

Who's Viewed You? The Impact of Feedback in a Mobile Location-Sharing Application

Janice Y. Tsai, Patrick Kelley, Paul Drielsma, Lorrie Faith Cranor,

Jason Hong, Norman Sadeh

Carnegie Mellon University
Pittsburgh, PA

jytsai@andrew.cmu.edu, pkelley@cs.cmu.edu, paulhd@cs.cmu.edu, lorrie@cs.cmu.edu,
jasonh@cs.cmu.edu, sadeh@cs.cmu.edu

ABSTRACT

Feedback is viewed as an essential element of ubiquitous computing systems in the HCI literature for helping people manage their privacy. However, the success of online social networks and existing commercial systems for mobile location sharing which do not incorporate feedback would seem to call the importance of feedback into question. We investigated this issue in the context of a mobile location sharing system. Specifically, we report on the findings of a field deployment of Locyoution, a mobile location sharing system. In our study of 56 users, one group was given feedback in the form of a history of location requests, and a second group was given no feedback at all. Our major contribution has been to show that feedback is an important contributing factor towards improving user comfort levels and allaying privacy concerns. Participants' privacy concerns were reduced after using the mobile location sharing system. Additionally, our study suggests that peer opinion and technical savviness contribute most to whether or not participants thought they would continue to use a mobile location technology.

Author Keywords

Context-awareness, mobile location sharing technology, mobile social, information disclosure, privacy

ACM Classification Keywords

H.5.2 User Interfaces—user-centered design, H.5.3 Group and Organization Interfaces — evaluation/methodology, collaborative computing; K.4.1 Public Policy Issues — Privacy.

INTRODUCTION

Location-based technologies, including mobile phones with GPS capabilities, location-based contextual advertising, and vehicular navigation systems, are becoming more prevalent. These technologies may add an element of convenience to people's lives, but they bring a host of privacy concerns related to the storage, transmission, and sharing of data about

users' locations and movements. Past work in the HCI literature has emphasized feedback as an essential element of ubiquitous computing systems [4, 17]. Providing users feedback, for example allowing them to browse a log of who has requested access to certain information, can contribute to social translucency, allowing people to more efficiently use group-based systems [10].

However, the success of online social networks and existing commercial systems for mobile location sharing, which do not incorporate feedback, would seem to call the importance of feedback into question. Facebook and MySpace, the most popular online social networks (OSNs), have over 100 million active users each. The users of these systems provide personally identifiable information, lists of friends, photographs, and other information, but receive no feedback about who accesses this information. Similarly, commercially available providers of mobile phone-based location-sharing services, such as Loopt and Helio's Buddy Beacon, allow users to view friends' locations but do not provide information about who has been querying users' locations.

Thus, the primary question we investigate in this paper is "how important is feedback for managing personal privacy in a ubiquitous computing system?" We report on the findings of a user study involving a field deployment of a system for mobile location sharing. Our study is unique in several ways. To our knowledge, it is the largest such study, based on the real-world deployment of an application that allowed 56 users to selectively disclose their locations to friends, acquaintances, and strangers within a social network. In our study, one experimental group was given feedback in the form of a history of requests for their locations, and a second group was given no feedback at all. Our major contribution is to show that feedback is an important contributing factor towards improving user comfort levels and allaying privacy concerns. We show that, while both groups' significant initial privacy concerns abated over the course of the study, the users who had access to feedback were much more comfortable with being located by friends and strangers after using the system. This improved comfort level translated directly into greater location sharing, and we observed that the users in the feedback group made themselves available for a greater period of time. Our study also suggests that peer opinion and technical savviness contribute most to whether or not participants thought they would continue to use a mobile location sharing technology.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

CHI 2009, April 4 - 9, 2009, Boston, Massachusetts, USA.

Copyright 2009 ACM 978-1-60558-246-7/09/04...\$5.00.

We sought to understand how system feedback affects users' privacy concerns, the way they specify their disclosure rules, and their willingness to use the system. We believe the following results will help inform the design of future social network and social interaction tools.

RELATED WORK

As mobile location technologies become ubiquitous, developers have begun offering products and services that leverage location information. These applications may not comprehensively address the privacy implications of this sensitive geographic data [12]. As of now, location-based technologies are still on the cusp of becoming a "killer app." These technologies have been developed for both cellular phones and laptop computers. Skyhook Wireless began offering Wi-Fi positioning services in 2003.¹ Skyhook made its web toolbar application Loki available² in 2006, allowing users to view their own locations on a Google map. Since 2002, several products for cellular phones have been available, such as AT&T's now-defunct Friend Finder [6], and services currently offered by Loopt³ and Helio (the Buddy Beacon).⁴ Only recently have technology providers begun to offer technology platforms on which others can build location-finding applications, including the iPhone SDK,⁵ Google's Android SDK,⁶ and Yahoo's Fire Eagle API that facilitates privacy-enhanced location-sharing.⁷ It remains to be seen how these services will be received by the general public.

Several research groups have also developed location-finding technologies for research purposes. These deployments include PARC's Active Badges [30], Active Campus [3], My-Campus [25], Intel's PlaceLab [11], and MIT's iFind [14]. Most of these efforts have focused on developing accurate location-finding solutions, not extended field explorations of user behavior.

Social Translucency and Feedback

While several OSNs do not provide feedback, others have found it to be a useful feature in system design for creating ties between users. Friendster and Orkut, OSNs, have added "Who's Viewed You" features with mandatory reciprocity. Several online dating sites offer a feedback feature, variously named "Who's viewed me" (Match.com⁸, Yahoo! Personals⁹) or "My Stalkers" (OkCupid.com¹⁰).

