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LOCATION-BASED SERVICES

Evaluating user perceptions of location-tracking and location-awareness services.

"Federal law enforcement attempts to use cell phones as tracking devices were rebuked twice this month by lower court judges, who say that government cannot get real-time tracking information on citizens without showing probable cause" [12]. As this news report illustrates, a new data type—location data provided by mobile devices—has captured the interest of U.S. law enforcement agencies. However, viewing location data solely from a surveillance perspective misses the point. Such data has the potential to expand many existing information services by adding a location dimension.

Even though location-based services (LBS) were predicted to become the "killer application" of mobile commerce, their dominance has not yet materialized—but is predicted to do so soon. The LBS market size has been predicted to grow exponentially from 2006 to 2010. Within this four-year time span, for example, Asia's LBS market is expected to increase from $291.7 million to $447 million [8], Europe's market from $191 million [9] to $622 million [3], and the U.S. market from $150 million to $3.1 billion [10]. LBS have been available for several years. Initially, location determination for mobile phones was solely cell-based, and location accuracy was determined by the cell size. Whereas cell-based approaches do not require modifications to the handset or network, other localization techniques, such as network-based (TOA, E-OTD), handset-based (GPS), or hybrid approaches (A-GPS), require modification to give increased location accuracy.

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In the U.S., the LBS market seems to be less driven by user demand or technology innovations than by regulatory agencies. In 1996, the Federal Communications Commission (FCC) issued the E911 mandate intending to improve emergency responses to wireless 911 calls by determining a caller's longitude and latitude, with final implementation targeted for the end of 2005. The stated goal is providing the coordinates of an E911 caller: the location accuracy must be within 50 to 100 meters for 67% of all calls and within 150 to 300 meters for 95% of all calls [2]. At present, this level of accuracy can be provided only to a limited number of public safety answering points (PSAPs). As a result, U.S. cellular providers were fined for not meeting the long-past deadline [6]. However, once implemented, the E911 mandate will provide the technical foundation for LBS in the U.S.

In Europe, the European Commission initiated a similar pursuit in 2002 by issuing the Directive for Mobile Communication—E112—which represents the European equivalent of the U.S. E911. Even though legally binding, the European Commission has not stated any accuracy requirements or any policy regarding the localization technique to be used. In 2006, seven (out of 25) European countries were E112-operational, three had limited scope, and nine had initiated implementation and were upgrading their existing infrastructure [4].

Generally, the slow adoption of LBS has been explained primarily by three causes. First, the implementation of more accurate localization techniques (such as E-OTD, U-TDOA, or A-GPS) through providers has taken longer and has been more costly than expected. Second, the few available LBS applications display long response times, often too long for users to handle. And third, users are concerned about privacy issues that are an inevitable side effect of LBS. Whereas other studies have demonstrated the impact of privacy concerns on LBS, for our study we chose to examine LBS in an environment that was not affected by slow response times or imprecise localization information. We analyzed LBS in an experimental laboratory setting that provided faster transmission rates than any currently available cellular phone infrastructure and higher localization accuracy than mandated by the FCC in its E911 mandate.

Location-Based Services

Location-based services are any service that takes into account the geographic location of an entity. First, the term "entity" means the object triggering location information can be human or non-human. A pallet of groceries is, for instance, a non-human object that often needs to be tracked for logistical purposes. The Germany-based METRO Group, after a comprehensive pilot project with suppliers, warehouses, and retail stores using various generations of RFID to track pallets along the entire process chain, recently completed its rollout to 180 locations [5].

Second, there are always at least two entities involved in a location-based service request—just like there are at least two people in a phone conversation. In a generic geographic grid (such as longitude and latitude), entity A is always in relative position to entity B. Moreover, each of the entities can be either static or moving. Static can imply two things: either they are truly static (such as retailers) or

they are only temporarily static (such as a parked car).

