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Location-Based Services for Mobile Telephony: a study of users' privacy concerns

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Abstract: Context-aware computing often involves tracking peoples' location. Many studies and applications highlight the importance of keeping people's location information private. We discuss two types of location-based services; *location-tracking* services that are based on other parties tracking the user's location and *position-aware* services that rely on the device's knowledge of its own location. We present an experimental case study that examines people's concern for location privacy and compare this to the use of location-based services. We find that even though the perceived usefulness of the two different types of services is the same, location-tracking services generate more concern for privacy than position-aware services. We conclude that development emphasis should be given to position-aware services but that location-tracking services have a potential for success if users are given a simple option for turning the location-tracking off.

Keywords: Location-based services, context-aware computing, mobile telephony, human-computer interaction

1 Introduction

Context-aware computing describes applications, often implemented for mobile devices that adapt to environmental sensor information. Many of these applications rely solely on location information as their context and although some researchers claim that too much attention is given to this type of sensor information (Schmidt *et al*., 1999), it is predicted that location-based services will be the most common form of context-aware computing (Ljungstrand, 2001). As mobile telephony becomes increasingly common as a handheld computing platform, location-tracking of mobile phones enables location-based services to spread outside closed environments. Location-tracking of customers by mobile telephony providers via GSM and later GPS-enabled services generates a need for addressing privacy issues in relation to the building of location-based technologies and services. We distinguish between two types of location-based services: *location-tracking* and *position-aware* (Snekkenes, 2001). Location-tracking services are services relying on the tracking of peoples' location by other parties such as mobile telephony service providers, whereas position-aware services are based on the device's own knowledge of its position. Examples of the two services include locating friends or family members and updating the time when entering a new time zone, respectively. By studying peoples' concern for and use of location-based services, it is our goal to provide insight about the degree to which location-based services are considered to be intrusive on users' privacy and whether location-tracking or position-aware services generate more concern.

We present a case study that examines peoples' concern for location privacy in relation to location-based services. We presented each study participant with four hypothetical location-based features (two location-tracking and two position-aware services) for their mobile phone, and studied their preferences and concerns as well as their expected use of the services. By comparing the findings, we found that people are positive towards the location-based services as long as they perceive them to be useful. We also found that location-tracking services generate more concern than position-based ones.

We first present related work in the area of privacy and location-tracking. Second we present our

study and its design and third, we present the results of the study. Finally we discuss these results and conclude that development emphasis should be given to position-aware services and that location-tracking features should be implemented giving the user control over who can track their location. Finally we give suggestions for further research.

2 Related Work

Research within location-tracking in indoor environments has been conducted for over a decade. Early work such as the Active Location Badge system (Want *et al*., 1992) uses infra-red technology but other sensor technologies have been explored as well (Hazas and Ward, 2002). Because we propose location-based services limited to mobile phones, however, the related work falls in the category of outdoor location-tracking using GSM and GPS technologies. This approach generates a different set of privacy issues, since it is likely that people have different concerns about being tracked by, for example, their service provider than their employer.

2.1 Location-Based Services

The research focusing on location-based services is vast and a number of these services have been implemented and tested; for example the Guide project (Cheverst *et al*., 2000) and Cyber Guide (Abowd *et al*., 1997). Most of these applications use the position-aware approach, meaning that an application's actions are based on its knowledge of its own position. Location-tracking services, such as safety-based ones, for children or the elderly, have been developed (Marmasse and Schmandt, 2003). Applications outside the research lab include 'friend finder' services, which some mobile phone service providers offer (AT&T, 2003).

2.2 Privacy and Location

According to much of the research in location-based computing, privacy is an essential issue (Snekkenes, 2001; Bisdikian *et al*., 2001), and the subject is often addressed in terms of how sensitive information is kept secured in the application. Privacy is a general concern, also for stationary application such as web-based applications, and studies focusing on keeping sensitive information safe are numerous. In this type of research, most often *identity* is at the core of privacy studies (Langheinrich, 2002). Identity has several aspects to it and we consider a person's position to be a specific attribute of identity, like full name and social security number. The major difference between location and most other attributes is that location changes continually and is mostly relevant to mobile computing.

Where much research focuses on technology that ensures the user a high level of privacy, there is a lack of studies that really examine the underlying need for privacy. Most studies base their research on the common notion that a high degree of privacy is essential to the users, but few present research confirming this. The next section briefly looks into the most relevant studies of user behaviour and concern for privacy.

2.3 User Related Studies

Although some studies of users' privacy and identification preferences exist, none of them focus solely on concerns about location-tracking or positioning. One study examines people's attitude to online privacy; the focus is on how comfortable they are in revealing identity information to known or unknown parties (Ackerman *et al*., 1999). The study find that their concern for privacy depends on what types of information they are asked to give up, but also on the application's usefulness to the user. Another study compares general privacy concerns in different situations to the inquirer of the information and finds that inquirer is a greater determinant for what people want to reveal, than situation (Lederer *et al*., 2002). The study most relevant to our notion of location privacy, focuses on the social act of rendezvousing and finds that for example 'friend finder' features will potentially enhance people's everyday tasks (Colbert, 2001). The study also indicates how participants were overly positive about giving up their location information to a fairly large group of pre-selected individuals, not unlike our findings. Finally the study calls for research into users' perceived usefulness in exchange for giving up their position, which is the focus of this study.