The research community has looked at the question of feedback from different angles. On the one hand, feedback has

been found to be one of the major principles that should be considered when designing new systems to mitigate privacy concerns [4, 13], yet comprehensive methods of feedback are restricted by the timing, perceptibility, obtrusiveness, intrusiveness, and cost of those mechanisms [4]. For example, in Bellotti and Sellen, feedback was added in an audio-video environment via a LED to indicate the recording of the cameras, but projecting the names of people who could watch the public area was found to be too expensive and intrusive. New technologies and interfaces have made it easier to provide more comprehensive feedback.

With these new web interfaces, users can audit the actions the system has taken on their behalf and monitor how people use the system. Feedback also provides social pressure which should help to avoid abuses of the system. Previous work has also focused on leveraging feedback from users through machine learning techniques to increase the accuracy of user privacy and security policies [26]. Promisingly, Stumpf et al. [29] found that users were willing and able to provide considerable amounts of auditing feedback to systems that show improvement in their reasoning, based on each user's responses.

Studies of Privacy in Location-Based Applications

Generally, people have significant privacy concerns about broadcasting their location to others [2, 3, 21] (for a comprehensive survey of privacy in HCI see [15]). Such privacy concerns may be one of the top reasons for the slow adoption of location-based services [18]. However, concepts of privacy often adapt to changing social norms that surround the use of new technology [4], so attitudes about location information may shift over time.

Many previous studies of location-sharing applications have employed a variety of methods to examine the usage of such systems and privacy concerns that these systems raise. The Experience Sampling Method (ESM) has been employed by several researchers to determine how much information people would share and to what degree of detail [7], the social context of location-disclosures [19], and the context in which people are willing to share their location information [1]. Similarly, diary studies and small laboratory experiments have also been conducted [3, 8, 23] to examine the usefulness and invasiveness of the technology. Deployments of such systems have typically involved small groups of participants who were members of an existing social group where the requestee responded via SMS with their location information [16, 27] or had their location provided automatically when their phone was on [2]. Other deployments involved groups who may already be aware of or have access to each other's location information, such as family members using the Whereabouts Clock [5]. While users are willing to share their locations when presented with a request for that information [7, 19, 26], past work strongly suggests that users have concerns over who is trying to find them and the context in which that person is requesting a location [5, 7, 16, 19, 20, 27]. Others have examined control mechanisms for mobile applications, finding that users will create groups of contacts for permission control [13, 23].

¹Skyhook Wireless. <http://www.skyhookwireless.com/>

²Loki. <http://loki.com/>

³Loopt. <http://loopt.com/>

⁴Helio. <http://www.helio.com/>

⁵iPhone Dev Center. <http://developer.apple.com/iphone/>

⁶Android. <http://code.google.com/android/>

⁷Fire Eagle <http://fireeagle.yahoo.net/>

⁸Match.com. <http://match.com/help/helpdtl.aspx?sec=35>

⁹Yahoo! Personals. What is Who's Viewed Me? <http://yahoo.personals.com>

¹⁰OkCupid.com. Your OK Stalkers. <http://www.okcupid.com/stalker>

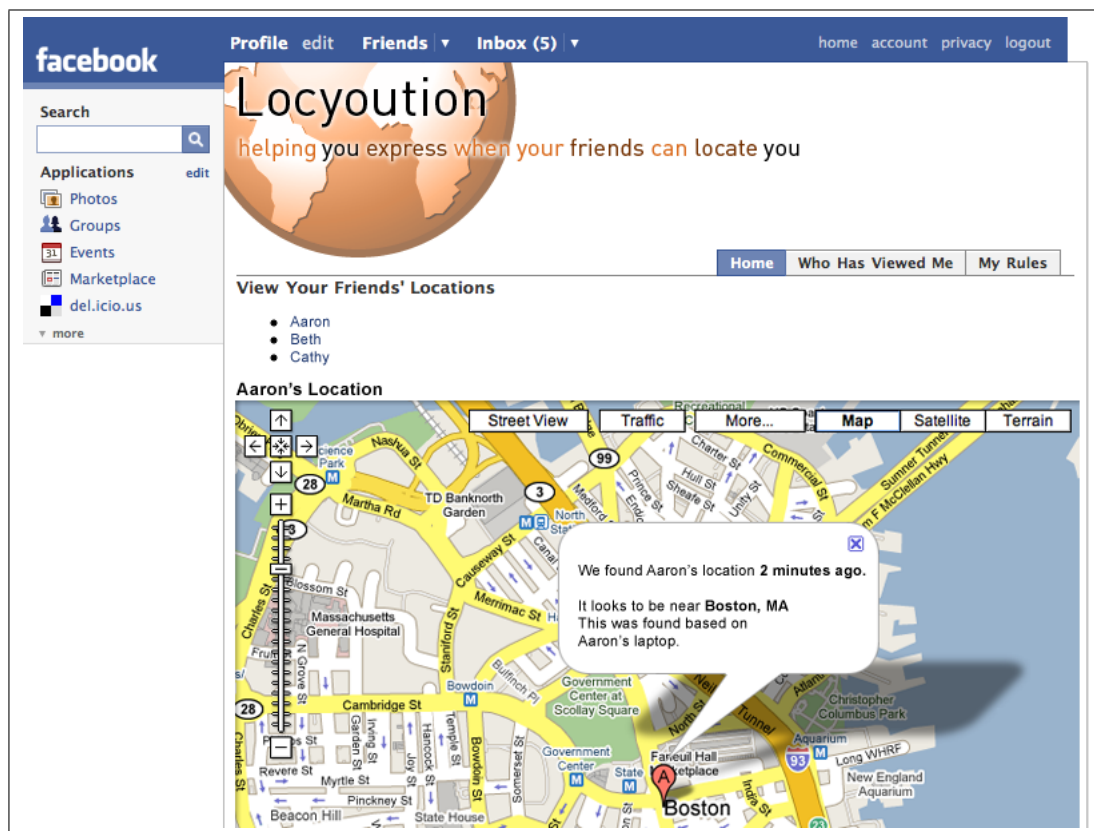


Figure 1. The Locyoution "Home" interface, displayed in Facebook. It shows, by default, the user's own location, and presents a list of friends using Locyoution. This allows users to quickly query their friends locations without having to navigate to each of their Facebook profiles individually.

