.

6 Discussion

The analysis suggests that at present the USA and the EU have already reached phase two of the roadmap model and are moving towards phase three: The LBS market in the EU and the USA is driven both by legislation and by customer demand; the trend is to search for new types of customer focused services and to develop innovative applications. Japan and South Korea have reached phase three: In Japan and South Korea LBS are advanced and especially in South Korea, are driven by customer demand. Phase four is definite possibility for South Korea depending also on the global economic climate. In contrast New Zealand has reached only the initial phase one and its progress to phase two will depend on future developments in the areas of the roadmap model determinants.

It was also found that in the USA the regulatory legislation enforcing emergency call location played a major role as a driver of advanced positioning technologies adoption and commercial LBS/applications development. In South Korea, Japan and in the EU, the regulatory environment also has played a strong accelerating role. Therefore it maybe concluded that a supportive regulatory environment with respect to telecommunication networks is as an important driver of LBS development especially at the initial two phases.

In the cases studied, technology has played a role of an LBS driver only in phase one, to start up the LBS market. However information content and other aspects of the service have been the factors affecting adoption, moving the focus of LBS development and deployment from technology to customers. For example in Japan and in Europe the relatively cheap Cell-ID is still widely used allowing more diverse customer oriented services to be provided, without necessarily adopting more reliable and accurate but also more costly technologies [36, 101].

With respect to customer demand of LBS the model suggests that customer demand becomes the driver of wide LBS deployment once LBS have been made available and customers have become aware of them—i.e., mostly in the second two phases. Customer use of LBS is likely to increase as the quality of the service increases. With LBS becoming highly specialized and personalized customers will be likely to adopt LBS which have the potential to enhance customer lifestyle and experience. The role of personalization as a driver of customer adoption of LBS has been highlighted in recent research on highly personalized and context-aware LBS applications including for example customers playing location based mobile games [102] or participating in location-based mobile learning [103], and a traffic management support system where the customer can initiate a request for information or share information with other users [104].

Four potential directions for future LBS development and deployment emerge: Personalized (and innovative) applications for individual customers (such as navigation), business oriented applications for individual employees (such as vehicle tracking), public services available to all citizens and organizations such as emergency call management, highly customized services targeting segment groups such as elderly citizens. However for a location-based service to be viable and successful the needs of the customers need to be well understood and met by the design specifications of the service and the business model [6, 8]. As multiple industry players

contribute to the quality of service and to the creating of location value, increasing customer demand will also depend on the degree of collaboration between the industry participants. While commercial initiative can play a role in driving demand government regulation may help leverage the LBS infrastructure potential [9].

In developed countries such as New Zealand where LBS development and customer demand are low, a boost may be provided by industry specific demand for navigation and routing services from sectors such as tourism [95, 105, 106]. The second driver (as in the case of the USA) may be the public safety demand for emergency call location regulation. However upgrading the positioning network infrastructure may be costly and delay the process significantly.

7 Conclusion

In this study LBS were investigated from the point of network infrastructure, positioning technology, business applications, and customer demand and concerns. In order to structure the findings and analyze them the study draws on results reported in prior work in the areas of user adoption and demand, and supporting technology including improving the accuracy of positioning. The study proposes and applies an LBS reference framework in order to present the case data. A four phase roadmap model for LBS development is derived; it suggests that the driving forces of LBS development and deployment and their importance may change from phase to phase.

As LBS mature customer demand becomes the most significant driver however customer expectations about the quality of the service also increase. A positive regulatory environment plays an important role as a stimulator to develop and offer LBS initially. Location accuracy contributes significantly to the quality of LBS and therefore is important however customers are likely to adopt even a 'low tech' service if their requirements are met. Advanced positioning technologies are important for offering quality LBS but are unlikely to drive alone LBS development. Customers are likely to be attracted to LBS by the overall quality of the services and by their lifestyle enhancing potential including location-based versions of existing applications such as mobile gaming and mobile learning.

