Sharing Motion Information with Close Family and Friends

Frank Bentley and Crysta Metcalf
Applications Research Center
Motorola Labs
1295 E. Algonquin Rd
Schaumburg, IL 60196 USA
{ f.bentley, crysta.metcalf } @motorola.com

ABSTRACT
We present the Motion Presence application, an augmented phone book style application that allows close friends and family to view each other's current motion status ("moving" or "not moving") on their mobile phones. We performed a two week long field trial with 10 participants to observe usage and investigate any privacy concerns that might arise. We found that our participants used the motion information to infer location and activity as well as to plan communication, to help in coordinating in-person get-togethers, and to stay connected to patterns in each others' lives. Participants saw the motion data as mostly confirming their existing thoughts about the locations and activities of others and expressed few privacy concerns. In fact, they frequently asked for more information to be shared to make the application more compelling.

Author Keywords
Mobile presence, Awareness, Motion Detection, Privacy.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Mobile telephony has brought the telephone from a device associated with a fixed location to a device associated with a person active in the world. In this change, the need to moderate availability and have a sense of a person's remote location or activity has become increasingly important. Previous research [3, 15, 25, 26] has shown that people often share their current location or activity with each other in mobile telephone calls for a variety of purposes including determining availability, micro-coordination in meeting up [17], and maintaining a sense of social awareness. While actively calling someone and requesting or volunteering one's location is one way of sharing this information, we envision a much simpler and less-intrusive way for people to stay connected and still achieve these goals.

CHI 2007, April 28–May 3, 2007, San Jose, California, USA.

We believe that a system that shares absolute location information, while useful, has the potential to share too much information, and make people feel uneasy about the privacy implications (as has been noted in the literature [6, 21]). We also believe that it is important for a presence system to create a means of plausible deniability [2] in the information that it provides. With other researchers looking into using GSM cell ID for providing location information [1, 19] and Ho and Intille's work showing that people are most available for communication in transitions between activities [12], we decided to look at using cell ID for determining *motion status* and sharing this more ambiguous piece of information.

We developed an accurate way to determine motion between "places" (see [11] for a discussion of "place") by analyzing patterns in the way that GSM phones attach to cell towers and developed a means to convey this data as presence information to members of one's strong-tie social network. The Motion Presence application allows users to see the current status ("moving" or "not moving") of their close friends and family as well as the amount of time that a person has been in that state. For example, if one's wife had been driving to work for the past ten minutes, the husband's phone would read "moving (10)" next to the wife's name. The application also allows users to call or text message each other from the presence display, serving as a presence-enhanced phonebook.

In the summer of 2006, we conducted a two week long field trial of this application with three groups of significant others and one group of four friends for a total of ten participants. This study addressed five main research questions:

- Among a close social group, is motion presence used to infer something other than motion? If so, what?
- Does having motion information about a potential communication partner influence when people initiate a communication with them?
- Does having motion information about a potential communication partner affect how "connected" people feel?

- How do ambiguities and errors in motion presence detection/presentation affect the derived value of the application?
- In a close social group, what privacy concerns are raised by the use of this prototype?

We hypothesized that our users would be able to infer the locations and activities of their significant others or close friends based on a combination of the motion information and other information exchanged as a part of their existing social relationships (for example, schedule). We also hoped that sharing presence information would provide enough plausible deniability to reduce privacy concerns. Finally, we were interested in the ways that users would find unique uses for this application beyond checking for availability of others.

RELATED WORK

The idea of seeing what is happening in a remote space is not a new idea. Starting with the Media Spaces of the 1990s, researchers began investigating the type of information that would be meaningful to share across distance from a Computer Supported Cooperative Work standpoint. These CSCW researchers were often concerned with the availability of colleagues and the early systems such as the Portholes project at Xerox PARC [9] literally provided a view into a remote office by viewing live video from that location. The idea was that it would be like looking in a window to see what that person was doing and it was left up to the human to interpret this video data into activity or interruptability information. These media space systems led to a good deal of discussion about privacy. Some users of the PARC system felt that video was too intrusive and ended up covering their cameras or putting up written messages in front of the camera.

Other work in this space explored the use of other kinds of information to help people find colleagues. Systems such as the MIT Zephyr system [7] could tell users which computer friends or colleagues were currently logged into. Since the MIT Athena system names computers by building number and room, this allowed users to be able to find colleagues for collaboration and allowed friends to find each other for breaks or opportunely discover that one of their friends was in the room next door.

Later messaging clients were not able to exploit this location-aware property as all computers on the internet are not named in such a precise fashion. However, these systems provided presence information in different ways. Many clients, including AOL's Instant Messenger (see [10] for an analysis of AIM usage), provide active or idle presence information as well as the ability for users to post "away messages" providing detail on where they are or what they are doing. These messages and idle state information help users negotiate availability and also learn general patterns of their friends' days.