Our implementation of a mobile location-sharing system builds upon this previous research with a large-scale field trial to examine other factors that may impact participants' privacy concerns. We compare privacy concerns and usage of a mobile location-sharing system for users who have been given access to their disclosure history and those who have not. Notably, our study deploys a mobile location application in an OSN environment where queries are not limited to a small number of pre-set contacts, buddies, or social relations. Instead, any Facebook user who can access our participant's Facebook profile may have the ability to view a participant's location, restricted by time-based rules. Our technology and its implementation are described in the following section.

LOCYOUTION

Locyoution is our Facebook interface for a mobile location-sharing application built on PeopleFinder [26] technology. It consists of two main pieces of technology: software that users install on their laptops and an application that is added on Facebook. By using Facebook, we leverage a social network of which participants are already a part [22, 24].

In Locyoution, the user interaction primarily occurs with the Facebook application. We refer to participants in this study as Locyoution users. Locyoution benefits from iterative improvements to the PeopleFinder system based on feedback collected from several other pilots of the technology over the previous two years [26].

PeopleFinder determines a user's location based on the WiFi access points in range, leveraging technology created by Skyhook Wireless. The Skyhook database provided generally accurate information for the city and covered the majority of the city. We also maintain a database of the buildings and room numbers of all WiFi access points on the university campus. When the Locyoution user is on campus, the building and room number information is listed on the user's map.

When people wish to check a Locyoution user's location, they must go to that user's Facebook profile and click on the icon for the Locyoution application. They then are able to view a map of that user's exact location (address, city, and state), subject to the rules that the user has defined.

User Interface

The Locyoution Facebook interface consists of three main areas. The first area, "Home," is viewable by Locyoution users as well as by anyone on Facebook. The other two areas, "My Rules" and "Who Has Viewed Me," are only viewable by Locyoution users. Locyoution users are provided with a username and password so that they authenticate with the system once they add the Facebook application, linking their laptop software with their Facebook account.

Home Screen

After the installation of the Locyoution software and Facebook application, the user is presented with the Locyoution home screen on Facebook, as shown in Figure 1. This screen

Figure 2. The Locyoution “My Rules” interface

Figure 3. The Locyoution “Who Has Viewed Me” interface.

has four elements. Common across all interface areas are the first two elements: the Locyoution title bar and logo, followed by a set of tabs. These tabs, in the Facebook style, allow for navigation between pages. The final two elements, which appear only on the home screen, are the Friends with Locyoution list and the map. The Friends with Locyoution list is the user’s friends who have the Locyoution application installed; and, thus, can have their locations queried.

The map shows the location of any person that a user selects from their list. If they have not yet located another user, it will show them their own current location. Locyoution allows a small degree of plausible deniability. Location requests can be denied for two reasons: the locatee is offline, or has a rule that does not allow for the disclosure of his or her location. If the request is not a success, the user is presented with a message which simply indicates that the requestee’s location is not available at that time.

Rules Screen

From the tabbed navigation area, Locyoution users can return Home or to go edit or view their rules via the “My

Rules” tab. The Rules interface (Figure 2) allows users to control when others can view their location.

Rules in Locyoution are solely time-based rules, e.g. Only show my location between 9 am and 6 pm on Mondays and Wednesdays. Users can define rules based on specific days of the week and a combination of times of the day. Participants may also add additional durations to rules.

When a location request is made, that request is passed to the server, and if the request falls within the allowable period, the map location is passed back to be displayed on the Home screen; otherwise, the “unavailable” message will be displayed on the Home screen.

Due to limitations at the time of the study, we were unable to allow users to create group-specific rules. While Patil and Lai have found that people like defining permissions by group [23], being able to use Facebook, a social community with which that they are already familiar, was worth the tradeoff of group rule-defining functionality. Facebook has recently added functionality to define settings and permissions based on “Friend Lists.”

Who Has Viewed Me

The final tab in the Locyoution interface allows users to see who has viewed their location as a history or audit log, as shown in Figure 3. When a Facebook user clicks on the Locyoution map graphic on a Locyoution user's profile page, the identity of the requester is recorded. Additionally, the time of the request, the Locyoution user's location, and the system's decision are stored.

Users can view the location requests made of them, and each request is colored green or red based on whether or not their location was displayed to the requester. Locyoution users can also indicate their satisfaction with the decisions of the system by clicking the "Thumbs Up" or "Thumbs Down" buttons, styled after Facebook's system wide user satisfaction mechanism.

Facebook Privacy Settings

Facebook itself also provides a comprehensive set of controls for users to protect their privacy. Users are able to change the privacy settings for their applications to restrict who is able to view the application on their profile page. Users of Locyoution can restrict the Facebook application privacy settings to "My Networks & Friends," "Some Networks (which the user selects) and Friends," or "Friends Only." For actual usage of this feature see Table 3. The default setting for Locyoution allowed all networks & friends to access Locyoution.