The mapping of LBS development stages to customer expectations and requirements shows suggests that customers may adopt LBS based on a less advanced technology if the service meets specific customer requirements. Therefore customer expectations about the quality of LBS as well as about their usefulness are likely to be factors influencing customer adoption of mobile services, and drivers of LBS development. The model can be applied to analyze the state of LBS development in a specific geo-political entity in order to identify its position on the proposed roadmap and highlight the future trends and possible demand drivers.

The main limitations of the approach are the study scope: only five data collection units were used, with all cases being developed nations or regions. Further work may involve studying cases of developing countries, and modelling LBS adoption from a customer-centric perspective. Directions for further research include the development of a comprehensive mobile service adoption model, comprising variables to measure the benefits of location identification and LBS to the customer, and empirical studies

of the relationships between customer and the players in the mobile service value chain represented in the model [107].

Acknowledgement The authors would like to acknowledge the support provided by the Auckland University of Technology in the form of a contestable research grant which allowed them to complete the study some of the intermediate results of which were reported earlier in [108].

References

1. Antikainen, H., Rusanen, J., Vartiainen, S., Myllyaho, M., Karvonen, J., Oivo, M. et al. (2006). Location-based services as a tool for developing tourism in marginal regions. *Nordia Geographical Publications*, *35*(2), 39–50.
2. Docter, J., Licciardi, C. A., & Marchetti, M. (2007). The telecom industry and context awareness. In *Proc. of the international conference on the management of mobile business* (pp. 35–41).
3. Fritsch, L., & Scherner, T. (2005). A multilaterally secure, privacy-friendly location-based service for disaster management and civil protection. In *LNCS: Vol. 3421* (pp. 1130–1137). Berlin: Springer.
4. Koutsiouris, V., Polychronopoulos, C., & Vrechopoulos, A. (2007). Developing 3G location based services: The case of an innovative entertainment guide application. In *Proc. of the international conference on the management of mobile business*. doi:10.1109/ICMB.2007.26.
5. Heinonen, K., & Pura, M. (2006). Classifying mobile services. *Sprouts: Working Papers on Information Systems, 6*(42). http://sprouts.aisnet.org/6-42/ (accessed July 1, 2010).
6. Tsalgatidou, A., Veijalainen, J., Markkula, J., Katasonov, A., & Hadjiefthymiades, S. (2003). Mobile e-commerce, & location-based services: technology and requirements. In *Proc. of the Scandinavian research conference on geographical information sciences*. doi:10.1.1.75.6119.pdf.
7. Raper, J., Gartner, G., Karimi, H., & Rizos, C. (2007). A critical evaluation of location based services and their potential. *Journal of Location Based Services*, *1*(1), 5–45.
8. Rao, B., & Minakakis, L. (2003). Evolution of mobile location-based services. *Communications of the ACM*, *46*(12), 61–65.
9. Seeman, E., O'Hara, M., Holloway, J., & Forst, A. (2007). The impact of government intervention on technology adoption and diffusion: the example of wireless location technology. *Electronic Government*, *4*(1), 1–19.
10. Shiode, N., Li, C., Batty, M., Longley, P., & Maguire, D. (2002). *The impact and penetration of location-based services*. CASA Working Paper 50. http://www.casa.ucl.ac.uk/working_papers/paper50.pdf (accessed June 23, 2010).
11. Virrantaus, K., Markkula, J., Garmash, A., Terziyan, V., Veijalainen, J., Katanosov, A. et al. (2001). Developing GIS-supported location-based services. In *Proc. of the international conference on Web information systems engineering* (Vol. 2, pp. 66–75).
12. Petrova, K. (2005). A study of the adoption of mobile commerce applications and of emerging viable business models. In *Proc. of the international conference of the information resources management association* (pp. 1133–1135).
13. Unni, R., & Harrmon, R. (2003). Location-based services: models for strategy development in M-commerce. In *Proc. of the Portland international conference on management of engineering and technology* (pp. 416–424).
14. Giaglis, G. M., Kourouthanassis, P., & Tsamakos, A. (2003). Towards a classification framework for mobile location services. In B. E. Mennecke & T. J. Strander (Eds.), *Mobile commerce: technology, theory and applications* (pp. 67–85). Hershey: IGI Publishing.
15. Yunos, H. M., & Gao, J. (2003). Wireless advertising. http://www.engr.sjsu.edu/gaojerry/report/wireless-add-paper2.pdf (accessed July 1, 2009).
16. Zeimpekis, V., Giaglis, G. M., & Lekakos, G. (2003). A taxonomy of indoor and outdoor positioning techniques for mobile location services. *ACM SIGecom Exchanges*, *3*(4), 9–27.
17. Katasonov, A., & Sakkinen, M. (2005). Content quality in location-based services: a case study. In *Proc. of the IEEE international conference on pervasive services* (pp. 461–464).
18. May, A., Bayer, S. H., & Ross, T. (2007). A survey of 'young social' and 'professional' users of location-based services in the UK. *Journal of Location Based Services*, *1*(2), 112–132.
19. Paay, J., & Kjeldskov, J. (2008). Understanding the user experience of location-based services: Five principles of perceptual organisation applied. *Journal of Location Based Services*, *2*(4), 267–286.

