Control, Deception, and Communication: Evaluating the Deployment of a Location-Enhanced Messaging Service

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Abstract. We report on a two-week deployment of a peer-to-peer, mobile, location-enhanced messaging service. This study is specifically aimed at investigating the need for and effectiveness of automatic location disclosure mechanisms, the emerging strategies to achieve plausible deniability, and at understanding how place and activity are used to communicate plans, intentions and provide awareness. We outline the research that motivated this study, briefly describe the application we designed, and provide details of the evaluation process. The results show a lack of value of automatic messaging functions, confirm the need for supporting plausible deniability in communications, and highlight the prominent use of activity instead of place to indicate one's location. Finally, we offer suggestions for the development of social mobile applications.

1 Introduction

Social mobile applications are a category of mobile computing applications that support individuals and groups in interacting with their social milieu. These applications, which include mobile voice and messaging, person finders, and geographic recommendation systems, are characterized by a common set of requirements and concerns, especially related to availability, privacy and management. We are particularly interested in location-enhanced applications, because our own observations, ethnographic literature and market research surveys all suggest that location plays a fundamental

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role in accomplishing everyday communication and coordination tasks. For example, English [7] and German [10] studies agree that one of the most frequent uses of SMS is to coordinate and schedule meetings, for which location plays a significant role.

We are interested in understanding how people use location and place to communicate with each other, considering the phenomenological characteristics of place and the cultural baggage that is associated with it, including notions of presence, privacy, activity and cultural geography. One application we have recently developed is Reno, a peer-to-peer, location-enhanced service for cell phones that allows users to communicate their position to others. Considerable preparations have preceded the deployment of Reno. We first performed an Experience Sampling Method (ESM) study [4]; the communication strategies suggested by the participants of that study led to the development of a prototype, which was piloted with members of this research group [30]. The pilot study confirmed the potential usefulness of the application, and exposed some of the consequences engendered by the communication of one's location.

In order to minimize disruption of people's activities, Reno supports automatic 'pull' and 'push' disclosures of the user's location, which raise questions regarding the balance of usefulness, management effort and control, as well as safety and privacy concerns. These issues were not specifically addressed in the pilot study, which focused instead on the role of location in interpersonal communication. We thus set out to investigate the concerns and practices engendered by Reno, with special attention to the need, motivation and risks associated with artifacts acting on the user's behalf, and the widely acknowledged need for plausible deniability in interpersonal relations [5, 15, 17]. This article reports on the findings of a real-world deployment of Reno with two families with teenage children and their friends. In the remainder of this article, we briefly describe Reno, provide details of the study process and results, and offer some remarks useful for developing social mobile applications.

2 Reno

The version of Reno we used in this study is the latest in a series of successive designs, refined after the pilot study [30], interviews with users and a cognitive walkthrough performed by two expert HCI professionals. Reno is a location-enhanced messaging application for Nokia Series 60 phones that allows the user to request the location of other users and to tell his/her location to them.

Before using Reno to disclose a location, the user must define place names (*e.g.*, "School" or "Home") and assign them to physical locations. The program will offer the name whenever the user subsequently visits that location. When sending a location, either as a reply to a request or by the user's initiative, Reno offers a selection of nearby place names, as computed by the location algorithm. Location sensing is performed using cell tower connection patterns, similar to the technique described by Laasonen *et al.* [18]. The physical location (cell tower) of the user is never sent by Reno: only the place name or activity defined by the user is (Fig. 1). Reno also provides a customized, pre-defined list of activities that may be used instead of place names for replying to messages. One of the aims of this design is to minimize the need for typing on the phone for messages involving location disclosures: if the place name is already defined, only two interaction steps (selections) are necessary for

Fig. 1. A usage scenario for Reno. The application presents a list of likely locations and a static list of activities when replying to request. (Drawing by K. Truong)

replying to a location request. All basic tasks require three or fewer selections to be completed (excluding typing new place names).

Reno has two automated features: the *Instant Reply List* and *Waypoints*. Reno will automatically reply with the current most likely location to any request coming from a person on the *Instant Reply List* (which is a user-defined subset of the Reno contact list). If the location is undetermined, Reno transmits "Unknown Location." *Waypoints* cause Reno to trigger a location disclosure whenever the user enters a specific, pre-defined location (to avoid bursts of messages when the user briefly leaves and returns to the same location, there is a two-hour timeout). To set up a Waypoint, the user must indicate both the location of interest and the recipient of the message. Users can see how many times Reno disclosed their location automatically using an audit tool called *Activity Report*.

Reno uses SMS messages to communicate. The messages consist of two parts: a human-readable sentence, followed by compressed information, a checksum and a 'magic' string used for message recognition. Human-readable messages increase the opportunities for using the application with people not using Reno.

3 Hypotheses

Before engaging in an actual deployment of Reno, we performed a pilot study [30], to identify fundamental issues requiring further investigation. The short duration (5 days) and the choice of participants (the researchers with some family and friends) did not provide a firm basis for the collected evidence. Moreover, we refrained from addressing privacy questions in that study because the specific skills and knowledge of the participants would not support general observations. In this study, we set out to test the following hypotheses:

1. Automatic disclosures are not problematic with appropriate corrective measures.
2. Deception and denial practices will occur with Reno.
3. Activity, as well as place, will be used by participants in their communications.

The selection of the first two research questions resulted from an analysis process balancing the need for and usefulness of automatically disclosing location to others and the privacy concerns of the application's stakeholders [12]. The third question

was motivated by the observation of the pilot participants' uses of location disclosures.

3.1 Automatic Location Disclosure Is Not Problematic

This hypothesis is particularly interesting due to the ongoing debate about the trade-offs between automatic technology and people's concerns about its impact on privacy and social relations. Research in the mid-90's on the management of availability for receiving calls on cell phones suggested that caller identity, the stated urgency, and topic of the communication could be used to decide on a case-by-case basis whether to answer the phone [27]. Other research used rule engines to automatically decide, on the user's behalf, whether to disclose personal information such as location [11].