LOCYOUTION STUDY

We examined the use of Locyoution in a field investigation. Participants, solicited from a university population, were asked to install and use Locyoution over a period of four weeks. The study consisted of four phases: a pre-study questionnaire, Locyoution installation and troubleshooting, Locyoution deployment, and an exit survey. In Phase 1, participants completed a questionnaire and study consent forms. In Phase 2, participants were provided with a Locyoution username and password, and installation tutorials. We provided assistance to anyone who had difficulty installing the software and viewing their location. In Phase 3, participants were asked to use Locyoution. Usage patterns of Locyoution were determined by examining server logs. Finally, in Phase 4, participants completed an exit survey on their experience with Locyoution.

To determine the impact of feedback on the privacy attitudes and adoption of our mobile location application, participants were divided into two conditions:

No Feedback condition: Participants did not receive information about who had requested their location ($n = 30$).

Feedback condition: Participants were able to view their location disclosure history ($n = 26$).

Method

We recruited participants from a university population, offering a \$20USD online gift certificate as compensation for completion of the study. We posted flyers around campus,

and advertised on university mailing lists. We realized that there was a significant potential for participant attrition due to the nature of the study (a field investigation with a relatively "hands-off" approach), and thus recruited a large number of participants. After respondents completed the pre-study survey, we invited 123 users to participate in our study.

To mimic real world usage, participants were provided with online instructions for participation, no physical meetings or lab sessions were conducted. Participation involved downloading and installing the Locyoution software and adding the Facebook application. Users were also provided with a username and password so that they could link their laptop software to their Facebook account.

In the course of the study, we disqualified 6 users for not completing all pre-study requirements and 1 due to a operating system related incompatibility. Additionally, 16 users dropped out: 3 people were unable to get the software to work, 3 people did not have wireless on their laptops, 2 people were too busy to use Facebook, 2 people were too concerned about their privacy to use the technology, and 6 people declined participation for indeterminate reasons. Of the remainder, 75 users added the Facebook application. From this group, 64 were able to successfully use the software and Facebook application. Of those, 56 participated in our active data collection phase of the study. The results discussed in this paper are based on the data analysis of these 56 participants.

Data Analysis

The duration of the study was 4 weeks: the first two weeks consisted of installation and troubleshooting, during which the majority of participants were away from campus for a week, and the final two weeks consisted of "normal" usage. We kept in touch with participants periodically, sending email reminders about using Locyoution. To the feedback group, we sent information about the "Who Has Viewed You" feature of the application. Our data analysis covers the full 4 weeks of the study.

After the conclusion of the study, we analyzed the usage of Locyoution and the results of the pre-study and exit surveys. We examined differences between the conditions and their privacy attitudes, technology acceptance, and rule usage. In the next sections, we focus on the implications of privacy, feedback, and rule expressiveness.

Usage

A total of 233 requests were made to locate our 56 participants, or about 4 requests per participant, over the main two-week usage period. Of those requests, 43.4% were successful. Between the two conditions, there were no statistically significant differences between the proportion of requests where locations were returned to the requestees, Fisher's exact $p = 0.57$, with 44.9% of requests being successful in the no feedback condition and 40.3% of requests being successful in the feedback condition.

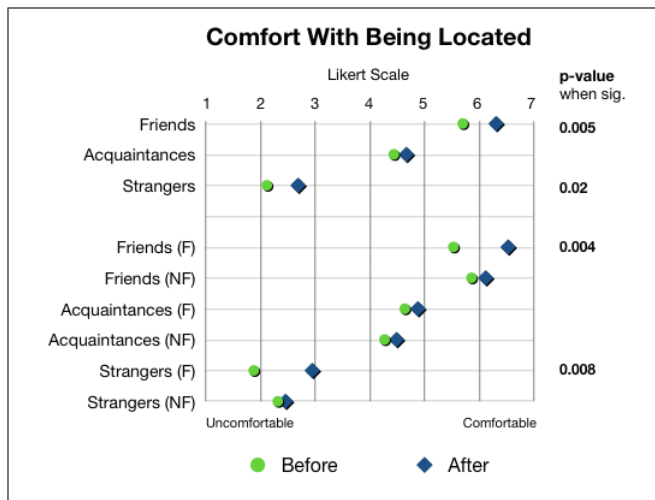


Figure 4. Survey results for comfort levels in location-finding. These results are based on a Likert scale from 1 to 7, ranging from not comfortable at all to fully comfortable. For the Feedback condition, participants were less uncomfortable afterwards with allowing themselves to be located by friends and strangers. This explains the statistical significance for both conditions combined (top section), where overall participants are more comfortable with displaying their locations to friends and strangers than they were prior to using Locyoution.

PRIVACY

Participants were asked about the level of concern they had with using a location-sharing application before and after they used Locyoution. We wished to study any differences in perceived privacy concerns before and after participants used the mobile location-sharing technology. In the surveys, users indicated their level of concern using a Likert scale from 1 to 7, ranging from no concern to extremely concerned. Prior to using Locyoution, participants indicated they had moderately high concerns for their privacy, $M = 4.63$ (99% CI = 4.04 - 5.21). After using Locyoution, the level of concern they had for their privacy ($M = 3.96$, 99% CI = 3.31 - 4.62) was reduced a statistically significant amount, $t(55) = 2.21$, $p = 0.031$. Based on these results, we see that users of Locyoution were concerned about their privacy prior to using the technology, and after a month of usage, participants' privacy concerns were slightly reduced.