20. Mohapatra, D., & Suma, S. B. (2005). Survey of location based wireless services. In *Proc. of the IEEE international conference on personal wireless communications* (pp. 358–362).
21. Clarke, I. (2001). Emerging value propositions for m-commerce. *Journal of Business Strategies*, *18*(2), 133–149.
22. Chang, S. E., Hsieh, Y.-J., Lee, T.-R., Liao, C.-K., & Wang, S.-T. (2007). A user study on the adoption of location based services. In K. C. Chang et al. (Eds.), *LNCS: Vol. 4537* (pp. 276–286). Berlin: Springer.
23. Shiow-Yang, W., & Kun-Ta, W. (2006). Effective location based services with dynamic data management in mobile environments. *Wireless Networks*, *12*(3), 369–381.
24. Yates, D., Lee, K. M., & El Sawy, O. (2006). Leveraging presence in the design of mobile services: Challenges, opportunities, and value creation. *Sprouts: Working Papers on Information Systems, 6* (54). http://sprouts.aisnet.org/6-54 (accessed July 1, 2010).
25. Jorns, O., Quirchmayr, G., & Jung, O. (2007). A privacy enhancing mechanism based on pseudonyms for identity protection in location-based services. In *Proc. of the Australasian symposium on ACSW frontiers* (Vol. 3421, pp. 133–142).
26. Nouwt, S. (2008). Reasonable expectations of geo-privacy? *SCRIPTed*, *5*(2), 375–403.
27. Patrikakis, C., Voulodimos, A., & Giannoulis, G. (2009). Personalized location based services with respect to privacy: A user oriented approach. In *Proc. of the international conference on pervasive technologies related to assistive environments*. Article No 75. doi:10.1145/1579114.1579189.
28. Adusei, I. K., Kyamakya, K., & Erbas, F. (2004). Location-based services: advances and challenges. *Electrical & Computer Engineering*, *1*(35), 1–7.
29. Dao, D., Rizos, C., & Wang, J. (2002). Location-based services: technical and business issues. University of New South Wales. http://www.gmat.unsw.edu.au/snap/publications/dao_etal2002a.pdf (accessed April 5, 2010).
30. Perusco, L., & Michael, K. (2007). Control, trust, privacy, and security: evaluating location-based services. *IEEE Technology and Society Magazine*, *26*(1), 4–16.
31. Jarvenpaa, S., & Lang, K. (2005). Managing the paradoxes of mobile technology. *Information Systems Management*, *22*(4), 7–23.
32. Junglas, I. (2005). An experimental investigation of location-based services. In *Proc. of the Hawaii international conference on systems sciences*. doi:10.1109/HICSS.2005.90.
33. Benford, S. (2005). Future location-based experiences. JISC Technology and Standards Watch. http://www.pervasive.jku.at/download/future%20location-based%20experiences.pdf (accessed September 5, 2009).
34. Chincholle, D., Goldstein, M., Nyberg, M., & Eriksson, M. (2002). Lost or found? A usability evaluation of a mobile navigation and location-based service. In F. Paterno (Ed.), *LNCS: Vol. 2411* (pp. 211–224). Berlin: Springer.
35. In-Stat. (2004). Business demand for location-based services-Executive summary. http://www.instat.com/panels/pdf/2004/2004_june_location.pdf (accessed September 18, 2009).
36. Kaasinen, E. (2003). User needs for location-aware mobile services. *Personal Ubiquitous Computing*, *7*(1), 70–79.
37. Kam, M., Tibuzzi, A., & Hua, X. (2004). Location-based services for low-income communities in the California Central Valley. In *Proc. of Berkeley EECS annual research symposium*. http://www.eecs.berkeley.edu/BEARS/2004/STARS/final/kam.pdf (accessed July 5, 2010).
38. Osman, Z., Maguire, M., & Tarkiainen, M. (2003). Older users' requirements for location based services and mobile phones. In L. Chitaro (Ed.), *LNCS: Vol. 2795* (pp. 352–357). Berlin: Springer.
39. PricewaterhouseCoopers (2006). Enterprise mobility-understanding what the workforce wants in the new converged. http://www.pwc.com/extweb/pwcpublications.nsf/docid/820bdc03064bfd01852573d0005686c1 (accessed January 18, 2010).
40. Schmidt-Belz, B., Laamanen, H., Poslad, S., & Zipf, A. (2003). Location-based mobile tourist services-first user experiences. In *Proc. of the international conference on tourism and communication technologies* (pp. 115–123). doi:10.1.1.11.5956.
41. Zipf, A., & Jöst, M. (2003). User expectations and preferences regarding location bases services – results of a survey. In *Proc. of the symposium on location based services and telecartography* (pp. 63–68). http://www.i3mainz.fh-mainz.de/publicat/zipf04/telecarto2004_userEval_az-mj.pdf (accessed July 15, 2010).
42. Akesson, M. (2007). Value proposition in m-commerce: Exploring service provider and user perceptions. In *Proc. of the L. A. global mobility round table*. https://dspace.hh.se/dspace/bitstream/2082/2609/2/akesson.pdf (accessed May 5, 2010).