However, recent work in information security has highlighted the importance of optimistic security for controlling access to information in organizations [26]. Optimistic security employs social pressure to achieve self-restraint, and simple technical means and *ex post facto* redress to prevent unauthorized access, instead of creating complex security and access control policies upfront. This approach could be used for limiting unwanted access to location information. Our objective is to understand whether lightweight mechanisms are good enough for users of social mobile applications, or whether more complex technical solutions are really necessary.

3.2 Denial and Deception Practices Will Occur

To the best of our knowledge there has been no real-world study of deception and denial in location-enhanced applications, except for Benford *et al.*'s, which however relates to the unusual situation of a mixed-reality game [2]. However, commonsense observation and social science research [5, 7, 15, 17] indicate that these practices are essential for protecting one's environmental privacy ("being left alone"), simplifying interaction and meeting others' expectations. Acceptance of ubicomp applications require that these practices be understood and accommodated.

In our ESM study, participants stated that they preferred not to deceive outright, but rather use denial strategies (*e.g.*, not answering) instead. So, we built various ways for achieving deception and denial with Reno (*e.g.*, using inaccurate names to label locations, not labeling the location, responding with an activity, or ignoring requests). We hypothesized that users would deny disclosing their location in some instances by delaying replies, time-shifting answers, and ignoring requests, but not by outright deception. Participant selection was crafted to expose potential tensions [15].

3.3 Activity, as Well as Place, Will Be Used

In the pilot study, we observed that participants used location as a proxy for other messages, including their current activity and availability, their future movements, and for predicting arrival times. This observation mirrors ethnographic literature on the use of mobile phones, which points out that even though people often begin cell phone conversations with telling or asking about location, what they really communi-

cate are activity and availability [31]. In this study, we set out to understand how people use place and activity, by providing an option to tell their current activity instead of their location with Reno and characterizing instances of use.

4 Demographics and Process

We enrolled two families with teenage children by posting ads on high school bulletin boards in Seattle. We asked the parents and two children from each family to participate. We then asked each child to contact one friend or schoolmate, so that we could observe usage within parent-child and peer relationships. We chose families with children 16 or under to expose coordination and dependence dynamics, as well as a need for independence. Participation requirements included: use of a cell phone for adult participants (to reduce novelty effects), adults not in Information Technology-(IT) related occupations, at least one parent working outside the home, and children attending school outside the home (to guarantee a minimal amount of mobility).

The need for entire families, the proximity of the holiday season and busy lifestyles made recruitment challenging. Maximum compensation was USD160 per participant, for a total involvement of 10 hours over 3 weeks. Compensation was tied to participation in the interviews and to the number of email surveys completed, to encourage active participation without impacting the usage of the application.

We enrolled 11 participants (6 female). The ages of the parents were between 48 and 52. All were employed full-time outside of the home; two were architects, one was a program director for social services and the fourth was a traveling salesperson. Six teenage participants were 16 years old, and one was 14 years old. All attended one of two schools. All participants had lived in the Seattle metropolitan area anywhere from 9 to 25 years (avg. 14.2).

Participants were representative of a large segment of the US population regarding their familiarity with IT. All owned a computer and used a PC both at home and at school/work, and all but two used email and the web frequently. No adult used Instant Messaging (IM), whereas all teenagers did (5 out of 7 did so frequently). Adult participants all owned cell phones, as well as 4 teenagers—consistent with statistics of cell phone use in the US[1]. Adults did not use Text Messaging (SMS) on the phone regularly. Of the teenagers who owned cell phones, one reported sending more than 100 messages per month, another reported 21–40 messages per month, and two reported less than 10 messages per month (also consistent with SMS use statistics).

Fig. 2 depicts the social networks involved in this study. Lines connect participants who knew each other before the study and indicate the self-reported assessment of how often the two participants meet each other in person (if the paired responses differed, we defaulted to the most frequent). The adults are depicted in darker circles. The two families and their friends formed two substantially distinct social groups although some of the children attended the same school and knew each other. Participants 1–5 formed Group 1, while participants 6–11 formed Group 2.

[1] 72% of US adults and 56% of teenagers owned a cell phone at the end of 2004. Sources: Harris Interactive Survey, The Yankee Group 2004 Mobile Users Survey.

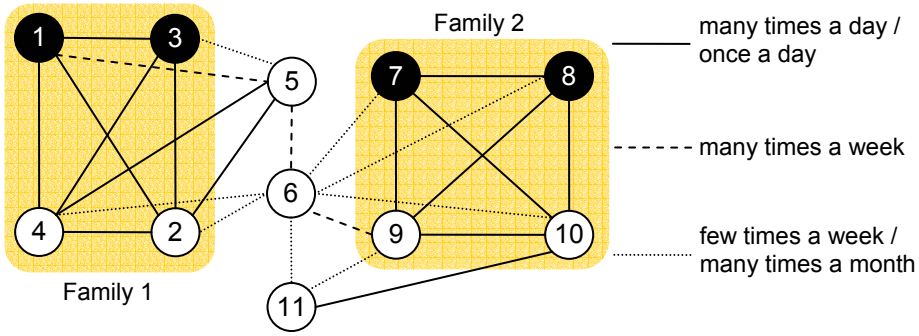

Fig. 2. Graph depicting how often participants see each other. (Adults in darker circles.)

After a screening phone interview and the selection of the two families, we invited each participant for a 60 minute introductory session, in which we explained the study goals, demonstrated the application, and administered demographic surveys and release forms. We also asked participants to compile lists of activities they would likely engage in and places they would visit during the following weeks. These lists were pre-coded into the software as shortcuts to reduce the negative impact of typing.

Deployment started one week thereafter. Participants participated in a short training session at our offices and were provided with a Nokia 6600 phone with Reno preloaded. We transferred the SIM cards and contact lists of the participants who had GSM phones and who agreed to do so (5 out of 11 participants). Participants used Reno for a period of 14 to 18 days. Every other day, participants were sent an email survey with questions about their use of Reno including whether they had left the phone behind; why and when they had requested or disclosed a location; and whether they had ignored requests, delayed responding, responded with something other than their actual location or communicated about location by other means than with Reno.