To examine the impact of relationships on willingness to share location, participants were asked, prior to the study, about the level of comfort they thought they would have with friends, acquaintances, and strangers finding their locations anytime, at times they had specified, or at locations they had specified. As expected, participants were much more comfortable, in general, with friends finding their locations as compared to acquaintances, and acquaintances as compared to strangers. The differences between each of the types of relationships is statistically significant.

When comparing within each relationship type the period when their location information would be shared, we see that people are the least comfortable with allowing any of the groups to view their locations at anytime. For friends and acquaintances, participants indicated that they had the highest

	Before	After	<i>t</i> statistic	<i>p</i> value
Friends	5.71	6.32	-2.94	0.005
Acquaintances	4.45	4.70	-0.99	0.33
Strangers	2.12	2.70	-2.33	0.02

Table 1. Comfort levels of being located by certain groups of people before and after using Locyoution. Paired T-tests have a degree of freedom of 55 for each type of relationship. Mean values are based on a Likert scale from 1 to 7, ranging from not comfortable at all to fully comfortable.

level of comfort sharing their locations using location-based rules. For strangers, participants were equally uncomfortable with allowing access using time-based rules or location-based rules.

At the end of the study, we again asked our participants how comfortable they had been with allowing friends, acquaintances, or strangers view their locations subject to time-based rules. See Table 1 for mean values and significance levels and Figure 4 for a graphical comparison. For the aggregate dataset, we found that participants, afterwards, were statistically significantly more comfortable with friends and strangers viewing their locations than they had been prior to using the system. While comfort levels for acquaintances also increased, this difference was not statistically significant.

Based on responses to the exit survey, we see the differentiation between privacy concerns in the Feedback and the No Feedback conditions. Participants with feedback were much more comfortable with being located by *friends* and *strangers*, compared to their perceived levels of comfort at the beginning of the study, based on results of paired T-tests by condition. We attribute the statistical significance for the aggregate dataset (Table 1) to the change in comfort levels to people in the Feedback condition. For participants who did not receive feedback, we observe that their comfort levels did not change after using the system. See Table 2 and Figure 4 for these results. Participants in the Feedback condition assumed they would be comfortable with being located by friends based on time-based rules. After using Locyoution, they became much more comfortable about being located by friends. Participants in the Feedback condition were not comfortable being located by strangers, even with time restrictions. After using the system, they became slightly less uncomfortable about being located by strangers at the time allowed by their rules.

In summary:

- People have privacy concerns about sharing their location, but experience with the system slightly reduced their privacy concerns.
- People who had received feedback become more comfortable with sharing their location information with friends and strangers.
- Users in the Feedback condition had a lesser degree of concern for their privacy after using the technology.

	Cond.	Before	After	<i>t</i> statistic	<i>p</i> value
Friends	F	5.54	6.54	-3.14	0.004
	NF	5.87	6.13	-1.03	0.31
Acq.	F	4.65	4.89	-0.59	0.56
	NF	4.28	4.5	-0.81	0.42
Strangers	F	1.89	2.96	-2.90	0.008
	NF	2.33	2.47	-0.43	0.67

Table 2. Comfort levels of being located before and after using Locyoution by condition and relationship type, Friends, Acquaintances (Acq.), and Strangers. Paired T-tests have a degree of freedom of 25 for the Feedback condition and 29 for the No Feedback condition. Mean values are based on a Likert scale from 1 to 7, ranging from no concern to high concern.

FEEDBACK

Based on the pre-study questionnaire, participants were interested in knowing who had looked at their Facebook profiles, $M = 5.02$ (99% CI = 4.44 - 5.59), (based on a Likert scale from 1 to 7, from not interested at all to extremely interested), but were neutral about how they would feel if others knew they were looking at other people's profiles, $M = 3.96$, (99% CI = 3.31 - 4.62), (based on a Likert scale from 1 to 7 from not comfortable at all to fully comfortable). As one participant noted, "So, I'm interested in seeing who has seen me, but obviously, I'm concerned [about] them knowing if I looked up their locations." There is lack of reciprocity; wanting information for yourself, but not wanting others to have that same information.

At the end of the study, we surveyed the Feedback condition on their experiences and opinions of the "Who Has Viewed Me" feature. To the No Feedback condition, we presented screenshots of the "Who Has Viewed Me" interface to solicit their viewpoints on the future inclusion of such a feature. The majority of people in both conditions wanted feedback (76.9% of those who had it were happy they did and 83.3% of those who did not have it wanted it, Fisher's Exact $p = 0.58$). Only one person in the Feedback condition would have preferred an opaque system.

We asked our participants if knowing who had viewed them made them or would have made them more willing to share their location with others. For those in the Feedback condition, having feedback made them more willing to share their location (84.6%). Fewer people in the No Feedback condition thought having feedback would make them more willing to share their location (56.7% were willing, 23.3% were not willing, and 20% were unsure). These differences were marginally significant, Fisher's exact $p = .09$.

In summary:

- In general, people want to know who has been viewing them. But, for those who did not receive feedback, more people were unwilling or unsure if they would be more willing to share their locations with others.
- The desire to know who has been viewing one's profile is compelling enough that participants would be willing to trade in an opaque system to have it.

	Feedback	No Feedback
All Networks/Friends (Default)	57.7%	46.7%
Some Networks/All Friends	7.69%	3.33%
Only Friends	34.6%	50.0%

Table 3. The Facebook-based application privacy settings used by participants in the Feedback and No Feedback conditions. The differences in proportions are not statistically significant, Fisher's exact $p = 0.22$.

