Cogito Ergo Mobilis Sum: The Impact of Location-based Services on Our Mobile Lives

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INTRODUCTION

Over the most recent decades most of the world's civilization has turned into a *mobile information society*. Increased mobility has impacted various areas, such as travel and tourism, communication, social behavior, and the environment. Mobile persons have to face and solve novel spatiotemporal problems, such as during navigation or multimodal trip planning. Finding one's way from the airport to a hotel in an unfamiliar city is not trivial and requires a number of decisions to be made on the spot (Rüetschi and Timpf, 2005; Winter et al., 2001): Do I take the bus, train, or taxi into the city? Where do I buy my tickets? Where and when do I change to the subway? Which train and direction do I take? Where do I exit the subway station?

Location-based services (LBS) support users during their mobile decision making. They are information services that are sensitive to the location of a mobile user and relate their location to the surrounding environment, which in turn provides location-based information to facilitate the successful completion of spatiotemporal tasks. For example, LBS inform clients about the locations of nearby hotels, restaurants, and cultural sites; they support users of public transport systems; and they help people to locate nearby friends. They also affect society as a whole through their capabilities for tracking people's behavior in space and time, location-based social networking, or potential privacy invasion.

LBS emerged in part due to a general shift in geographic information science (GIScience) from *Big GIS* to *Small GI* (Frank, 1999). In the past, geographic information systems (GIS) were mainly used by large organizations, such as public utility companies, regional planning offices, and highway departments, to support them in their decision-making processes. These organizations collected the necessary data, managed them in their own databases, and produced reports and maps for various internal uses. Nowadays, different providers offer services for geospatial problem solving and by that means sell geographic information (GI) to many users in small quantities. Although the search for a “killer application” is ongoing, the use of LBS in various application areas has risen dramatically over the years and in the longer term, many expect the technology to impact our lives in unpredictable ways, similar to the initial development of the Internet (Jensen et al., 2002; Turner and Forrest, 2008). Based on the multidisciplinary nature of location-based services – involving GIScience, the cognitive sciences, computer science, and the social sciences –, research in these fields will contribute to achieving the highest objective for location-based services, namely improving their utility to help people in making good decisions in their mobile everyday lives (Raper et al., 2007b). Personalization of services is thereby a critical factor.

This chapter continues with an overview of location-based services and mobile decision making. I discuss aspects of personalization, briefly describe some technical issues such as positioning, and identify LBS applications. The third section identifies core domains of LBS that strongly relate to GIS and Society research. I focus on traditional application areas, where LBS can have positive impacts, for example, navigation and emergency services, and discuss innovative ideas on mobile social networking and social positioning. In addition, critical issues regarding privacy and security, and their potential dangers and consequences are highlighted. In order to demonstrate how LBS can impact our daily lives, the fourth section introduces a specific location-based decision service (LBDS), the *HotelFinder*. This novel application shows how users can be supported in their mobile decision making. The chapter ends with conclusions and directions for further research.

LOCATION-BASED SERVICES

Progress in the areas of geospatial technologies and wireless communication in recent years has led to the development of information services that are sensitive to the location of a mobile user. These services, LBS or more specifically *mobile location-based services* (mLBS), have been defined as “the delivery of data and information services where the content of those services is customized to the current or some projected location and context of the user” (Brimicombe and Li, 2006: 7). It is important to emphasize that such content may include information on how, when, and with whom an activity can be performed, in addition to where. LBS therefore deliver applications to a mobile terminal, such as a mobile phone or personal digital assistant (PDA), by exploiting geospatial information about a user’s surrounding environment, their proximity, and distance to other entities in space (Urquhart et al., 2004). This facilitates the successful completion of spatiotemporal tasks such as navigation (Winter et al., 2001).

Tremendous benefits may be achieved from the widespread adoption of these services, providing large segments of the population real-time decision support for purposes ranging from trivial (wayfinding and friend-finder services) to critical (emergency response). LBS also have great potential to serve as tools for collecting disaggregate activity-travel data from users, providing researchers and planners detailed information with regard to spatiotemporal patterns of interaction in urban environments (Ahas and Mark, 2005; Miller, 2005). However, while current services often provide multiple thematic layers to choose from, such as points-of-interests (POIs), restaurants, or bus stations, they still assist the user’s decision making based on a small number of constraints – typically only distance and one additional thematic attribute.