The software performed extensive logging of user activity. At startup and every 24 hours thereafter, the program sent status messages to the investigators via SMS, containing statistics such as cumulative running time, messages sent and received, cumulative time in unlabeled locations, and up to four samples of the participant's location disclosures per day. Finally, the phone kept an internal log of communication activity, creation/deletion of places and contacts and of application malfunctions.

We interviewed each participant for 30–45 minutes after one week of use and for one hour at the end of the study. The interviews were recorded and transcribed for further analysis. We asked participants how they had used the application, both in specific instances and generally. The answers to the email surveys and the status and sample messages sent back by Reno were used as a basis for these interviews, to increase the quality of recollection and provide the opportunity to give situated comments on Reno. We did not directly address privacy or plausible deniability issues until the latter part of the final interview, to avoid influencing their responses.

Waypoints and the Instant Reply List were enabled after one week of deployment, when participants came for the mid-study interview. We chose not to alternate the presence of automatic features between groups (that is, providing automatic features to one group the first week, and to the other the second week) to lower the learning curve by providing simpler functions initially and more complex ones later on. Par-

ticipants were asked to indicate what Waypoints they would like other participants to create for them and on whose Instant Reply List they wanted to be. These requests were then summarized and sent to each participant in a follow-up email inviting them to set up at their discretion the automatic features others had requested.

In the email reminder for the last interview, we offered participants the opportunity to continue using the application for one additional month, with a token compensation but without the duty of filling out the bi-daily email surveys. Despite the appeal of high-end phones (especially for the teenagers), and the desire by one mother to continue using Reno, both groups declined this offer. Usability issues deriving from OS-application integration were among the main reasons for not continuing to use Reno. These issues included lack of integration with the normal SMS application of the phone (some participants in Group 1 at first did not differentiate between the two), reliability of the Java implementation, and Java UI quirks such as the 'Exit' item on all context menus (which quits the application without warning) and security prompts at each startup of the application.

5 Results

Excluding test messages and messages sent by accident, participants sent a total of 347 messages, of which 212 were disclosures (including 34 automatic disclosures). Fig. 3 depicts the volume of messages exchanged over the two-week period between each couple of participants. Outgoing arrows from participants 5, 8, 10 and 11 indicate Reno messages addressed to people outside of the study. Fig. 4 shows the volume of messages sent over the two week period. Note that most of Group 1 started two days later than Group 2. Participants added an average of 4.1 persons to their Reno contact list (which was separate from the phone's standard contact list), excluding test entries (min 1, max 10, median 4).

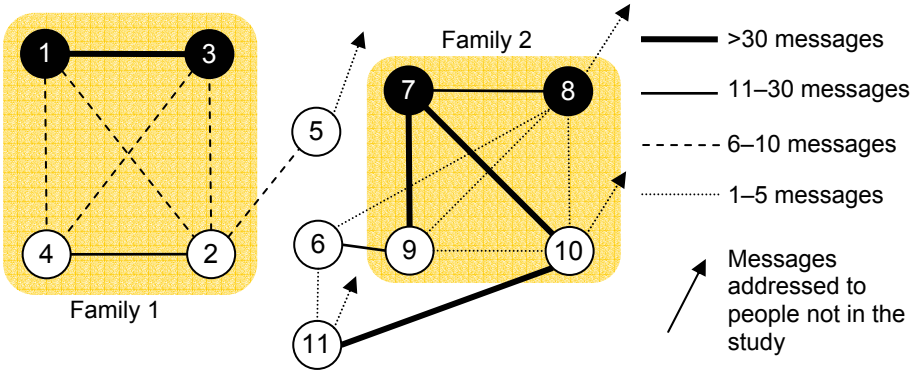

Fig. 3. Volume of messages exchanged between pairs of participants (compare to Fig. 2).

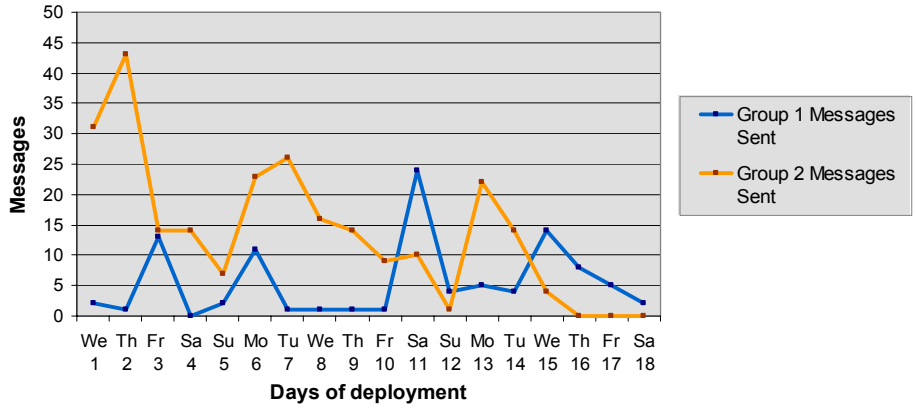

Fig. 4. Daily messages sent; group aggregate.