RULE EXPRESSIVENESS

To examine the impact and usability of rules, we asked people to rate the usefulness of time-based rules and to provide feedback on other types of rules. Participants, in general, indicated that they were able to easily create and define rules ($M = 5.4$, 99% CI = 4.79 - 5.9), they were confident that their rules represented their privacy preferences ($M = 5.3$, 99% CI = 4.73 - 5.77), and most were confident that the rules worked ($M = 5.53$, 99% CI = 4.87 - 5.43). When asked if time-based rules provided enough control ($M = 4.95$, 99% CI = 4.47 - 5.42), most agreed.

Users were also asked about their likelihood of using additional types of rules. We found that users say they are likely to use rules based on groups of people or friend lists, ($M = 5.88$ (99% CI = 5.48 - 6.27) and location based rules ($M = 5.45$ (99% CI = 4.86 - 6.03). Means are based on a Likert scale from 1 to 7 ranging from very unlikely to very likely. Users said they were less likely to use proximity, making one's location available to people within 1 mile of you, and granularity-based rules, displaying only the city or state of their current location, ($M_{granularity} = 4.34$, 99% CI = 4.96 - 3.72; $M_{proximity} = 3.68$, 99% CI = 3.13 - 4.23).

Another type of rule that several users requested was that of being able to "include/exclude specific people rather than networks." These whitelists or blacklists would allow users fine-grained control over who is able to see their location information. Having the ability to restrict a mobile location technology to actual, real friends, yet still use the convenient medium of Facebook may also have a significant impact on reducing privacy concerns and encouraging the continued use of such an application.

Examining participants' use of Facebook's application-based privacy settings, we see that the majority of participants (51.8%) used the default setting of allowing "All of their networks and friends" to view the Locyoution application in their profile. The other large proportion of users (42.9%) changed this setting so that only "Friends" could use Locyoution to locate them. Differentiating by condition, a greater proportion of people in the No Feedback condition set their Facebook privacy settings to that of "Friends Only," but the differences in proportions are not statistically significant. See Table 3 for the proportions and privacy settings for each condition.

After the conclusion of the study, we examined the users' final rules, per condition, to evaluate how "open" the rules were in terms of number of hours that users allowed themselves to be found. The average number of hours that partic-

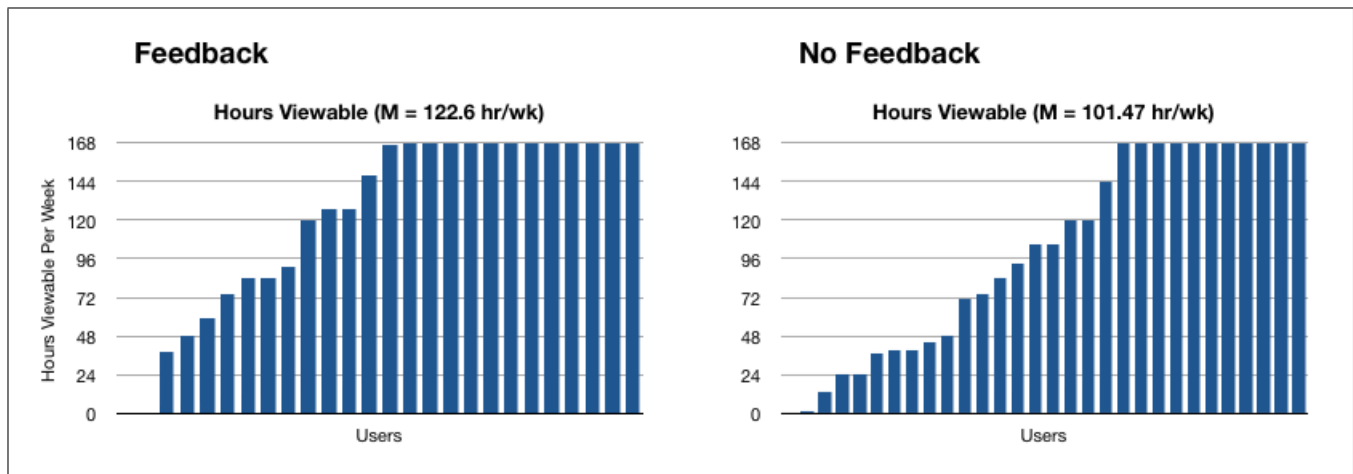


Figure 5. The number of hours per week that a user's rules allowed him or her to be viewable at the conclusion of the study are displayed above split by the Feedback and No Feedback conditions.

Participants in the Feedback condition made themselves available ($M = 122.7$ hours) is greater than that in the No Feedback condition ($M = 101.5$), see Figure 5; but the differences in the one-sided T-test ($p = 0.096$), are only marginally significant. It may be that people who have feedback made themselves available for a greater number of hours because they are more comfortable with the use of the system. Due to the "Who's Viewed You" feature, they can see when, how often, and by whom they are being queried and adjust their rules accordingly.

- Users in the study seem to feel comfortable enough with the level of control they were given to actually use the system, while at the same time indicating that they wished they had access to more expressive rules.
- Participants were relatively happy with time-based rules, but feel that they would be likely to use location-based rules and group-based rules.
- Users of mobile location sharing systems may make their locations viewable for a greater number of hours (if using time-based rules) if they can see who has been checking their locations.

TECHNOLOGY ADOPTION

To explore what factors contribute to the continued use of location-based technologies, we included a series of questions in the pre-study survey and in the exit survey based on a model of technology adoption for privacy-enhancing technologies [28]. This allows us to determine participants' general privacy attitudes, how technically savvy they were, their opinions on the ease of use of the technology, the importance of the perceived control they had with the ability to create rules, their sense of helplessness in the use and existence of such a technology, the opinion of their peers of mobile location technologies, and their opinion of new technology representing positive progress in the world. We conducted a logistical regression to determine whether people could continue to use the technology, based on these factors. The results of the regression are presented in Table 4.