The limited number of studies of actual concern for location privacy means that, while privacy issues are considered essential to location-tracking, it needs to be determined how great a concern, location-based services actually are. We now present the study we conducted with the goal of determining peoples' expected use and concerns about privacy with respect to location-based services.

3 Research Method

Our study was conducted as an experimental case study where 16 participants are given a 5-day journal in which they answer pre-specified questions about the usefulness and level of concern in using presented location-based services. A subset of the participants was interviewed after completing the

journal to elaborate on their entries. Because it was not possible to implement all the proposed location-based services, the study asks participants to 'imagine' the existence of the services. The services are outlined in table 1; note that services A and B are position-aware and services C and D are location-tracking based. At the end of each day, our study participants reported how many times they would have used the service and to what degree it would have been useful to them. Both variables were measured on a Likert scale from 1 to 5. They also reported whether they found the tracking of their location intrusive. The journal also gave them the option to elaborate on their ratings, which most of the participants took advantage of. In addition, 5 of the participants were interviewed to elaborate on their concerns about location privacy.

Service	Description
Service A: Ringing profiles in private settings	The mobile phone 'knows' when the user is in a meeting or in class
Service B: Ringing profiles in public settings	The mobile phone 'knows' when the user enters a movie theater or a restaurant
Service C: Lunch service	A suggestion for lunch is pushed by the retailer to the mobile phone when the user is around a restaurant or fast food place
Service D: Localization of predefined friends	The mobile phone can locate predefined friends and alert the user when they are within a certain distance

Table 1: Location-Based Services.

3.1 Participants

The 16 participants were found among young mobile phone owners and both students and non-students were selected. Ages ranged between 19 and 35 with a mean of 23.7. The number of years the participants had owned a mobile phone varied from 6 months to 6 years with an average of 2.6 years.

4 Perceived Usefulness of Services

The participants' perceived usefulness of services was measured by having the participants answer how many times they would have used the different services during the day, as well as directly asking the participants to rate the usefulness of each service. Finally, the services were presented again during the interviews and discussed with participants.

Overall, participants found services A and D (private ringing profile and localization of friends) to be the most useful services and service C (lunch) to be the least useful one. One service for each of our two types was perceived as useful, whereas the other two services were not viewed as being that useful, as seen in table 2. The lunch service is seen as the most intruding service where the private ringing profiles are the least intrusive. Service D (localization of friends) shows an unexpected positive correlation of 0.31 (significant to the .05 level), meaning that if the participants found the service useful, they were also likely to find it intrusive.

The self-reported level of use highly correlates with the participants' perceived usefulness. While values for service A, B and D are correlated 0.56, 0.73 and 0.54, accordingly and are all statistically significant to the .025 level, only values for service C (lunch service) are not correlated. In general this service was not used very much as seen in table 2.

Service	Rated useful-ness	Rated intrusi-veness	Average # of daily use
Service A: Private ringing profiles	3.75	2.1	1.5
Service B: Public ringing profiles	2.6	2.2	0.4
Service C: Lunch service	2.2	3.7	0.3
Service D: Localization of predefined friends	3.75	3.25	1.3

1= not useful at all, 5 = very useful
1= not intrusive, 5 = very intrusive

Table 2: Average rating of the services.

5 Concern for Privacy

Users' concern about being tracked was assessed by directly asking them if they found each service intruding and if they would be worried about their privacy while using such a service. This issue was also discussed in the interviews.

We find that people, in general, are not overly concerned about their privacy when using location-based services. On a scale from 1 to 5, where 1 is 'not concerned' and 5 is 'highly concerned', the participants averaged 2.75 for all the services. Only 5 of the participants were 'concerned' or 'highly concerned' about their privacy for the location-tracking services, where 11 were either 'not concerned', a 'little concerned' or 'neutral'. Evaluating the position-aware services, only 3 participants were 'concerned' or 'highly concerned' for their privacy, where 13 were 'not concerned', a 'little concerned' or 'neutral'. The position-aware services were also rated as less *intrusive* than the

location-tracking ones, supporting the notion that people are more concerned when others can track their location than when their mobile phone reacts to its own location.

6 Discussion

Our results show that while some services are viewed as highly useful, the level of intrusiveness and concerns for privacy are much higher for location-tracking than for position-aware based services.

Based on previous research, it was our initial belief that concerns for privacy would be high. Although few studies have examined people's concerns for location-tracking, the vast amount of technologies focusing on keeping location information safe lead to the impression that people are not likely to adopt location-based services. However, our results show that people are less concerned about their location being tracked, as long as they find the service useful.

7 Summary and further research

We have presented two types of location-based services, location-tracking and position-aware services. We then presented a case study that examines people's concern for privacy in relation to location-based services and compared people's perceived usefulness of the two types of services. We conclude that although people, in general, consider both types to be equally useful, the concerns for privacy are higher when the service is based on other parties tracking the user's location. Because of this finding, we suggest that development emphasis should initially be on the more acceptable position-aware services.

Future research should focus on studies involving implemented technology. Because our study is based on hypothetical services, the findings do not necessarily reflect users' behaviour in a real setting. Longitudinal studies should also be conducted to assess if the use level is consistent or mostly due to initial excitement. Finally, research focusing on implementing technology to ensure privacy, should consider looking into what level of privacy is actually needed and desired by users.

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