Mobile decision making and personalization

There is still little knowledge about how *mobile* location-based decision making is different from generic decision making (Raper et al., 2007b). General decision theory covers a wide range of models with different foci on describing how decisions could or should be made and on specifying decisions that are made (Golledge and Stimson, 1997). It has been found that human decision making is not strictly optimizing in an economical and mathematical sense (Simon, 1955), such as proposed by the algorithms of classical decision-making theories, therefore behavioral decision theory has been emphasized in the cognitive literature. In order to investigate whether principles of generic decision making can be transferred to mobile decision making and find potential differences, researchers have developed tools to study the interaction between environments, individuals, and mobile devices. Most case studies focus on pedestrian navigation in various settings, such as urban environments (Li and Longley, 2006) – see also (Raper et al., 2007b) for an overview. Raubal et al. (2004) proposed a user-centered theory of LBS, which specifically focuses on individuals' mobile decision making. It integrates spatial, temporal, social (using affordances), and cognitive (using decision-making theory) aspects of a LBS.

Recent research activities have focused on aspects of *personalization* – the customization and adaptation of LBS to their users. This trend to highly specialized geospatial services has been intensified by people's increased need to acquire and use spatial information. In today's world of vast mobility and change we frequently face new situations in unfamiliar environments, such as finding one's way in an unfamiliar city or airport. Personalized LBS can only be achieved by considering various dimensions of context, which includes more than location (Schmidt et al., 1999). People's information needs depend highly on temporal, situational, and personal context, such as time of day, the physical and social environment they are situated in, and their preferences, abilities, activities, and knowledge (Reichenbacher, 2007). For example, when looking for a place to stay overnight a business traveler has fewer constraints due to price, and at the same time higher demands with respect to the quality of accommodation, than a low-budget traveler. Disabled people require different route instructions from a navigation service than other wayfinders. Several researchers in the area of cartography and geovisualization have stressed the need for mobile map adaptation (Reichenbacher, 2005; Sarjakoski and Sarjakoski, 2008) and the utilization of multimedia presentations for mobile mapping (Dransch, 2007). Recently, Raubal and Panov (2009) proposed a formal model for mobile map adaptation that can be employed for different LBS applications.

Architectures and positioning

LBS are imbedded within complex technical infrastructures, including positioning infrastructures, application servers, and handheld location-aware devices (Küpper, 2005). Their technological place lies at the intersection of GIS, the Internet, and new information and communication technologies (NICTs) (Brimicombe and Li, 2009). The recently evolving *geospatial web*, "an interconnected, online digital network of discoverable geospatial documents, databases, and services" (Turner and Forrest, 2008: 2), provides a rich foundation for LBS. A user situated in the real world may access information through a variety of NICTs such as 3G phones. Queries and responses are communicated to and from a server with GIS software through a wireless network. The server in turn has access to additional services and databases, including the World Wide Web, which facilitates answering a particular query.

Position determination is crucial and the requirement by the US Federal Communications Commission that all cellular carriers must identify the position of a 911 caller (Wireless Communications and Public Safety Act 1999)[1] was in fact one of the main drivers of LBS (the European version was established in 2003 through the EU Directive E112).[2] Positioning of mobile devices works either *actively*, that is, the device can recognize its current position such as through a GPS (global positioning system) receiver (Leick, 2003), or *passively*, that is, the position is accessed over a network connection such as the mobile phone network. A disadvantage of GPS is that it does not work well or not at all in dense urban and indoor environments. Other technologies, such as infrared sensors, RFID (Radio Frequency Identification), or Wi-Fi technology can be utilized for indoor positioning. The most important methods for network-dependent outdoor positioning include Cell-ID, Time of Arrival (TOA), and Observed Time Difference (OTD). Detailed information about local positioning systems can be found in (Kolodziej and Hjelm, 2006).