43. Jessup, L., & Robey, D. (2002). The relevance of social issues in ubiquitous computing environments. *Communications of the ACM*, *45*(12), 88–91.
44. Burghardt, T., Buchmann, E., Müller, J., & Böhm, K. (2009). Understanding user preferences and awareness: privacy mechanisms in location-based services. In R. Meernan, T. Dillon, & P. Herrero (Eds.), *LNCS: Vol. 5870* (pp. 304–321). Berlin: Springer.
45. Krug, K., Abderhalden, W., & Haller, R. (2003). User needs for location-based services in protected areas: case study Swiss national park. *Information Technology & Tourism*, *5*(4), 235–242.
46. Benbasat, I., Goldstein, D. K., & Mead, M. (1987). The case research strategy in studies of information systems. *MIS Quarterly*, *11*(3), 369–386.
47. Ackerman, L., Kempf, J., & Miki, T. (2003). Wireless location privacy: A report on law and policy in the United States, the European Union, and Japan. DoCoMo USA Labs. http://www.docomolabs-usa.com/pdf/dcl-tr2003-001.pdf (accessed May 9, 2010).
48. Henten, A., Olesen, H., Saugstrup, D., & Tan, S.-E. (2004). New mobile systems and services in Europe, Japan and South Korea. *INFO*, *6*(4), 197–207.
49. Lee, Y., Kim, J., Lee, I., & Kim, H. (2002). A cross cultural study of the value structure of mobile internet usage: Comparison between Korea and Japan. *Journal of Electronic Commerce Research*, *3*(4), 227–239.
50. GSM Association (2007). GSM facts and figures. http://www.smworld.com/about/index.shtml (accessed March 1, 2009).
51. Aloudat, A., Michael, K., & Yan, L. (2007). Location-based services in emergency management—from government to citizens: Global case studies. In P. Mendis, P. Lai, E. Dawson, & H. Abas (Eds.), *Recent advances in security technology* (pp. 190–201). Melbourne: Australia Homeland Security Research Centre.
52. OECD (2009). OECD Broadband Statistics. http://oecd.org/sti/ict/broadband/ (accessed October 10, 2009).
53. Federal Communications Commission (2001). FCC acts on wireless carrier and public safety requests regarding enhanced wireless 911 services. http://www.fcc.gov/bureaus/wireless/news_releases/2001/nrwl0127.html (accessed January 29, 2010).
54. Wilde, G., Saunders, J., Melcher, J., Sage, A., Curry, G., & Jones, D. (2004). E-112 issues and answers - recommendations and insight for the optimal planning and implementation of E-112, emergency wireless location for the European Union. *TruePosition*. http://www.trueposition.com/e112_issues_and_answers.pdf (accessed May 14, 2010).
55. Maxon, T. (2009). Cell phone companies add tracking abilities. *FSView*. http://media.www.fsunews.com/media/storage/paper920/news/2005/07/25/Lifestyles/cell-phone.companies.add.tracking.abilities-2355874.shtml (accessed November 12, 2008).
56. Verizon (2007). Enhanced 911. http://www.verizonwireless.com/b2c/aboutus/wirelessissues/enhanced911.jsp?market=all (accessed October 30, 2008).
57. In-Stat. (2006). Wireless location services for businesses could top 1 million subscribers by 2010. http://www.instat.com/press.asp?ID=1630&sku=IN0602898MBM (accessed March 15, 2010).
58. Barkuus, L., & Dey, A. (2003). Location-based services for mobile telephony: A study of users' privacy concerns. In *Proc. of the IFIP TC13 international conference on human-computer interaction* (pp. 702–712).
59. European Commission (2003). Recommendation 2003/558/EC. http://eur-lex.europa.eu/LexUriServ/site/en/oj/2003/l_189/l_18920030729en00490051.pdf (accessed January 28, 2010).
60. Veijalainen, J. (2006). Mobile commerce regulatory frameworks under digital convergence. *Sprouts: Working Papers on Information Systems, 6*(55). http://sprouts.aisnet.org/6-55 (accessed July 1, 2010).
61. van Loenen, B., & Zevenbergen, J. A. (2007). The impact of the European privacy regime on location technology development. *Journal of Location Based Services*, *1*(3), 165–178.
62. Berg Insight (2006). Mobile location-based services revenues will reach 622 million in Europe by 2010. http://www.lbszone.com/index2.php?option=com_content&do_pdf=1&id=127410 (accessed October 12, 2009).
63. Carlsson, C., & Walden, P. (2008). Reliving the history of Bomarsund with a mobile value service. In *Proc. of the global mobility round table* (paper 15). http://www.code.auckland.ac.nz/comwebcontent/pages/UserFiles/File/documents/2008/08062%20GMR%20programme%20pages.pdf (accessed July 1, 2010).
64. Rainio, A. (2001). Location-based services and personal navigation in mobile information society. In *Proc. of the annual working week of the international federation of surveyors*. http://www.fig.net/pub/proceedings/korea/full-papers/pdf/plenary1/rainio.pdf (accessed July 3, 2010).