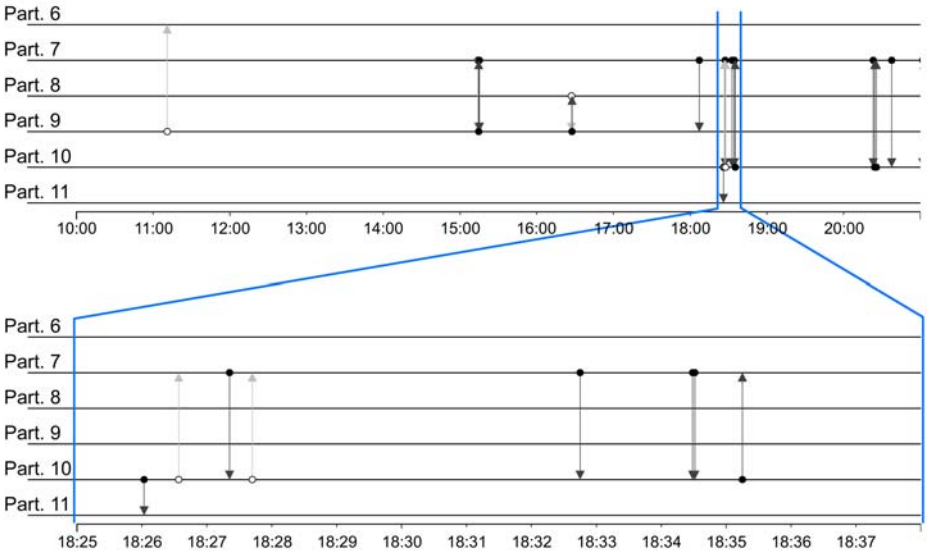

Fig. 5. Messages exchanged by Group 2, on Tue, December 7th. The upper graph shows time span 10:00–21:00. Lower graph zooms in on 18:25–18:38. Light arrows indicate location requests. Dark arrows indicate disclosures.

Use of Reno was concentrated in short bursts around specific events. Fig. 5 shows a sample of use, specifically by Group 2 on Tuesday, December 7th, with a detail of 13 minutes in the late afternoon. Participant 10 was waiting for her mother to come home. This snippet shows three types of messages. The disclosure at 18:26 from participant 10 to her friend (participant 11) was an *awareness* disclosure—"Relaxing." At 18:26 and 18:27, she asked where her mother (participant 7) was because the mother was late—a *waiting* message, to which the mother replied that she was at a store (18:27). The second request may have been sent before the daughter received

her mother's reply, due to SMS transfer delays. The mother then sent 3 *unprompted status* messages: at 18:32 still from the store; at 18:34 she informed the daughter that she was finally "driving" and on her way home (the same message was sent twice, perhaps because she pressed the send button multiple times). The daughter then replied with another awareness message to her mother that she was "studying" (interestingly, different from the message she sent 9 minutes earlier to her friend).

5.1 Automatic Features Are Not Needed

At the outset of this study, we hypothesized that participants would find Instant Replies and Waypoints useful and not invasive, and that these functions just needed to be fine-tuned. However, observed behavior and interviews suggest a radically different conclusion: the participants *did not want* automatic features. The main motivation for the Instant Reply List was to reduce the burden of replying to a large number of messages each day. When asked about the amount of messages sent and received daily, no participant mentioned being overwhelmed by the number of requests.

Only three participants enabled any automated features. When the other participants were asked about their reasons for not configuring Waypoints and the Instant Reply List, only one cited potential privacy issues. All others indicated that 1) they were not completely confident of how the features would work in practice (even though we provided them with extensive training and documentation on the features); and 2) they did not feel a subjective need for setting up Waypoints or the Instant Reply List.

Regarding the Instant Reply List, three participants said that they preferred to control what they tell to others, to avoid confusing the recipient with potentially erroneous disclosures ("I felt like sometimes it [Reno] would be wrong;" [part. 9] "it's just like, y'know, the phone is taking over" [part. 6]).

Participants of the ESM study opposed unsupervised "broadcasting" of messages to others. We introduced Waypoints to verify this in practice. Two of the three participants who had set up Waypoints feared that repeated messages may disturb the recipient ("Cause I thought—well, this could get really obnoxious." [part. 7] "With this pinging all the time—after a while you would quit checking it" [part. 3]). Our participants thought that the other person would not be interested in receiving constant updates about their whereabouts ("So, you control [manual disclosures], I guess is what I'm saying. And—and that sort of process is very important." [part. 3] "I sure don't want to just keep receiving messages when somebody's at some place. Therefore, I don't really want to just send 'em just for the heck of it either." [part. 8]). Reno was used for prompting attention and awareness of oneself: the expressiveness of communication draws on the intentionality of that communication, and automatic notifications do not achieve the same intentional effect as manual messages. Teens seemed particularly concerned by this: no teen set up Waypoints or Instant Replies.

The lack of value of automated features may be caused by the small size of the social networks who participated, each comprising 5–6 users; however, there is reason to question whether social location disclosure applications would be used with much larger groups. In Smith *et al.*'s study on communication within social groups [29], adults' social network size was approx. 20. In our ESM study, participants confirmed that they would share their location with no more than 23 other people, with an aver-

age of 11 people. Teenager social networks size may be larger (in Smith's *et al.* study it averaged 59), but the same study suggests that people with large social networks are willing to invest the effort to manage them. These considerations indicate that automatic functions are *not* a priority for social mobile applications.

These observations contradict some of the preliminary findings of the pilot study, where Waypoints had been useful to participants for a variety of purposes. Pilot study participants were, however, the designers of the application, who had tailored the application to meet their personal needs and knowledge. Real-world evaluation demonstrated that the actual need and perceived usefulness of both automatic features was much lower. Especially the teenagers did not choose to adopt automatic features, and one voiced strong concerns of his parents using the technology to put a leash on him. On the contrary, two adult participants suggested uses of Waypoints and Instant Replies at work, such as using the Instant Reply function to track the whereabouts of employees and Waypoints to receive notifications about the arrival of "scarce resource" consultants at a construction site, in order to arrange unplanned meetings (an ambush-type function [23]). Both participants suggested that the use of this technology could be mandated in employment contracts. While these comments suggest possible uses for automatic location disclosure, they refer to controlled organizational settings, and are aimed at improving workplace coordination and efficiency.

5.2 Control and Environmental Privacy

Seven participants out of 11 (three adults) valued being able to withdraw from a communication and avoid invasions of their and other's personal space, something that is commonly called *environmental privacy* ("you know, I really don't want anybody calling me during a meet [*sic*]" [part. 6] "I didn't want to call him [the son] during class." [part. 7]). Seven participants (two adults) reported that they would intentionally ignore messages to signal unavailability or comply with social etiquette and this protocol was understood by the initiator of the communication. ("I don't always carry my cell phone with me… On purpose." [part. 8]) We found similar results in our ESM study. Reno messages were used by parents to prompt their children during school hours without "get[ting] her in trouble" [part. 3]. All our teenage participants mentioned that school policy prohibited them from using cell phones during class (however, only two teens left their phones in their lockers—all others silenced the phones in class and reported no problems using them there.)