Applications

LBS applications can be classified into business-to-consumer (B2C) and business-to-business (B2B). The various types of services are utilized by individuals, businesses, and governments to facilitate their spatial and temporal decision making. Two core questions of individual users are "where am I?" and "where is a certain object?," for example, when trying to find the nearest Italian restaurant or gas station. Once such an object is found, a LBS supports the user in getting there through guided route instructions. Businesses can make use of LBS through targeted advertising or finding optimal delivery routes for shipping goods based on customers' locations and traffic conditions. Typical application areas for administrations and government are local commerce, emergency dispatch, and asset management (Francica, 2008). A comprehensive overview of LBS applications is given by (Raper et al., 2007a).

LOCATION-BASED SERVICES AND SOCIETY

This section identifies areas where location-based services impact individuals, organizations, and our society as a whole. The domains in which these areas fall are widespread and affect different aspects of our daily lives, some of them trivial, others critical. The spaces in which LBS are used are based on complex interactions between physical, social, and cultural aspects, and it is therefore important to account for these when looking at the encounters between people and location-based technology (Dourish and Bell, 2007). Although there are potential dangers that must not be ignored, LBS have a vast potential to improve our decision making in significant ways.

Navigation services and mobile guides

Car navigation systems have been one of the early accomplishments of LBS and their commercial success is still on the rise. Decreasing costs of this technology and the availability of up-to-date street network data have made car navigation systems almost a commodity. The advantages are obvious: support in finding optimal routes for the driver, easy communication through verbal turn-by-turn instructions and maps, and low maintenance. On the downside, it has been argued that the use of such systems results in higher visual and cognitive demands for the driver (Burnett et al., 2004), and that the operation of automatic navigation systems may lead to an overall degradation in spatial knowledge acquisition (Parush et al., 2007).

Navigation services are also available to pedestrians, although the wayfinding behavior of pedestrians is much more complex because they are not bound to a given street network. These services are especially helpful for disabled people because their route instructions can be adapted to the type of disability. For example, route instructions for people in wheelchairs must not include segments with stairways. There is also a large body of literature on navigation systems for the visually impaired (Golledge et al., 1998) and indoor routing algorithms for the blind that can be utilized in wayfinding services have been developed (Swobodzinski and Raubal, 2009).

Over the last decade it has been realized that route instructions from existing navigation services lack cognitive adequacy (Strube, 1991), because they mainly rely on quantitative values, such as “go straight for 1.35 km, then turn left, go 0.76 km, and so on,” instead of providing landmark-based instructions, such as “go straight until you reach the large yellow building, turn right after the building, and so on.” Researchers have therefore investigated methods for the automatic detection of landmarks to be used in wayfinding instructions (Sadeghian and Kantardzic, 2008). Raubal and Winter (2002) addressed the question of how to enrich instructions from a wayfinding service with local landmarks in order to make them compatible with human thinking.

Navigation services are often an integral part of *mobile guides*, currently the largest group of LBS applications. Mobile guides are portable and location-sensitive digital guides that provide a wealth of information about the user’s surroundings (Raper et al., 2007a), therefore replacing traditional guidebooks and paper maps. One of the main advantages is that the data behind digital mobile guides can be easily revised, providing both spatially and temporally up-to-date information to their users. Furthermore, these LBS can be adapted to user preferences and with regard to the visualization of geographic information (Krüger et al., 2007). These features allow for personalized information and interaction, a tremendous improvement over conventional tourist guides or maps. Recent research has focused on the integration of small mobile displays and large static paper maps to get the best of both worlds (Rohs et al., 2007). For example, *Wikeye* (Hecht et al., 2007) is an approach to improve the understanding of places that combines digital Wikipedia content with a paper-based map. When the user views a small portion of a map through the mobile device, Wikipedia-derived content relating to chosen objects is offered. Through its extension *WikEar* (Schöning et al., 2008), this content is automatically organized according to principles derived from narrative theory and creates an educational audio tour starting and ending at stationary city maps (Figure 9.1).