65. Mallenius, S., Rossi, M., & Tuunainen, V. K. (2007). Factors affecting the adoption and use of mobile devices by elderly people-results form a pilot study. In *Proc. of the L. A. global mobility round table*. doi:10.1.1.130.2463.pdf.
66. Hunaiti, Z., Almasri, S., Sedoyeka, E., Matar, N., & Fenton, A. (2008). Location based guided tour m-learning. *IEEE Multidisciplinary Engineering Education Magazine*, *3*(4), 163–167.
67. Bayer, S., Ross, T., & May, A. (2004). The requirements for location-based services: differences between target user groups. In *Proc. of the wireless world conference on managing wireless communications*. Gilford: Digital World Research Centre, University of Guildford. https://dspace.lboro.ac.uk/dspace-jspui/handle/2134/901 (accessed July 1, 2010).
68. de Vos, H., Haaker, T., Teerling, M., & Kleijnen, M. (2008). Consumer value of context aware and location based mobile services. In *Proc. of the Bled conference on eCollaboration: overcoming boundaries through multi-channel interaction* (pp. 50–62). http://www.bledconference.org/proceedings.nsf/0/a9dd7db01cb70634c1257481003cba07/$FILE/05deVos.pdf (accessed July 1, 2010).
69. Ministry of Internal Affairs and Communications (2007, May 25). Emergency location reporting system: providing location information in emergencies using mobile telephones. *MIC Communication News, 18*(3).
70. Srivastava, L., & Kodate, A. (2004). Shaping the future mobile information society: the case of Japan. In *Proc. of the ITU/MIC workshop on shaping the future mobile information society*. http://www.itu.int/osg/spu/ni/futuremobile/general/casestudies/koreacase-rv22.doc.pdf (accessed July 23, 2010).
71. Kamil, A. G., & Ellen, K. (2003). Towards a mobile multimedia age – location-based services: a case study. *Wireless Personal Communications*, *26*(2/3), 105–116.
72. Shiode, N. (2004). Digitally united? A case study on the penetration of wireless and ubiquitous information technologies in Japan. In *Proc. of the winter international symposium on information and communication technologies* (pp. 1–6). Dublin: Trinity College.
73. Kitayama, D., Teratmi, T., & Sumiya, K. (2008). Digital map restructuring method based on implicit intentions extracted from users' operations. In *Proc. of the international conference on ubiquitous information management and communications* (pp. 43–53). doi:10.1145/1352793.1352804.