An interesting distinction between teens and adults is revealed: while the concerns with disturbing a teenage recipient relate to the risk of causing potential trouble (in class), the concern with adults is related to interrupting or disturbing *the parent*. These observations are consistent with ethnographic studies that point out the appealing features of text messaging for teens in controlled environments [14, 20]. Participant comments on automatic features related interestingly to environmental privacy, as two participants expressed concern about using Waypoints to avoid "driving her crazy just hearing [the incoming messages]" [part. 3].

5.3 Control and Deception

It is widely acknowledged in social psychology that interpersonal relationships and communication involve significant amounts of deception, from harmless lies told to simplify communication and respond to expectations, to sophisticated constructions to achieve specific goals [4]. Common sense, as well as psychological and sociological studies [15, 17], suggests that teenagers in particular lie to adults for various reasons, and on a variety of topics including their past or present location, whom they are with, and what they are doing [17]. We set out to measure the number of occurrences of:

- delayed answers (*i.e.,* the user knowingly delays answering even if s/he could);
- time-shifted answers (*i.e.,* the answer describes a past or future location, but not the current location);
- ignored requests; and
- explicit deception (*e.g.*, deliberately sending an inaccurate location).

This was done by keeping a log of disclosures in which the disclosed location differed from the most likely location as calculated by the phone, and by asking specific questions in the email surveys and interviews. Participants reported three cases of deception delivered through Reno: one case of time-shift and two inaccurate disclosures. In the first case, a participant was supposed to pick up another person, and replied "Driving" to a location request, though she still was in the office and that option was available when she replied. In her account, she was "actually walking out of the door" and thought "it would be good for [the other participant] to know that I was on my way at least and driving". The second case involved one participant who was home shopping online and replied with "Running errands" as a simple way "of just [letting] them know—I'm just kind of doing some things that aren't too important—if you need me." In the third case the same participant replied "Running errands" instead of his actual location, while he was shopping for Christmas presents to avoid curiosity and accountability; during the interview, he commented: "if I say I'm Christmas shopping, then they'll want to know for who [*sic*] and where."

All in all, these three accounts of deception (out of 212 disclosures) expose a much lower amount of deception than we had expected given social psychology literature. For example, in an influential study on the topic, DePaulo *et al.* indicated that children use some form of deception in up to 30% of the social interactions with their parents and parents use deception in 8% of interactions with their children [5]. There are several plausible explanations for such a discrepancy. First, the definition of social interaction is not clear; in the DePaulo study, for example, social interaction appears to refer to an entire conversation, and it may be questionable whether a single Reno message constitutes a social interaction. Second, participant self-selection may have produced social networks with a high degree of reciprocal trust. Third, while we stressed the confidentiality of interviews to all participants, the teenagers might not have felt comfortable discussing cases of deception with us.

A simpler explanation, however, might lie in the contingent context of the deployment: the study was executed during a busy part of the school year, just before Christmas vacation, and most participants had very regular schedules packed with extracurricular activities. Most teenage participants did not drive or did not have a car—they *needed* their parents to know their location when they were not at school or at home, so they could be ferried from one activity to the next. Furthermore, each family spent both weekends of the study together, a circumstance which reduced the

chance for children to be in unusual or unallowed places. From the methodological perspective, the question ensues of whether a two-week deployment is sufficient for gathering statistically plausible data about such an elusive phenomenon.

While most participants claimed that they would not have a problem disclosing their location to close friends and family, many participants were also acutely aware of privacy issues (the terms "spyware" and "bear collar" were brought up spontaneously by four participants). When asked specifically about privacy concerns, participants suggested that their experience with Reno had not caused concern for various reasons, including the facts that they exchanged location with close family and friends, that location disclosures were intentional and that *place names* were fully under their control: "The person's picking the place. *Of course* it's [the place name] expected. *They* put it on the list." [part. 1]

One of the teenagers expressed concerns that his parents might use Reno to track his whereabouts, and to prevent him from visiting certain friends. Although he used Reno very little because he found calling more convenient, during the interviews he demonstrated a very accurate mental model of the application. He mentioned that his parents (who were not among the study participants) might use the Instant Reply feature as a "punishment," and that they might check his phone regularly to ensure that they were on the list. He reported deceiving his parents about his location in normal phone conversations, and claimed that he would associate different names to the same location and use them based on who was requesting his location, as a deception strategy within Reno.

In summary, we did not gather sufficient quantitative information for verifying our hypothesis on deception, but the qualitative observations provide compelling evidence that the application would allow participants to modulate their disclosures as they felt appropriate, even if this involved deceitful communication. Many participants understood the implications of subjective place naming and the automatic functions. As mentioned above, however, control and usefulness, and not privacy concerns, were the main reasons why participants chose not to use automatic functions.

5.4 Privacy and Social Relations

The results of our field study allow us to draw some conclusions on the characterization of privacy in social relations. Participants viewed privacy concerns as interrelated with broader requirements for control and application utility. While participants unanimously said they would not reply to location requests from unknown people, many teens pointed out that they would feel comfortable telling their location to any of their acquaintances who would go to the trouble of asking. This assertion should be taken with a grain of salt, given that it refers to hypothetical situations, but it demonstrates an expectation of self-restraint and social control that would prevent just any person from asking the location of another.

Self-restraint manifested itself in different ways across participants. Most adults were quite conscious that in a working environment, increased efficiency could justify mandatory use of the application. In the relationship with their children, they valued the ability to inquire their location, but they also considered it inappropriate to spy on their children, even if they felt it was legitimate ("And you know, it's pretty cool sometimes, as a parent, to know where your teenager is […]—but then you're big

brother and I don't know what I think about it." [part. 8]). Most teenagers assumed that none of their peers would request their location (or ask to be on their instant reply list) whom they would not disclose their location to. However, not all teens are alike: participant 5 suggested he would use automatic replies to spy on friends as well.