Location-based transportation and emergency services

The use of location-based transportation services can have a positive impact on both the environment and the safety of people. They provide more efficient transportation, which

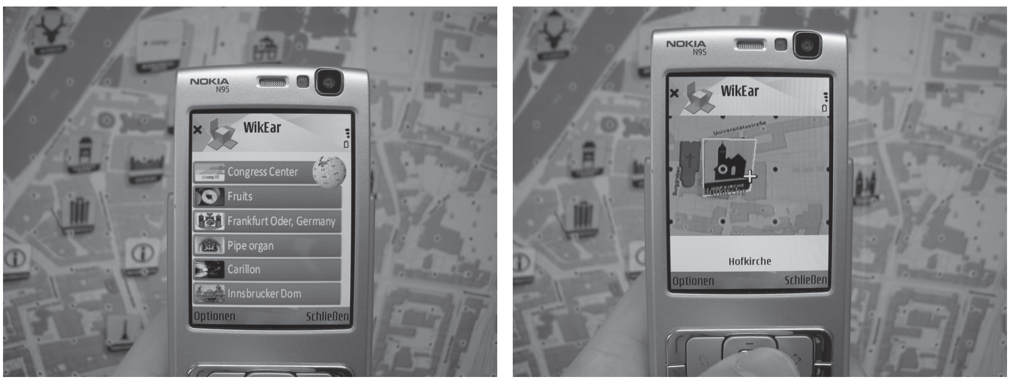

Figure 9.1 WikEar is a novel mobile guide that generates location-based audio tours (by Johannes Schöning, Institute for Geoinformatics, University of Münster, Germany)

in turn leads to less pollution, and location-based information and driver assistance enhance the protection of drivers. Location-based transportation services impact different application levels and people, such as individual car drivers but also businesses that depend on vehicle management (Raper et al., 2007a).

Emergency services are one key application of LBS. As described above, all cellular carriers are required to be able to identify the position of a 911 caller. This automatic position determination and communication technology can save critical time during rescue operations in car accidents, where injured people are unable to report their location. The OnStar[3] system combines a GPS device and wireless communication to provide both emergency response and other services, such as roadside assistance and stolen vehicle tracking. LBS can also contribute to the efficiency of geo-collaborative crisis management through the improvement of effective response operations (Rinner, 2007). An emergency operations center (EOC) can thereby locate and coordinate their emergency crews in the field through GPS. First responder teams use mobile client software to receive updated information and decision-making parameters from the EOC.

Social networking

The deployment of location-aware technologies and wireless networks not only affects people's experience and interaction with computation (Dourish and Bell, 2007) but also their social interaction with others. Location-based social networking is a novel social possibility offered by LBS technology. These services can be used to determine the locations of friends and family members. After subscribing to a service provider, the subscriber receives notification when one of their network members comes within a specified geographic proximity. These are essentially friend-finder services, which visualize the locations of contacts on a mobile map. Such services enable groups of users to spontaneously meet in order to perform common activities such as having dinner together. The selection of a meeting point, as well as a place for the activity, such as a restaurant, requires a group decision process. Current research investigates the integration of multiple criteria decision-making methods (Jankowski, 1995) into LBS with the goal of creating personalized location-based services that support user groups in their everyday decision-making (Espeter and Raubal, 2009).

Parents can utilize such services for the surveillance of their children's mobility. Fotel and Thomsen (2004) relate various parental monitoring strategies to the welfare and socioeconomic structures in the families. They discuss both the positive and negative implications of children's mobility surveillance by cellular phones. One of their conclusions is that the remote control of children's movements has implications on the levels of independence regarding the children's mobility while their actual reach in terms of geographical space may not be affected.

An extension to the functionality of mobile guides was suggested by Baus et al. (2005). Mobile guides could be integrated within a collaborative network, thereby utilizing the possibility of location-based social networking. Users will not only be able to locate their friends but also view their friends' spatiotemporal tracks and recommendations of places. This essentially constitutes an application of the social navigation approach to mobile devices (Höök, 2003; Persson et al., 2003). A currently popular service for social networking is Twitter™,[4] which allows its users to send and receive short text-based updates in real time. It was also used in combination with Google Maps™[5] for some of the 2008 US presidential campaigns to present real-time updates of their ballot access teams across the country.