74. Kaji, H., & Arikawa, M. (2008). Personal location based services on place-enhanced blog. In *Proc. of the ACM international conference on multimedia* (pp. 917–920). doi:10.1145/1459359.1459521.
75. Lei, Y., & Hui, L. (2006). Which one should be chosen for the mobile geographic Information service now, WAP vs. i-mode vs. J2ME? *Mobile Networks and Applications*, *1*(6), 901–915.
76. DTI (2004). Future mobile technology: Lessons from China and Korea. Mobile VCE. http://www.mobilevce.com/dloads-publ/FutureMobileTechnologyReport.pdf (accessed 5 December 5, 2009).
77. Reynolds, T., Kelly, T., & Jin-Kyu, J. (2005). Ubiquitous network societies: the case of the Republic of Korea. In *Proc. of the ITU workshop on ubiquitous network societies*, doc. UNS/08. http://www.itu.int/osg/spu/ni/ubiquitous/Presentations/2_kelly_korea.pdf (accessed July 12, 2010).
78. Kim, C. D. (2005). Privacy issue in telematics - LBS law. TU-T & ISO workshop on ICT in vehicles (the fully networked car workshop). http://www.itu.int/ITU-T/worksem/ict-auto/200503/presentations/s2-kim.pdf (accessed May 10, 2010).
79. Qualcomm (2007). Korean NEMA. http://www.qualcomm.com/news/partners/media/PDF/Korean%20NEMA_v2.pdf (accessed October 16, 2009).
80. Pyo, J., Hyun, M., Jeon, J., Jung, H., & Kim, J. (2004). Assisted GPS navigation system for aftermarket telematics system. In *Proc. of the Sydney international symposium on GNSS/GPS*. http://www.gmat.unsw.edu.au/gnss2004unsw/PYO,%20Jong%20Sun%20P170.pdf (accessed July 3, 2010).
81. Ha, T. J. (2006, Sept–Oct). Mobile convergence in South Korea: a paradigm shift calling for new strategies. *Asia-Pacific Monitor* (pp. 31–77).
82. Hwang, J.-S. (2005). Recent development of wireless broadband technology in South Korea. MIT Communications Futures Program. http://cfp.mit.edu/events/jan05/presentations/Korea-WiBro-MIT.pdf (accessed October 5, 2009).
83. inCode (2005). *The next step for location based services*. http://www.incodewireless.com/media/whitepapers/2005/WP_TheNextStepForLBS-Feb.pdf (accessed March 5, 2010).
84. Lau, T. Y., Kim, S. W., & Atkin, D. (2005). An examination of factors contributing to South Korea's global leadership in broadband adoption. *Telematics and Informatics*, *22*(4), 349–359.
85. Cho, Y. C. (2008). Assessing user attitudes towards mobile commerce in the U.S. vs. Korea: implications for m-commerce CRM. *Journal of Business and Economics Research*, *6*(2), 91–99.