Third, one of the entities, whether human or non-human, is always the object of LBS, that is, it is the entity about which location information is recorded. And fourth, one of the entities is always a recipient of the location information. LBS researchers distinguish between location-tracking services and position-aware services [1]. Location-tracking services provide information about a user's whereabouts to entities other than the user, while location-aware services supply the user (the information requester) with personal location data. In the case of location-aware services, the location-information-causing entity is the recipient, whereas for location-tracking services, an external third party requests and receives location information about another entity. A car navigation system is a location-aware service. Here, location information is provided to the requester (the driver) who, in return, receives real-time navigational services. Other examples of location-aware services include location-sensitive billing (paying while passing toll stations), and location-specific store advertisements sent to a consumer's mobile phone when the person is in proximity. An example of location-tracking services is UPS's truck-tracking system, where location information for each truck is used to increase fleet management efficiency.

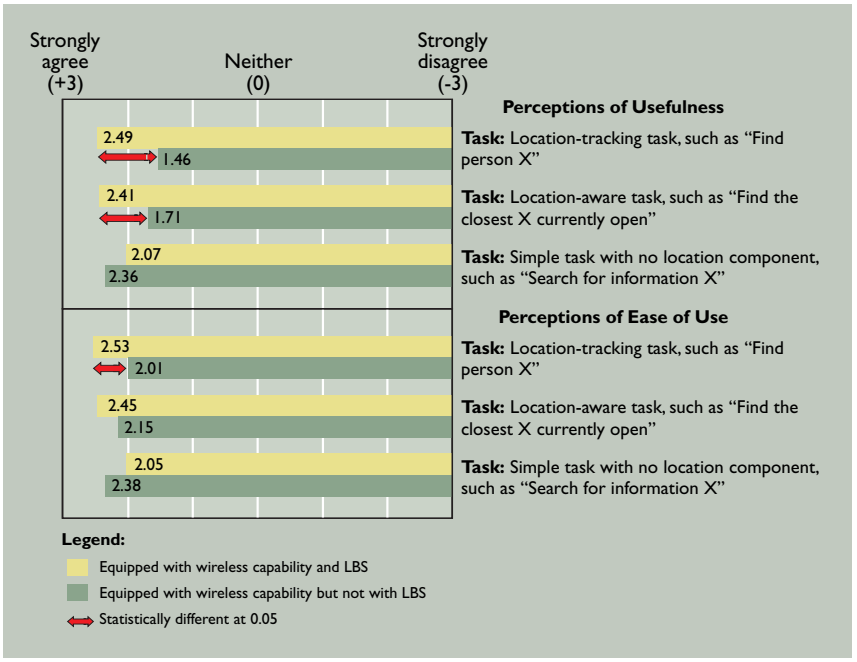

Figure 1. Usefulness and ease of use perceptions toward differing tasks.

The distinction between location-tracking and location-aware is important—not only from a technological viewpoint but also for other reasons. Whereas location-tracking services focus on particular coordinates, location-aware services go a step beyond: they also include the coordinates of the surrounding context and are expected to provide a better socio-technical fit. Thus, consumers may have different perceptions associated with each service and may find one form of service more attractive than the other or may simply detect that one form of service contributes more to their individual efficiency and effectiveness than the other. To examine these questions, we conducted an empirical study of the potential differences between location-tracking and location-aware applications. We were particularly interested in differences in performance and in perceptions of usefulness and ease of use. In addition, we also examined "traditional" (non-location) services, such as browsing the Web for information and writing/sending email, to provide a foundation for comparison. For meticulously singling out effects between location-tracking and location-aware services, a laboratory experiment has the advantage of achieving control over disturbing (or external) effects that allows for examining efficiency and effectiveness gains of LBS in the most accurate way.