Social positioning

The availability of people's location data has offered the possibility of automatically tracking people's behavior in space and time. Such deployment of LBS technology creates social, legal, and ethical questions, including privacy and security of the individual as discussed below. The social positioning method (SPM) (Ahas and Mark, 2005; Ahas et al., 2007) integrates the location coordinates of people with their social characteristics in order to study the space–time behavior of society (Mountain and Raper, 2001). It is envisioned that SPM will have a major positive impact on our future society in areas such as planning, marketing, and public participation. The resulting data and their analyses could be used to improve upon existing transportation infrastructures between cities and their suburbs, or to estimate the impact of projects on various social groups and their dynamic spatiotemporal patterns. Figure 9.2 shows a three-dimensional representation of personal activity tracks of a commuter in greater Tallinn, Estonia. SPM has been applied to the study of tourism, resulting in a higher spatial and temporal preciseness than for regular tourism statistics. One of the outcomes of this study was the mapping of typical routes for tourists categorized by their nationalities (Ahas et al., 2008) (see Figure 9.3). In essence, SPM data helps to project people's behavior into the future through simulation and therefore foresee and prevent potential problems arising from such behavior and movement.

Privacy and security

The rapid spread and use of geospatial technologies and LBS has brought up concerns in our society about information privacy and the

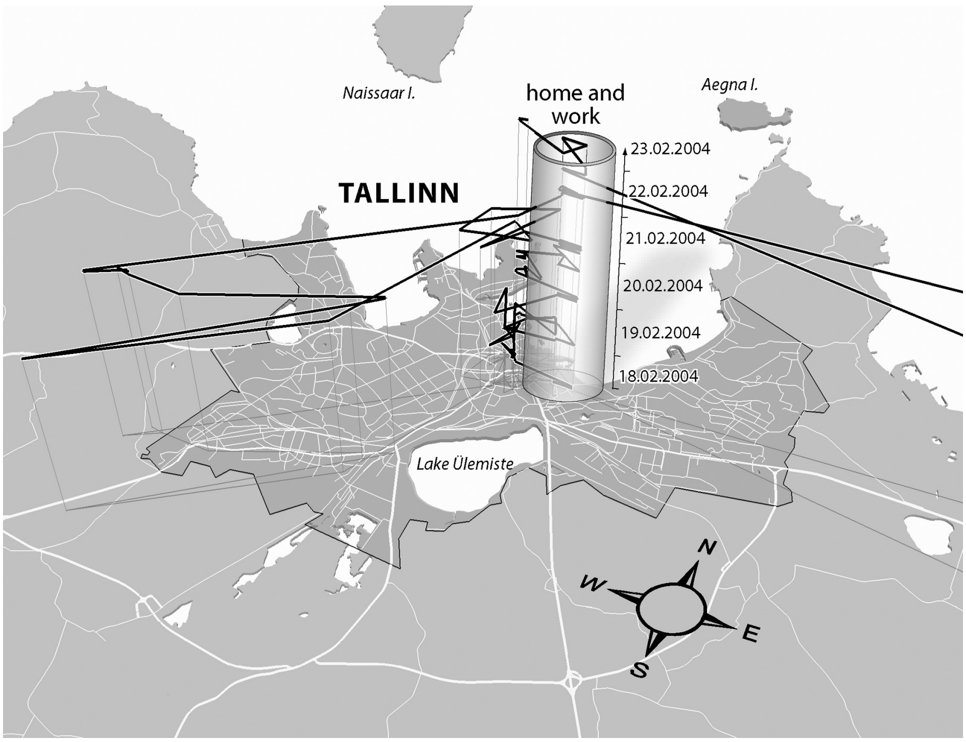

Figure 9.2 3D representation of personal activity tracks of a commuter in greater Tallinn, Estonia (by Raivo Aunap and Rein Ahas, Department of Geography, University of Tartu, Estonia)