86. ConsumerEase. (2006). South Korean mobile data white paper. http://www.5myths.com/publishing/whitepapers/skorea/all.aspx (accessed April 10, 2010).
87. Budde (2006). 2007 mobile and broadband in New Zealand. http://www.budde.com.au/publications/annual/new-zealand-south-pacific/new-zealand-mobile-and-broadband-summary.html (accessed October 10, 2009).
88. Vodafone, N. Z. (2007). Undertaking to the commerce commission under Schedule 3A in respect of national roaming and co-location services. http://www.comcom.govt.nz/industryregulation/telecommunications/investigations/contentfiles/documents/vodafone%20national%20roaming%20%20colocation%20amended%20undertaking.pdf (accessed March 13, 2010).
89. Telecom, N. Z. (2009). XT Network. http://www.telecom.co.nz/mobile/xt (accessed September 1, 2010).
90. Cappel, L. (2005). NZ in mobile map attack. *iStart*. http://www.istart.co.nz/index/hm20/pc0/pvc197/ex245/ar27413 (accessed March 06, 2010).
91. Mrhawk (2007). Your own GPS tracking services. http://mrhawk.co.nz/ (accessed October 6, 2009).
92. Telecom NZ (2007). Solutions for your mobile sales and service teams. http://www.telecom.co.nz/content/0,8748,204599-202888,00.html (accessed November 14, 2009).
93. Berger, S., Lehmann, H., & Lehner, F. (2003). Location-based services in the tourist industry. *Information Technology and Tourism*, *5*(4), 243–256.
94. Hinze, A., & Buchanan, G. (2005). Context-awareness in mobile tourist information systems: challenges for user interaction. In *Proc. of the workshop on context in mobile HCI held in conjunction with the international conference on human-computer interaction with mobile devices and services* (pp. 257–266).
95. Hinze, A., & Osborne, W. (2007). Location-based indexing for mobile context-aware access to a digital library. *Computing and Mathematical Sciences Papers*. http://hdl.handle.net/10289/99 (accessed July 10, 2010).
96. Leung, C. (2006). The perceived value of location-based services in New Zealand tourism. http://clara.orconhosting.net.nz/claraleung-LBS-tourism.pdf (accessed October 23, 2009).
97. Parsons, D. (2005). Implementing a map based simulator for the location API for J2ME. *Research Letters in the Information and Mathematical Sciences*, *7*, 157–160.
98. Mbira, F., & Symonds, J. (2008). Exploring the location-based service requirements of tourists visiting Wiaheke Island, New Zealand. In *Proc. of the global mobility roundtable (paper 4)*. http://www.code.auckland.ac.nz/comwebcontent/pages/UserFiles/File/documents/2008/08062%20GMR%20programme%20pages.pdf (accessed July 1, 2010).
99. Scornavacca, E., & Herera, F. (2007). Unveiling the strategic value of mobile technologies in the New Zealand real-estate industry. In *Proc. of the international conference on the management of mobile business* (p. 40). doi:10.1109/ICMB.2007.71.
100. Pauleen, D., & Harmer, B. (2007). How emerging technologies change the way New Zealanders work and live: research in progress. In *Proc. of the Pacific Asia conference on information systems (paper 137)* (pp. 25–31). http://aisel.aisnet.org/pacis2007/137/ (accessed July 1, 2010).
101. Peppard, J., & Rylander, A. (2006). From value chain to value network: insights for mobile operators. *European Management Journal*, *24*(2–3), 28–141.
102. Lonthoff, J., & Ortner, E. (2007). Mobile location-based gaming as driver for location-based services (LBS) – exemplified by mobile hunters. *Informatica*, *31*, 183–190.
103. Tan, Q., Kinshuk Kuo, Y.-H., Jeng, Y.-L., Wu, P.-H., Huang, Y.-M. et al. (2009). Location-based adaptive mobile learning research framework and topics. In *Proc. of the international conference on computational science and engineering* (pp. 140–147). doi:10.1109/CSE.2009.96.
104. Ragia, L., & Deriaz, M. (2006). Location based services for traffic management. ASG Technical Report. http://asg.unige.ch/publications/TR07/04LBSforTrafficMgt.pdf (accessed July 2, 2010).
105. Ministry of Tourism (2007). The tourism industry. http://www.tourism.govt.nz/quicklinks/ql-tourismindustry.html (accessed 30 May 2009).
106. Statistics New, Zealand (2006). Tourism satellite account 2005. http://www.tourismresearch.govt.nz/NR/rdonlyres/3c4584e3-7abd-42ca-bf70-25b1c4f5d341/19440/tsa2006.pdf (accessed October 24, 2009).
107. Petrova, K., & MacDonell, S. G. (2010). Mobile services and applications: towards a balanced adoption model. In *Proc. of the international conference on mobile ubiquitous computing, systems, services and technologies* (pp. TBA).
108. Petrova, K., & Wang, B. (2008). In *Proc. of the annual conference of the new Zealand national advisory committee on computing qualifications* (pp. 95–100).