	# items	Cronbach's α	Wald χ^2	p value
Condition	-	-	0.33	0.57
Control	1	-	0.02	0.89
Easy to Explain	1	-	0.57	0.45
Helplessness	4	0.82	2.32	0.13
Peer Opinion	2	0.71	9.2	0.002
Privacy Scale	6	0.86	1.34	0.25
Tech. Savviness	3	0.80	5.82	0.016
Tech. Progress	1	-	0.50	0.48

Table 4. Above, the technology adoption factors included in our pre-study and exit surveys are presented showing their influence in continued use of location-based technology. In the logistic regression model, the Wald's χ^2 degrees of freedom is 1 and $n = 56$.

The logistic regression model has a likelihood ratio $\chi^2 = 0.0001$, indicating that the factors included in the model have a significant impact on whether or not people decide to continue using the mobile location-sharing technology. The model has a max rescaled R^2 of 0.57, indicating that the factors included in the model can explain about 57% of the variance in deciding whether to continue using the mobile location sharing technology. The two main factors of significance are peer opinion ($p = .002$), and technical savviness ($p = 0.016$). In the 7-point scale for peer opinion, for every 1-point increase, the odds of continuing use of the technology are increased by a factor of 4.44. Similarly, for every 1-point increase in the 7-point scale for technical affinity, the odds of continuing use are increased by a factor of 2.64.

- Peers have a significant impact on whether or not a user will accept and continue to use a mobile location-sharing technology.
- The more technically savvy someone is has an impact on whether or not a user will continue to use a mobile location-sharing technology.

DISCUSSION

In this field experiment, we find that feedback can play a role in the adoption of mobile location-sharing technologies. Despite the success of existing OSNs or mobile location technologies that lack feedback, feedback has a role in the comfort of using such technologies. For designers of ubiquitous computing technologies, we offer the following insights to consider as they develop new technologies.

Context

The overall context may have an impact on whether or not feedback is necessary. In the case of real-time location requests, people desire social translucency due to the sensitive nature of this information. The interface and technical mechanisms in place in our mobile location-sharing technology allowed the system to provide to users details of who had viewed their locations. Subsequently, this information played a role in easing people's privacy concerns. In other contexts—for example, online profiles (Facebook), current music choices (last.fm), or the number of miles run (Nike Plus)—feedback may be less important.

Control

Designers should examine the types of controls and the amount of expressiveness that the controls provide. We find that people are willing and able to use rules to control access to their location information, and feedback does not cause users to lock down or severely restrict their information sharing, certainly a present fear of many OSNs, but may actually lead to more open policies. For future systems, mobile location-sharing technology developers may be well served by building disclosure history feedback into their systems as well as methods to define more expressive privacy preferences. Offering a diverse palette of rule types to govern the disclosure of personal location information empowers people to protect their own privacy, lessening concerns. While the top current OSNs do not have any system translucency, this initial work may address many of their reservations. Giving users more control over their privacy and knowing that this information is likely to make users more comfortable with the spectrum of people inquiring about their information are both positive for the OSNs.

Bells & Whistles

Designers should understand the customer they are trying to target. In addition to the technology acceptance model's tenets of perceived usefulness and perceived ease-of-use [9], other factors may influence technology adoption. We have seen that adoption of a mobile location-sharing technology depends highly on technical ability. While developers need to target the "bleeding edge," they must maintain a positive buzz about their services to keep users and their peers enthusiastic about location-based technologies. As OSNs continue to grow in features and population, we hope to see a balancing of the amount of social translucency and information users receive and their comfort in exploring and using the network.

CONCLUSION

This research presents the findings of a study examining the impact of control and feedback for sharing location disclosures. Based on a four-week field investigation of a mobile location-sharing application embedded in an online social network, our findings can inform the design of mobile social systems:

- Providing feedback to users about when and by whom they have been queried tends to make them more comfortable about sharing location information.
- Feedback is a desired feature in such a system and makes users more willing to share their location information.
- Users are able to use time-based rules to control access to their location information, and they feel that these rules accurately represent their privacy preferences.
- In addition to time-based rules, users also indicated that they are likely to use location-based and group-based rules.
- Users who have feedback are more likely to set rules that make themselves findable for a greater number of hours.
- Peers and technical savviness have a significant impact on whether or not a user will accept and continue to use a location technology.

ACKNOWLEDGMENTS

This work is supported by NSF Cyber Trust grant CNS-0627513 and ARO research grant DAAD19-02-1-0389 to Carnegie Mellon University's CyLab. Additional support has been provided by Microsoft through the Carnegie Mellon Center for Computational Thinking, by FCT through the CMU/Portugal Information and Communication Technologies Institute, and by FranceTelecom and Nokia. PeopleFinder's WiFi-based location tracking functionality runs on top of technology developed by Skyhook Wireless.

REFERENCES

1. D. Anthony, D. Kotz, and T. Henderson. Privacy in location-aware computing environments. *IEEE Pervasive Computing*, 6(4):64–72, 2007.
2. L. Barkhuus, B. Brown, M. Bell, M. Hall, S. Sherwood, and M. Chalmers. From awareness to repartee: Sharing location within social groups. In *CHI '08*, pages 497–506, April 2008.
3. L. Barkhuus and A. Dey. Location-based services for mobile telephony: a study of users' privacy concerns. In *INTERACT'03*, pages 702–712, 2003.
4. V. Bellotti and A. Sellen. Design for privacy in ubiquitous computing environments. In *ECSCW '93*, 1993.
5. B. Brown, A. Taylor, S. Izadi, A. Sellen, J. Kaye, and R. Eardley. Location family values: A field trial of the whereabouts clock. In *Ubiquitous Computing (Ubicomp '07)*, pages 354–371. Springer-Verlag, 2007.