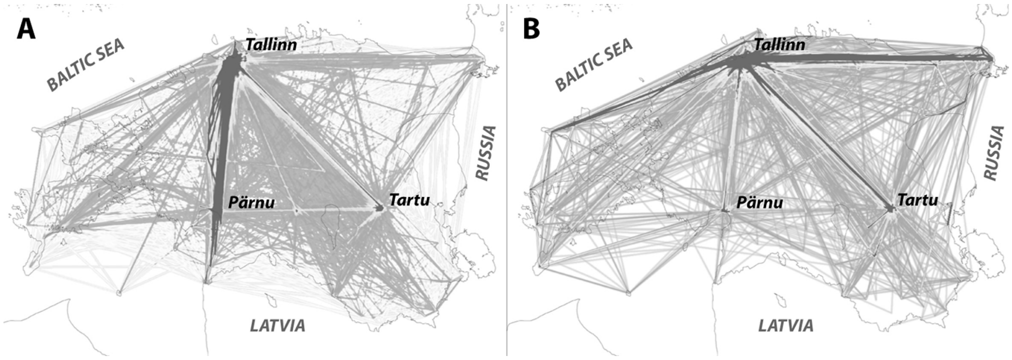

Figure 9.3 Linear movement corridors of Latvians (A) and Russians (B) during holidays in Estonia (by Rein Ahas, Department of Geography, University of Tartu, Estonia)

security of individuals. Virtual globes such as Google Earth™[6] have contributed to these concerns through their high-resolution imagery, which makes it possible to virtually identify individual houses and cars. The main threat is seen to be the capacity for real-time integration of location information and personal data, which in extreme cases may lead to geoslavery. *Geoslavery* has been defined as "a practice in which one entity, the master, coercively or surreptitiously monitors and exerts control over the physical location of another individual, the slave" (Dobson and Fisher, 2003: 47–8). This potential for real-time control is made possible by commercially available human tracking systems and therefore several initiatives have called for laws to regulate and restrict their use. Different forms of surveillance have raised concerns during the recent Beijing Olympics. For example, taxi drivers had devices in their cars, which were linked to the vehicles' navigation systems and allowed a central monitoring station to listen to anything inside the taxi (Magnier, 2008). Blakemore (2005) provides an overview of various issues regarding the use of location-based technologies for surveillance in workplaces.

As is the case with most technology in general, there can be positive and negative uses. For location-based services it is necessary to find the right balance between customer service and privacy invasion. Several studies have investigated these issues and produced valuable results. Barkhuus (2004) has discovered that if LBS are sufficiently attractive to their users and provide adequate protection, then the users are less concerned about privacy issues. In a comprehensive field study in Finland it was found that users show high acceptance and trust towards service providers. There seem to exist strong cultural differences though to what counts as privacy invasion of the individual and therefore extended studies in different countries involving different cultural groups are required to arrive at a more comprehensive picture.

There has been research on technical measures to help provide the user's privacy and safety. Regarding GPS signals, encryption and licensed access are one way to go and have been actively discussed by the European Union in the context of *Galileo*, its global navigation satellite system that is currently under construction. On a larger scale, monitoring of the whole LBS industry may be required to keep LBS from serving unethical purposes (Dobson and Fisher, 2003). Duckham et al. (2006) developed a formal model of spatiotemporal aspects to be employed for safeguarding location privacy. Their "obfuscation" approach tries to minimize the information about a user's location.

The model also includes strategies for third parties to invade the user's location privacy through global and local refinement operators. A survey of other location privacy protection methods can be found in (Duckham and Kulik, 2006).

LOCATION-BASED DECISION SERVICES

Improving user acceptance of LBS in our society depends critically on enhancing their utility in helping people to make good decisions in their mobile everyday lives. One key to achieving this is *personalization*, that is, the personal managing of space and place through user preferences and characteristics. Recent research has focused on the conception and development of mobile *location-based decision services* (LBDS) that provide personalized spatial decision support to their users. These services are based on the integration of multicriteria decision analysis (MCDA) and can therefore provide analytic evaluations of the attractiveness of alternative destinations and choices being offered (Rinner, 2008). This section presents a mobile hotel-finder service to demonstrate how this novel form of LBS can support users in their mobile decision-making.