An Empirical Study

The experiment involved 58 subjects, of whom 36.2% were female and 63.8% male. The majority of subjects was between 19 and 23 years old (93.2%) and had either moderate or intensive experience (> 93.1%) with at least one of three technologies: Internet, computers, and cellular phones. Every subject was equipped with a wireless PDA and randomly assigned to one of two experimental groups: one had location-tracking and location-aware functionalities, while the other did not and was provided only with wireless connectivity.

The "wireless" experimental zone spanned two buildings and a courtyard in between, totaling 80,525 square feet (7,481m^2). Within this zone, wireless Internet accessibility at a transmission rate of 11Mbps was supported (using WiFi 802.11a). The level of localization accuracy at any point throughout the network averaged between 10 and 20 meters using cell-based localization techniques.

Every subject was given the same set of three tasks: location-tracking (find a moving person); location-

sensitive (find the closest office that is currently open); and those that did not have a location component inherent to them (such as checking for weather information, writing an email message)—all embedded in an encompassing scenario.

We measured performance, usefulness, and ease-of-use perceptions associated with the tasks. For example, we expected that individuals would perceive a technology with wireless and localization capability as more useful for finding a moving person than a technology with wireless capability only. In the same vein, we anticipated some tasks, such as checking weather information, were independent of the availability of LBS. Every subject underwent a 30-minute training session prior to usage. All received their first task (out of three different types of tasks) via email after some randomized amount of time. In order to avoid grouping and learning effects, task order and the time between issuing tasks were randomized. After every task fulfillment, subjects were asked to rate their perceptions of usefulness and ease of use. Overall, each subject spent approximately three hours participating in the study.

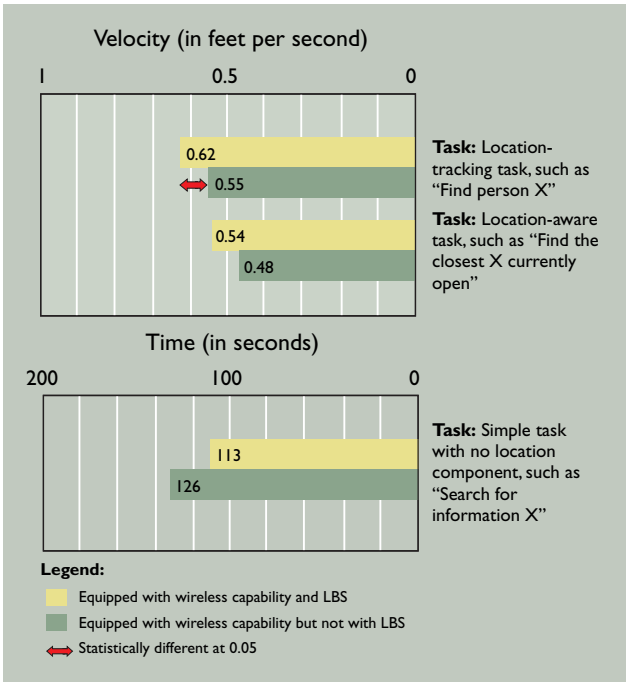

Figure 2. Task performance of differing tasks.

Task performance—the time it took for the subjects to complete a task—was measured automatically by the system. Because location-tracking and location-aware tasks stipulate that at least one of the participating entities is moving, the system also recorded geographic information. For example, a task that required a subject to find a moving person recorded not only location measures of the subjects at event time but also location measures of the (moving) person to be found. This was necessary in order to adjust time measures based on a subject's distance in relation to another person or place when executing the task. Adjustments were operationalized by calculating the velocity (the distance-time ratio) of the solution.

Four interesting outcomes were observed (see Figures 1 and 2). First, location-tracking capabilities displayed a high level of perceived usefulness and ease of use, along with an increased level of performance that was significantly different ($p < 0.05$) from their control counterparts equipped only with wireless capability. We observed that subjects were surprised by the possibility of supporting a traditional "seek" task with the help of information technology. Having a person's location information available with the press of a button was an overwhelming experience—as confirmed by some informal interviews conducted after the study. It typically took subjects one "round" of location tasks to understand the depth of the application and that the wireless system was tracking their geographic whereabouts throughout the experimental zone. Subjects expressed both enthusiasm and concern. They were fascinated by the technical possibilities and alarmed by the prospect of someone tracking their movements.

