The Impact of Expressiveness on the Effectiveness of Privacy Mechanisms for Location-Sharing

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ABSTRACT

A recent trend in social networking, photo/video sharing, and location-sharing services is a demand for more expressive *privacy mechanisms* that provide greater control over the conditions under which information is shared. We provide a methodology to inform the design of such mechanisms by identifying the most relevant privacy dimensions for a particular user population. We performed a week-long user study where we tracked the locations of 30 subjects. Each day we collected their stated ground truth privacy preferences regarding sharing their locations with different groups of people. Our results confirm that i) most subjects had relatively complex privacy preferences, and ii) that privacy mechanisms with higher levels of expressiveness are significantly more efficient in this domain.

Keywords

Expressiveness, Usable privacy, Location sharing, Web services, Social networking, Mechanism design

1. INTRODUCTION

Over the past few years we have seen an explosion in the number and different types of websites that allow individuals to exchange personal information and content that they have created. These sites include online social networks, photo and video-sharing sites, and location-sharing services on the Internet. While there is clearly a demand for users to share this information with each other; recently, we have started to see a change in attitude, with users demanding greater control over the conditions under which their information is shared. This change has led to expanded privacy controls on sites such as Facebook and Flickr.

More than 40 different location-sharing applications exist on the Web today, many of which emerged over the last year, and are anticipated as part of the expected billions of dollars in marketing revenue from location-based services [4]. These applications allow users to share their location (frequently, their exact location on a map) and other types of information, but have extremely limited privacy controls. Typically, they only allow users to specify a *black list*, or a listing of the individuals with whom they would never share their locations.

Despite the number of location-sharing applications that have been developed, none have yet to capture significant market share, and many people are still wary of sharing their locations online due to privacy concerns [1]. To explore privacy concerns surrounding the sharing of location informa-tion, diary studies and laboratory experiments, small group testing, and interviews have all been used extensively [5]. A field study of a location-sharing system found that having feedback, or being provided with information on who had viewed your location, had a significant impact in how comfortable people were with sharing their information with friends and strangers, and on reducing participant's levels of privacy concerns after using the location-sharing technology [6].

Prior to our original work on expressiveness in mechanisms [3], there had been relatively little work on expressiveness specifically.

In this paper, we conduct a user study where we track 30 participants over a one week period. Based on their location trails, we ask them to rate when, where, and to whom they would be comfortable sharing their locations. Our findings suggest that the privacy settings offered by today's location sharing applications (i.e., black lists) appear to be unsuitable to the wide array of privacy preferences revealed by our study. This finding may help explain the lack of broad adoption encountered by these applications so far.

2. AN EMPIRICAL STUDY OF LOCATION SHARING PRIVACY MECHANISMS

Our experiment was conducted over the course of two weeks in early October 2008. We supplied 30 participants with Nokia N95 cell phones[1] for one week at a time (15 subjects were run at once). The subjects were required to transfer their SIM cards to the phones we provided and use them as their primary phones for an entire week. This requirement ensured that the subjects kept their phones on their person and charged as much as possible. Each of the phones was equipped with our location-tracking program, which recorded the phone's location at all times using a combination of GPS and Wi-Fi-based positioning.

Each day, subjects were required to visit our web site and upload a file containing their location information from their phone. They were then asked to audit the location information by answering a set of questions about each location that they visited since their last login. For each location a subject visited, we asked whether or not he or she would have been comfortable sharing that location with different groups of individuals. These groups consisted of close friends, immediate relatives, people within the university community, and strangers. While no location-sharing to others actually occurred, we solicited the names of people from the friends

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[1] These phones were generously provided by Nokia.

and relatives groups so that the questions the users answered were more meaningful to the participant (i.e., are you comfortable with sharing your location with your mom?).

Subjects were paid a total of $35, corresponding to $5 per day, for their participation in the study. We also administered surveys before and after the study to measure the level of concern about their privacy that people had about sharing their location information, to collect relevant demographics, and to determine qualitative measures of the subjects' privacy attitudes.

3. RESULTS AND FINDINGS

In this section we will present the expected efficiency of the following four different privacy mechanisms. For a full discussion of all our results, please see the extended version of this paper [2].

- **Black list (BL).** The black list mechanism only allows users to express whether or not they would be comfortable sharing their locations with each group at all times.

- **Location-based (LOC).** The location-based mechanism allows users to express specific locations at which they would be comfortable sharing their locations with each group.

- **Time-based (TIME).** The time-based mechanism allows users to express time intervals (discretized into 15 minute blocks) during which they would be comfortable sharing their locations with each group (it does not consider the day of the week).

- **Location & time-based (LOC/TIME).** The location and time-based mechanism combines the expressions of the LOC and TIME mechanisms. It allows users to express time intervals during which they would be comfortable sharing specific locations with each group.

Our results, presented in Figure 1, explore the performance of different mechanisms for each of the four different groups about which we asked our subjects. For the friends, family, and university community groups the LOC/TIME mechanism has significantly higher expected efficiency than all of the other mechanisms. This confirms that location-based and time-based forms of expression are not redundant. Furthermore, in all of these cases, the LOC and TIME mechanisms both have significantly higher expected efficiency than the BL mechanism. For the anyone group, the only significant difference in expected efficiency is between the BL and LOC/TIME mechanisms. Interestingly, the LOC mechanism had significantly higher expected efficiency than the TIME mechanism for the colleague group (this is probably due to the fact that many of our subjects were comfortable sharing their locations with this group while they were on campus).

4. CONCLUSIONS AND FUTURE WORK

Our empirical results confirmed that i) most subjects had relatively complex privacy preferences, and ii) that privacy mechanisms with higher levels of expressiveness are significantly more efficient when information is sufficiently sensitive. Thus, the fact that most location sharing services use
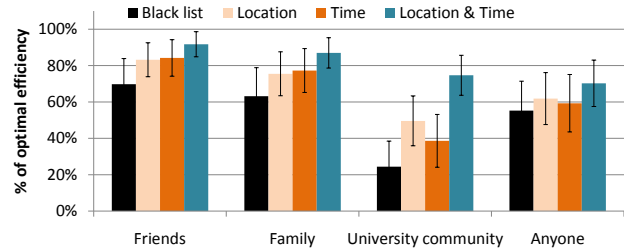

Figure 1: The percent of optimal expected efficiency (bars indicate 95% confidence intervals) achieved by the different mechanisms we tested by group.

simple black list mechanisms, which do not match the privacy preferences revealed in our study, may help explain the lack of broad adoption encountered by these applications so far.

The findings in this paper open several avenues for future work. We can explore additional dimensions of expressiveness, such as allowing expressions based on the day of the week, or the resolution at which the location information is provided (e.g., neighborhood, city, or state). Future work should also address the increase in user burden associated with increasing expressiveness. This increase in user burden could potentially lead to a discrepancy between a mechanism's optimal efficiency and the actual efficiency achieved by real users.

5. ACKNOWLEDGMENTS

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