Krassie Petrova is a Senior research Lecturer in Information Systems and Technology at the School of Computing and Mathematical Sciences at the Auckland University of Technology in Auckland, New Zealand. She received her M.S. in Computer Science from the University of Sofia and is currently a PhD candidate at the Auckland University of Technology in Auckland, New Zealand. She teaches postgraduate courses in information security and contemporary networking technologies, and undergraduate courses in eCommerce and electronic transactions. Krassie has over 80 peer reviewed publications including articles in *International Journal of Mobile Learning and Organization*, *International Journal of Innovation and Learning*, *International Journal of Information and Communication Technologies Education*, *International Journal of e-Services and Mobile Applications*, *International Journal of Education and Development using Information and Communication Technology*, and *Journal of Information Systems Education*. Her research areas include mobile applications adoption (mobile banking, mobile gaming, mobile learning, mobile payment systems, mobile government), eLearning, and IS/IT education, curriculum development, and student skills and capabilities building. Ms Petrova's current research is focused on developing models for mobile service adoption and approaches towards mobile artefact evaluation, and investigating the role of mobile service enablers such mobile payment, location-based services, and the mobile Internet in mobile service adoption. She contributes to the international research and academic community as a journal reviewer, editorial board and conference programme committee member, and associate editor of BACIT (The New Zealand Bulletin of Applied Computing and IT).

Bin Wang received his Bachelor's degree in Engineering from China and Master's Degree in Information and Computer Sciences from the Auckland University of Technology (Auckland, New Zealand). He has cross-industrial experience in IT support and management and is currently engaged in an IT engineering role. His research areas include wireless networks and network security.