In view of the great fluidity of these relations, the boundary-setting process of personal privacy, compellingly described by Palen and Dourish [25], is supported much better by optimistic security (which exploits self-restraint and redress mechanisms) than preventive access control. Reno is designed to support such fine-grained control on what the application discloses to others and provides audit functions (the Activity Report) to verify the performance of the automated features. However, the Activity Report was not used by any of our participants who activated Waypoints or the Instant Reply List, suggesting that auditing may be more effective when integrated within the core application interface.

5.5 Activity Vs. Place

In the pilot study we had observed that location was often used as a proxy for conveying other messages, such as status, estimated time of arrival (ETA), or reminders [30]. In response to these findings, we introduced the option of responding to a location request with an activity instead of with a place. Of the aggregate 212 disclosure messages sent, 52% indicated a place and 48% indicated an activity.[2] Most participants, both heavy and occasional users of the application, roughly displayed this breakdown.

To facilitate the naming of locations, we preloaded customized lists of locations for each participant. For this purpose, participants were asked to indicate up to 10 places by choosing among 15 suggested names or supplying their own. A similar questionnaire produced a list of five activities, which appeared in addition to the current location(s) when the user was selecting a message to send with Reno (Fig. 1).

Table 1 shows the number of place names and activities that were defined by the participants before the start of the deployment, names that were added subsequently, how many physical locations were labeled with place names, and how many place and activity names were actually used in messages. Participants added many new place names in addition to those they initially indicated in the questionnaires. Table 2 shows the places and activity names used by one teenage participant. Participants labeled an average of 2.9 locations (min 0, max 9, median 3) with place names (we excluded our office if it had been labeled during the training session).

Participants used 20 unique place names to tell their location: 13 place names were proper names of specific places, understandable by a person living in Seattle. These names are potentially available from a phone directory and could be retrieved based on the user's location. Most remaining place names can be categorized in what Schegloff groups in the set of R_m names or "relation to members," *i.e.*, names that have value in relation to the members taking part in the communication (*e.g.*, "Home," "School:" these names are relative to the speaker and must be understood by the recipient) [28].

[2] "Car" and "In Car" were considered places in this analysis.

Table 1. Place and activity names defined, used for labeling locations and actually disclosed. Identical names are counted once for each participant who used them.

		Names	Locations Labeled	Actually used
Places	**Initially defined**	95	11	9
	Added during use	22	21	18
Activities	**Initially defined**	57	N/A	34
	Added during use	6	6	6

Table 2. Place and activity names used by participant 10. First column: names indicated before deployment; Second column: names added during the deployment. Text in angle brackets is descriptive of the actual text removed for participant anonymity.

	Labeled Places	Used Activities
Initially Defined	Home School	Soccer Studying Relaxing
Added During Use	<participant brother's name>'s bball practice Library <neighborhood name> <abbreviation of the proper name of a place>	Hip hop Making lunch

Participants used 13 unique activity names when sending Reno messages. Users could not add activities to the activity list, but three participants (all teenagers) labeled *physical locations* with activity names instead of place names. Six locations were labeled with the activity that was taking place there (*e.g.*, "Hip hop," "Horticulture"). This shows that activity can be used as an R_m term for indicating location. On the other hand, activities can be more vague than place names and may thus be used in plausible denial dynamics. The participants who labeled locations with activities explained that the recipient of the disclosure already knew their location and that they wanted to be more descriptive (this agrees with other published research [31]): participant 10 regularly sent two replies to each request: one with her location and another with her current activity. This demonstrates that activity and place are often used jointly or interchangeably for achieving communication goals and that the choice of what to disclose is a function of, at least, the activity being accomplished with the communication—an extended form of the selection process described by Schegloff [28]. This has design implications, as activity may be added to location-enhanced people finders or messaging applications as a general-purpose fallback option.

6 Informing the Design of Social Mobile Applications

Although it is risky to infer general design guidelines based on relatively small-scale studies, some observations we made agree with other published research cited throughout this article. The mutually supporting evidence fortifies the credibility of our conclusions.

6.1 Don't Make Automated Functions a Design Priority

Automated features designed to streamline and facilitate communication should not be a design priority. Although the pilot study suggested promising applications for Waypoints, the participants in the field study described in this article unanimously preferred to maintain control over the messages their phones transmitted. Few participants used Waypoints even for very routine activities (such as leaving work or arriving home). Most participants felt that the time spent sending the message was well worth the gain in precision and purposefulness. This contradicts the mainstream view in the ubicomp community that increasing information overload demands "intelligent" technology to take up the role of an "electronic assistant" for the user. Quite the contrary, the main value participants saw in Reno was the lightweight interaction it afforded, which made it easy to use during *interstitial activity* (*i.e.*, those times, such as waiting for a bus, between sanctioned activities).

6.2 Lightweight Messaging: A Hit Social Mobile Application?

All participants viewed Reno as an enhanced messaging application, rather than strictly a location-enhanced service. They appreciated the convenience of quickly requesting location and adapting that request to inquire about availability and current activity, without having to type lengthy messages and having to make disruptive phone calls. We know that: "What are you doing?" and "Where are you?" are often-asked questions—which leads to the question of how a pre-coded set of common inquiries and replies could support lightweight routine communication tasks (*e.g.*, "Where are you?" "What are you doing?" "Busy," *etc.*) The Nokia 6600 message templates are a step in this direction, but the text messaging application could provide context-sensitive interpretation to facilitate responses (for example, it could present a list of activities in reply to a "What are you doing?" message). Such an 'intelligent' messaging application seems very promising, especially if coupled with simple location and activity sensing. Lightweight messaging would fill the value gap for people not accustomed to typing on the phone or in situations that do not afford distractions.