The *HotelFinder* was developed as a mobile LBDS and integrates MCDA methods, which had been introduced to GIS in the 1990s for applications such as site suitability analysis (Malczewski, 1999). The software features multicriteria decision support for the task of finding suitable hotels in an unfamiliar environment depending on the user's location and preferences. The original application (Raubal and Rinner, 2004) was extended in (Rinner and Raubal, 2004) by integrating the ordered weighted averaging (OWA) decision rule (Yager, 1988). The OWA method allows users to choose a decision strategy as part of their decision-making preferences. This leads to different answers by the LBS depending on people's level of risk-taking. Decision strategies range from "optimistic" (i.e., risk-taking) to "pessimistic" (i.e., cautious), and allow from a full trade-off to no trade-off between the different decision criteria. OWA uses a second set of weights (besides criterion importance weights), namely order weights, to emphasize either high or low standardized criterion outcomes. For example, with a pessimistic strategy, decision makers focus on the lower outcomes of each decision alternative to avoid the risk of selecting an alternative with poor performance in any criterion. In contrast, with the optimistic strategy, decision makers focus on the higher outcomes, thus incurring the risk of accepting an alternative with excellent performances in some criteria but possibly poor performances in other criteria.

The service was tested using profiles for a business traveler, a tourist, and a low-budget tourist. Simulated users run through the steps of an MCDA process that includes determining decision alternatives (hotel destinations), selecting decision criteria (e.g., room rate, checkout time), standardizing the criterion values for all alternatives, determining importance weights for criteria, and using a multi-criteria decision rule to aggregate the weighted standardized criterion values to an evaluation score and rank for each alternative (Rinner and Raubal, 2004). The user interface of the mobile device provides both the functionality for displaying the geographic data as well as a dialog component to elicit the user's input of MCDA parameters. A discussion of user interface design for LBDS can be found in (Rinner et al., 2005). The test cases demonstrated that different users can and should be offered specific choices through their LBS. Figure 9.4 shows the user interface of the original *HotelFinder* application for the city of Münster, Germany (Raubal and Rinner, 2004). Figure 9.5 demonstrates another version for the city of Toronto, Canada, where the map window is provided by map servers such as Google Maps™ or Microsoft® Virtual Earth®.[7] It presents the user standardization and

Figure 9.4 User interface for the Münster HotelFinder
Source: Raubal and Rinner, 2004

weighting of criteria, the selection of a decision strategy, and the presentation of the results with the additional option of calculating the route to the optimal hotel.

The usefulness of the *HotelFinder* was demonstrated through a comprehensive user test showing that MCDA can be employed for optimizing location-based decision processes (Bäumer et al., 2007). The goal of this test was to focus on the benefits and drawbacks of a personalized mobile LBDS. The results confirmed that applying the multicriteria decision strategy enhances people's decision support in unfamiliar environments.