6. B. Charny. New cell feature helps find friends, July 25 2002. <http://www.news.com/2100-1033-946224.html>.
7. S. Consolovo, I. Smith, T. Matthews, A. LaMarca, J. Tabert, and P. Powledge. Location disclosure to social relations: Why, when, & what people want to share. In *CHI '05*, 2005.
8. J. Cornwell, I. Fette, G. Hsieh, M. Prabaker, J. Rao, K. Tang, K. Vaniea, L. Bauer, L. Cranor, J. Hong, B. McLaren, M. Reiter, and N. Sadeh. User-controllable security and privacy for pervasive computing. In *IEEE Workshop on Mobile Computing Systems and Applications (HotMobile '07)*, 2007.
9. F. Davis, R. Bagozzi, and P. Warshaw. Extrinsic and intrinsic motivation to use computers in the workplace. *Journal of Applied Social Psychology*, 22:1111 – 1132, 1992.
10. T. Erickson and W. A. Kellogg. Social translucence: an approach to designing systems that support social processes. *ACM Trans. Comput.-Hum. Interact.*, 7(1):59–83, 2000.
11. J. Hightower, A. LaMarca, and I. E. Smith. Practical lessons from place lab. *IEEE Pervasive Computing*, 5(3):32–39, 2006.
12. L. Holson. Privacy lost: These phones can find you. *New York Times*, October 23 2007. <http://www.nytimes.com/2007/10/23/technology/23mobile.html>.
13. G. Hsieh, K. Tang, W. Low, and J. Hong. Field deployment of IMbuddy : A study of privacy control and feedback mechanisms for contextual IM. In *Ubiquitous Computing (UbiComp '07)*, pages 91–108, 2007.
14. S. Huang, F. Proulx, and C. Ratti. iFIND: a Peer-to-Peer application for real-time location monitoring on the MIT campus. In *CUPUM 07 - 10th International Conference on Computers in Urban Planning and Urban Management*, July 11-13 2007.
15. G. Iachello and J. Hong. End-user privacy in human-computer interaction. *Found. Trends Hum.-Comput. Interact.*, 1(1):1–137, 2007.
16. G. Iachello, I. Smith, S. Consolovo, G. Abowd, J. Hughes, J. Howard, F. Potter, J. Scott, T. Sohn, J. Hightower, and A. LaMarca. Control, deception, and communication: Evaluating the deployment of a location-enhanced messaging service. In *UbiComp 2005*, pages 213 – 231. Springer-Verlag, 2005.
17. G. Iachello, I. Smith, S. Consolovo, M. Chen, and G. Abowd. Developing privacy guidelines for social location disclosure applications and services. In *SOUPS '05*, 2005.
18. I. Junglas and R. Watson. Location-based services. *Communications of The ACM*, 51(3):65–69, March 2008.
19. A. Khalil and K. Connelly. Context-aware telephony: Privacy preferences and sharing patterns. In *CSCW '06*, 2006.
20. S. Lederer, J. Mankoff, and A. K. Dey. Who wants to know what when? privacy preference determinants in ubiquitous computing. In *CHI '03*, number 724-725, 2003.
21. C. McCarthy. The mobile social: Not ready for prime time?, February 13 2008. http://www.news.com/8301-13577_3-9870611-36.html.
22. A. G. Miklas, K. K. Gollu, K. K. W. Chan, S. Saroiu, K. P. Gummadi, and E. de Lara. Exploiting social interactions in mobile systems. In *UbiComp 2007*, volume 4717/2007, pages 409–428, 2007.
23. S. Patil and J. Lai. Who gets to know what when: Configuring privacy permissions in an awareness application. In *CHI '05*, pages 101 – 110, 2005.
24. M. Raento, A. Oulasvirta, R. Petit, and H. Toivonen. Contextphone: A prototyping platform for context-aware mobile applications. In *Pervasive '05*, pages 51 – 59, 2005.
25. N. Sadeh, F. Gandon, and O. B. Kwon. Ambient intelligence: The myCampus experience. Technical Report CMU-ISRI-05-123, Carnegie Mellon University, July 2005.
26. N. Sadeh, J. Hong, L. Cranor, I. Fette, P. Kelley, M. Prabaker, and J. Rao. Understanding and capturing people's privacy policies in a mobile social networking application. *Personal and Ubiquitous Computing*, Forthcoming 2008.
27. I. Smith, S. Consolovo, A. LaMarca, J. Hightower, J. Scott, T. Sohn, J. Hughes, G. Iachello, and G. Abowd. Social disclosure of place: From location technology to communication practices. In *Pervasive '05*, pages 134 – 151. Springer-Verlag, 2005.
28. S. Spiekermann. *User Control in Ubiquitous Computer: Design Alternatives and User Acceptance*. Shaker Verlag, 2008.
29. S. Stumpf, V. Rajaram, L. Li, M. Burnett, T. Dietterich, E. Sullivan, R. Drummond, and J. Herlocker. Toward harnessing user feedback for machine learning. In *IUI '07: Proceedings of the 12th international conference on Intelligent user interfaces*, pages 82–91, New York, NY, USA, 2007. ACM.
30. R. Want, V. Falcão, and J. Gibbons. The active badge location system. *ACM Transactions on Information Systems*, 10:91–102, 1992.