6.3 Explicitly Support Plausible Deniability

While supporting deception may appear an unethical proposition for designers to follow, we are convinced, by overwhelming literature and by our observations that people want to deceive, or deny replies, from time to time, for purposes that are important to them. Cases of outright deception about location occurred relatively rarely, both in the ESM study and in the deployment; however, participants in both studies indicated that in those instances having the option to deceive, "stretch the truth," or deny a reply would be important. They affirmed that they might lie about their location in order to preserve their individual privacy, or as a way of achieving positive, longer-term, social effects. All this supporting evidence led us to conclude that communication technology should support plausible deniability (*e.g.*, by preserving imperfect sensing and communication). Participants who felt a need to achieve deniability demonstrated the ability to do so with Reno by tailoring place names, the auto-

matic features and outgoing messages. This suggests that these qualities may be sufficient to enable plausible deniability and thus avoid the related acceptance problems.

7 Related Work

The telecom industry has hailed Location-Based Services (LBS) as the next killer app after the unexpected success of SMS. Ubiquitous person finders targeted at corporate customers were commercially launched by KDDI in Japan in 2002 [16]. DoCoMo introduced person-to-person LBS in the form of location-augmented iMode websites [24], amidst mounting privacy concerns [13]. Child-tracking applications are available in the United Kingdom [22]. A more general cell-phone based person-finder application has been developed by Kivera Inc. for AT&T Wireless (now part of Cingular). The system, called Find People Nearby (formerly known as Find Friends) allows the user to build a buddy list, and to locate other subscribers in any area covered by AT&T. The user can then call the person, send a message or invite him/her to a meeting point chosen from businesses in the AT&T Yellow Pages. Although AT&T does not disclose usage statistics, the success of this application has been arguably limited [3]. Probable causes include the lack of interoperability with other providers as well as usability issues.

Reno overcomes the former limitation by leveraging the universal interoperability afforded by SMS. Moreover, users of Find People Nearby cannot label locations, whereas Reno provides tools for creating and using meaningful place names, instead of hard-to-understand geographical or urban coordinates [9]. In Find People Nearby the user must grant permission to be located by a friend, similarly to the Instant Reply List; after granting permission, however, the system automatically discloses the location in the form of urban coordinates. Thus, the user cannot choose on a case-by-case basis whether to reply and what to disclose. This detracts from the tool's flexibility and curtails control and denial practices.

Schegloff provided an early account of how people formulate place in everyday conversations, and described it as a *selection problem* among several, formally correct alternatives [28]. He suggested that at least three factors influence the selection of a place name: location references (relative to one's current position, physical or otherwise), membership to specific social group(s) and the activity being accomplished with the place formulation. We have adopted this description and, in fact, the location and activity names that our participants chose can be categorized according to it. Recent studies on the formulation of place using mobile communication technologies include Laurier's account of how location is used to express much more than geographical position [21], and Weilenmann's account of the use of place to express activity and availability [31]. These studies report on "ethnographic" observation of already existing practices, whereas we have tried to study the use of place and activity with an emerging technology. While the agreement of our observations with these studies corroborate the credibility of our data, the novel ways people used Reno hint at how the formulation of location and availability might change with the widespread use of mobile social applications.

Lederer *et al.* [19] report that people decide whether to disclose information about their activities and location based on the identity of the requester more than on the

situation in which this happens. Both the ESM study [4] and the present study confirm this, and, in addition, highlight that users provide either the information that they think will be most useful to the requester, or none. Barkhuus and Dey investigated the balance between security and management burden and suggest that people are willing to forgive some control over their personal location information if the application is useful to them [1]. Our experience with Reno shows that users display similar feelings towards automatic disclosure of location information—what these authors term "active context-awareness." The imprecise nature of cell-phone tower-based localization can be viewed as both a problem and an advantage. In location-based games such as 'Can You See Me Now?' [6], the imprecise nature of location sensing is exploited by the designers to enrich the game by creating uncertainty. In Reno, imprecision and ambiguity afford a space for privacy.

Finally, Laasonen *et al.* show how cell-phone tower localization can be used in combination with user-based labeling schemes [18]. We have taken their concept of *areas* (clusters of sensed cell towers) to define signatures for a specific place. GSM phones, even when stationary, switch between cells and these patterns can be exploited to achieve increased precision. In addition, our software can sense whether the user has been moving across numerous cell boundaries; this knowledge is used to obtain more accurate signatures. We preferred cell tower-based sensing over GPS, because of its better performance in buildings and dense urban environments, and over WLAN-based positioning, due to the more simple hardware configuration.

8 Conclusions

We set out to understand how and why people choose to disclose their location information with a social mobile application, by probing three salient questions: how people relate to automatic disclosure mechanisms, what denial or deception techniques they would adopt, and how place and activity names are used. However, the results of our study required us to step back and reconsider our assumptions, which were based on our own common sense considerations and a straightforward interpretation of Weiser's idea of calm technology. The agreement of our observations with a great deal of published literature in related fields supports our claims and empowers our conclusions drawn from a relatively short field study.

Our participants did not use automatic functions and provided strong evidence suggesting that, even in a "complete" social network, automatic functions would be unnecessary in the face of loss of control. Although the low rate of deception prevents us from drawing firm conclusions, our participants did not voice any concern of being unable to use Reno within denial or deception practices, thus supporting our claim that the control provided by Reno is sufficient for achieving plausible deniability. We observed that activity was often used instead of place when responding to a request for location. This, combined with the praise for the ease of use and unobtrusiveness of Reno, hints at a vast untapped potential for simplified mobile messaging.