Second, with regard to location-aware services, subjects also said they were convinced of their usefulness—more so than the corresponding control group (see Figure 1). Though the interfaces for both location-tracking and location-aware functionalities were very similar, subjects equipped with location-aware capabilities did not report a significant higher level of ease of use (see Figure 1). Interestingly, subjects equipped with location-aware services did not perform significantly better than those without (see Figure 2). A possible explanation for this finding may lie in the experimental setup, more specifically in the geographical arrangements of the offices. Because of the size of the experimental cell, offices were not far apart from each other. Thus, the likelihood of subjects finding an open office (the task at hand) was not sufficiently different between LBS-assisted and unassisted searching.

Third, for simple tasks (those that did not contain a location component), perceptions of usefulness and ease of use did not expose any statistical difference (see Figure 1). The same was true for performance measures (see Figure 2, bottom). Here, subjects performed the same, irrespective of whether or not LBS were available. These outcomes were to be expected, as the sole reason for including simple tasks into our study was to provide a cross-check instrument for comparison purposes.

Overall, and as a final finding, subjects (with or without LBS) were highly motivated to partake in the experiment (even though it took more than three hours to complete). Throughout the study, the level of enjoyment among participants remained high to extremely high (88%), which indicates people were very interested in using a technology innovation providing LBS.

Conclusion

The localization factor has always been mentioned as one of the fundamental factors that differentiates m-commerce from e-commerce. However, until now, this prophecy has materialized only in Asia, in markets such as Japan and South Korea. In Europe, cell-based LBS have been around for some time, however, even for those services consumers are reluctant to pay more than for a text message [11]. More accurate localization techniques are only selectively available, as they not only require tremendous network investments but also a Pan-European strategy among operators. Therefore, an uptake of LBS is expected to become visible with the introduction of Galileo in 2008—the European equivalent of the U.S. GPS system. In the U.S., equivalent growth is expected to materialize with the completion of E911 implementation, with a revised deadline for full compliance of 2012 [6]. Among the U.S. cellular phone providers, only Sprint Nextel, considered to be the first mover in the LBS market [7], offers audible and visual navigation and mapping services to its customers (location-aware). On the business-application side, it offers viewing and monitoring of employee locations in real time on a zoomable online map (location-tracking).

We examined LBS in a laboratory setting that was not affected by slow response times or imprecise localization information. Removing real-world technical problems allowed us to focus on the pure effects of LBS on users' perceptions, as well as efficiency gains. Segregating between location-tracking and location-aware services demonstrated that differences do indeed exist between them. Location-tracking capabilities make an individual's life easier by being more useful, easier to use, and generating higher efficiency. Location-aware capabilities, on the other hand, seem not as valuable. Even though efficiency effects were observable, they turned out to be not significant. Nevertheless, subjects were highly intrigued by LBS capabilities, and the experiment left them with a formative impression. Along with enthusiasm, however, privacy concerns immediately followed, and individuals realized services that support navigational help can also be used to gain information about the navigator's whereabouts. More specifically, and from observation during the study, one would expect that people are willing to provide their location information to providers, but are hesitant to provide the same information to another entity. As this was not the focus of our study, we refer to preliminary findings of another of our studies, which shows consumers are inclined to forgo privacy if they consider the resulting services received sufficiently useful. The E911 emergency service is an instance of where the value of the service should override privacy concerns. For many services, however, where the individual benefit is not as apparent (for example, promotional offers from stores in the vicinity), consumers have a strong tendency to reject location-aware services. As a consequence, privacy considerations, besides efficiency gains and attitudinal perceptions, are likely to be a major determinant in the success of LBS. C

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