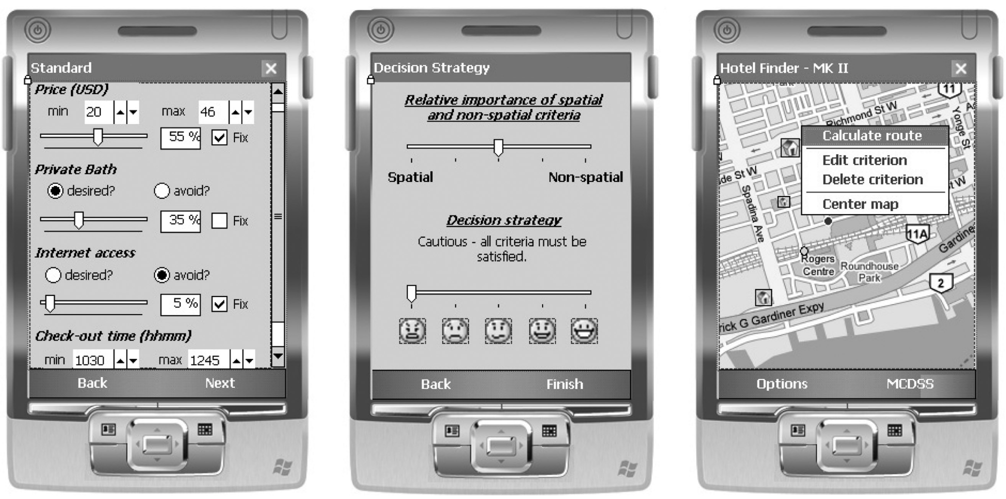

Figure 9.5 User interface for the Toronto HotelFinder

CONCLUSION AND FUTURE TRENDS

LBS have become an integral part in various domains of our lives and therefore impact the decision making of individuals, organizations, and our society as a whole. It is important to realize that although LBS can offer major benefits, there are also large risks to be considered. On the one hand, LBS help people in making good and efficient decisions. Navigation and transportation services, or emergency services provide fine examples. On the other hand, privacy and security issues must not be ignored when engaging in activities, such as mobile social networking and social positioning. Technological development has been moving at an incredibly high speed and nowadays geospatial technologies allow for real-time tracking and monitoring of people. Analyzing this wealth of data helps in modeling the space-time behavior of our society and can in a positive way be utilized to forecast and solve potential future problems. In the worst case though, it may lead to geoslavery.

Further research is needed to arrive at a comprehensive picture of LBS and their effects on our society. Although companies put different LBS on the market day by day, many of these services work inefficiently, are difficult to use, and have the potential to serve unethical purposes. Changes in technology happen so fast that research on critical issues is often lagging behind. In the following, we identify some of the important future research directions.

In order to enhance both the usability and usefulness of LBS, they must be designed by considering principles of human spatial cognition regarding the representation and processing of spatiotemporal aspects of phenomena. One of the goals of applying *spatial cognitive engineering* (Raubal, 2009) methods to LBS is the personalization of geospatial services due to the differences of geographic information users in their cognitive styles, abilities, preferences, and information needs. Research in this area should focus on formal conceptual representations that minimize the gap between system and user, theories of mobile real-time decision making and how it differs from classical decision making, and necessary context parameters to be accounted for by the services depending on the user's background, perspectives, and situation. In addition, continuing research on augmented reality visualization will eventually result in interfaces, where information and objects can be visually referred to in a direct way (Höllerer et al., 2007). A better understanding of these issues will provide the basis for LBS that facilitate mobile human-computer interaction and provide high-quality spatiotemporal decision-making support.

It is a widely accepted estimate that 80 percent of human decisions affect space or are affected by spatial situations (Albaredes, 1992). This number also indicates the future potential of LBS for governments, businesses, and individuals. For Europe it has been forecasted that LBS revenues will grow by 50 percent annually (Berg-Insight, 2006). More research is necessary to develop business models that account for the exact value of location for mobile decision making. Such research has to investigate cost and pricing of geospatial information and how these should be distributed among content providers, information brokers, service providers, and users. The main questions from a user perspective are thereby: What is the value of a particular piece of geoinformation, what improvement in the decision is achieved when this piece of information is available, and how much am I willing to pay for it (Frank, 2008)?

LBS technology nowadays allows for the tracking and monitoring of our spatiotemporal behavior and it is not clear yet what the exact consequences will be in the future in terms of privacy and security issues. Some research has been done but in order to get a more comprehensive picture of the potential dangers and how to counter these, studies have to be conducted over a wider range of domains and geographic space, including diverse social groups and cultures.

Geopositioning in the wired world has become more precise and accurate, therefore paving the way for optimal targeting of people through triggered location services, where users receive advertising messages when they come within a certain distance of a store or business. What are the impacts of such services? Does our society really want or need them? What are the effects of excluding people on the lower socio-economic end who might be left out from these geographies of Wi-Fi infrastructures and use (Torrens, 2008)?

In this chapter I have selectively identified areas where LBS affect individuals, organizations, and our society as a whole. Many more applications are possible and have been in use, such as location-based gaming or the use of tracking and monitoring functionality for health applications. There will no doubt be novel application areas in the future including mobile group-decision making and mobile public participation among others. The recently finished Android Developer Challenge I,[8] where LBS developer teams have been competing in the creation of novel LBS applications, provides convincing evidence that the search for the "killer application" still continues.

ACKNOWLEDGEMENTS

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NOTES

1 http://www.fcc.gov/pshs/services/911-services/
2 http://ec.europa.eu/environment/civil/prote/112/112_en.htm
3 http://www.onstar.com/
4 http://twitter.com/
5 http://maps.google.com/
6 http://earth.google.com/
7 http://maps.live.com/

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