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References

1. Barkhuus, L., Dey, A.: Location-Based Services For Mobile Telephony: A Study Of Users' Privacy Concerns. In: Proc. Interact 2003, IOS Press (2003) 709–712.
2. Benford, S., Seager, W., Flintham, M., Anastasi, R., Rowland, D., Humble, J., Stanton, D., Bowers, J., Tanadavanitj, N., Adams, M., Farr, J. R., Oldroyd, A., Sutton, J.: The Error of Our Ways: The Experience of Self-Reported Position in a Location-Based Game. In: Proc. Ubicomp 2004, LNCS 3205, Springer Verlag (2004) 70–87.
3. Brown, K.: On The Trail Of Location Services. Wireless Week, March 1, 2004, Reed Business Information (2004) 18.
4. Consolvo, S., Smith, I., Matthews, T., LaMarca, A., Tabert, J., Powledge, P.: Location Disclosure to Social Relations: Why, When, & What People Want to Share. In: Proc. CHI 2005, ACM Press (2005) 82–90.
5. DePaulo B.M., Kashy D.A.: Everyday Lies in Close and Casual Relationships. Journal of Personality and Social Psychology 74 (1), American Psychological Association (1998) 63–79.
6. Flintham, M., Anastasi, R., Benford, S. D., Hemmings, T., Crabtree, A., Greenhalgh, C. M., Rodden, T. A., Tandavanitj, N., Adams, M., Row-Farr, J.: Where On-Line Meets On-The-Streets: Experiences With Mobile Mixed Reality Games. In: Proc. CHI 2003, ACM Press (2003) 569–576.
7. Grinter, R. E., Eldridge, M.: 'y do tngrs luv 2 txt msg?' In: Proc. ECSCW '01, Kluwer Academic Press (2001) 219–238.
8. Hancock, J.T., Thom-Santelli, J., Ritchie T.: Deception and Design: The Impact of Communication Technology on Lying Behavior. In: Proc. CHI 2004. ACM Press (2004) 129–134.
9. Harrison, S., Dourish, P.: Re-place-ing Space: The Roles Of Space And Place In Collaborative Systems. In: Proc. CSCW '96, ACM Press (1996) 67–76.
10. Höflich, J. R., Rössler, P.: Mobile schriftliche Kommunikation – oder: E-Mail für das Handy. Die Bedeutung elektronischer Kurznachrichten (Short Message Service) am Beispiel jugendlicher Handynutzer. Medien & Kommunikationswissenschaft 49, Nomos-Verlag (2001) 437.
11. Hull, R., Kumar, B., Lieuwen, D., Patel-Schneider, D.F., Sahuguet, A., Varadarajan, S., Vyas, A.: Enabling Context-Aware and Privacy-Conscious User Data Sharing. In: Proc. MDM'04, IEEE Press (2004) 187–198.
12. Iachello, G., Abowd, G.D.: Privacy and Proportionality: Adapting Legal Evaluation Techniques to Inform Design In Ubiquitous Computing. In: Proc. CHI 2005, ACM Press (2005) 91–100.
13. Informa Telecoms & Media: What the Operators Are Doing. Mobile Location Analyst, Oct 2003 (2003). Available online: http://www.baskerville.telecoms.com.

14. Ito, M., Daisuke, O.: Mobile Phones, Japanese Youth and the Replacement of Social Contact. In: Ling, R., Pedersen, P. (eds.): Front Stage/Back Stage: Mobile Communication and the Renegotiation of the Social Sphere, Conference Proceedings, 22–24 June 2003, Grimstad, Norway.
15. Jensen, L., Jensen, J., Feldman, S., Cauffman, E.: The Right to Do Wrong: Lying to Parents Among Adolescents and Emerging Adults. Journal of Youth and Adolescence 33 (2), Kluwer Academic Publishers (2004) 101–112.
16. KDDI: GPS MAP, a Location Service For Mobile Phones. Available online: http://www.kddi.com/english/corporate/news_release/archive/2002/0718/.
17. Knox D., Zusman, M.E., McGinty, K., Gescheidler, J.: Deception of Parents During Adolescence. Adolescence 36 (143), Libra Publishers (2001) 611–614.
18. Laasonen, K., Raento, M., Toivonen, H.: Adaptive On-Device Location Recognition. In: Proc. Pervasive 2004, LNCS 3001, Springer Verlag (2004) 287–304.
19. Lederer, S., Mankoff, J., Dey, A. K.: Who Wants to Know What When? Privacy Preference Determinants in Ubiquitous Computing. In: Proc. CHI 2003, ACM Press (2003) 724–725.
20. Ling, R.: The Social and Cultural Consequences of Mobile Telephony as Seen in the Norwegian Context. Telenor R&D Report R 9/2002, ISSN 1500-2616 (2002).
21. Laurier, E.: Why People Say Where They Are During Mobile Phone Calls. Environment and Planning D: Society and Space 19, Pion (2001) 485–504.
22. Mapamobile: Available online: http://www.mapamobile.com/.
23. Mynatt, E., Tullio, J. (2001) Inferring calendar event attendance. In: Proc. ACM Conference on Intelligent User Interfaces (IUI 2001), ACM Press (2001) 121–128.
24. NTT DoCoMo: iArea: Location Based Services. Available online: http://www.nttdocomo.com/corebiz/imode/services/iarea.html.
25. Palen, L., Dourish, P.: Unpacking "Privacy" for a Networked World. In: Proc. CHI 2003, ACM Press (2003) 129–136.
26. Povey, D.: Optimistic Security: A New Access Control Paradigm. In: Proc. New Security Paradigms Workshop 1999. Ontario, Canada, ACM Press (1999) 40–45.
27. Reichenbach, M., Damker, H., Federrath H., Rannenberg K.: Individual Management of Personal Reachability in Mobile Communication. In: Yngström, L., Carlsen, J. (eds.): Information Security in Research and Business, IFIP TC11 13th International Conference on Information Security (SEC '97), Chapman & Hall (1997) 164–174.
28. Schegloff, E. A.: Notes on a Conversational Practice: Formulating Place. In: Sudnow D. (ed.): Studies in Social Interaction, The Free Press (1972) 75–119.
29. Smith, H., Rogers, Y., Brady, M.: Managing One's Social Network: Does Age Make a Difference? In: Proc. Interact 2003, IOS Press (2003) 551–558.
30. Smith, I., Consolvo, S., Hightower, J., Hughes, J., Iachello, G., LaMarca, A., Abowd, G.D., Scott, J., Sohn, T.: Social Disclosure Of Place: From Location Technology to Communication Practice. In: Proc. Pervasive 2005, LNCS 3468, Springer Verlag (2005) 134–151.
31. Weilenmann A.: "I Can't Talk Now: I'm In A Fitting Room": Formulating Availability And Location In Mobile Phone Conversations, Environment and Planning A 35, Pion (2003) 1589–1605.