Several researchers have begun to look at presence in a mobile setting and the benefits of sharing activity or location information with others away from the computer in everyday life. Smith et al. [21] developed the Reno application to share location information among members of a social network. In this application, users could explicitly request the location of a friend or relative and that person could choose to respond with a predefined location from a list ordered based on current location. Users could also manually push their location to another person or receive an automatic update when a person entered or left a particular place. This system was created to convey specific locations at specific times and not to serve as a more general awareness tool, nor was it intended to be ambient in nature. Since even in the automatic operation friends and coworkers received interrupting notifications of another user's location, the senders of the information felt that they wanted more control over when and how others were notified. In fact, Iachello et al. made the statement that automatic updates are not needed for mobile social applications. [13]

We hypothesized that sending updates about motion passively (without notifications of the update) would help with some of these concerns. We believed passive sharing would be more acceptable both because motion information is more ambiguous and because passive updates do not interrupt users. Sharing motion passively also ensures that the most current information is always available even when users might not want to bother someone else for their current status.

The work above on Reno was a follow on to Consolvo et al.'s research [6] into what location information people will share with others. They found that users felt uncomfortable sharing precise location information in some circumstances, even with spouses or close friends. For example one of their participants wanted to hide from her husband the fact that she was out shopping. Another participant didn't want others to know she was at particular places running errands because she thought that others might ask her to pick something up for them. We thought that by only sharing motion information, some of these privacy concerns would be addressed. Sharing motion introduces a greater deal of plausible deniability in the system compared to absolute location.

Marmasse et al. [18] also created a system that would allow users to share location information with others. Her system allowed users to see the current mode of transportation and inferred destination based on GPS data received from the phone. The device was never tested in the field and there is no information about how such a system would be used beyond the execution of a user interface evaluation.

Sohn et al. [22] have investigated ways to determine if a phone is in motion using GSM signals. While our goal was to determine motion on a large scale, their work focused on discriminating between standing still, walking or driving

using multiple cell ids and signal strengths. We opted for an easier problem of motion between cell towers as we were hoping to approximate motion from one activity/location to another. If one walks around an office as a part of their day, we didn't want our application to determine that they were in motion. Laasonen et al. [14] have also developed a system for determining when users travel between locations based on GSM cell tower information. Our main contribution is not in our motion algorithm, but rather in the application as a whole and the study of its use.

Ho and Intille [12] further explored the concept of interruptability. They found that people were most interruptible in the transitions between activities. We took this insight along with the idle vs. active indication of Instant Messenger to create the concept of Motion Presence. We hypothesized that users would use the moving/not moving data in order to find transition points when it would be appropriate to interrupt each other. We hoped our work would shed some light onto the usage of motion-based presence in real life situations.

We also hoped that participants would use this information for more than just determining availability to communicate. We hoped that users would feel a sense of connection with each other much like that described by Dey and DeGuzman [8] as "a positive emotional appraisal which is characterized by a feeling of staying in touch within ongoing social relationships." Vetere et al. [24] describe similar feelings when describing technology that can mediate intimacy in strong-tie relationships. We hoped that users would view motion presence information as a way to be aware of and reminded of each other throughout the day.

METHODS

In order to answer the research questions posed above, we planned two separate two-week long phases of data collection. The application resided on a Motorola A780 phone which we gave to the participants to use as their primary phone during the study. The participants were asked to record their calls with the other participants in the study, and the calls they were comfortable recording were stored on an SD card in the phone. A software program on the phone logged their interactions with the application, and each night the participants phoned our toll-free number and left a voice-mail journal entry discussing their use of the motion presence application and their reaction to it. At the end of the two-week period, the participants sent their SD cards back to us via FedEx and we used the information from the recorded calls to personalize the final interviews, which occurred the following day. During the final in-person interview, participants were asked about their experiences with the motion presence application, inferences they made, and their reactions to having this presence information available to themselves and others.

The first phase of the research was planned to collect data from three pairs of spouses/partners/significant others, while the other phase was planned to collect data from a group of 4 friends. For each phase, the participants were given A780s and their own SIM cards were put into the A780s so they would have access to their contact lists.

The participants for the study were recruited by an independent recruiting agency using a screener that we created. We recruited groups of friends and family because we believed that people who knew each other well would have reasons to be curious about the movements of the others, and they would know enough about each other's daily lives and schedules to make assumptions of activity and location based on those movements. We also believed that friends would know less about each others' schedules than significant others would, so we recruited both kinds of groups in order to explore the differences in inference-making in each type of group. Our participants ranged in age from their 20's to their 40's, and in occupations from mechanic to non-profit fundraiser to human resources manager to commercial loan officer.

During the introduction to the study and throughout the interview we were careful not to bring up possible uses of the application or possible inferences (such as location or activity) as examples. Upon receiving the phones, participants were simply told that the motion information would tell others if they were moving over a distance of a few blocks or more and that they were free to use this information as they wished. We made an active decision to collect only the inferences and uses people told us about freely, and did not prompt with possible uses or inferences even in the final interviews. This allowed us to gather inferences without concern that we biased the final data collection.

For the analysis, data was sorted and categorized using the research questions mentioned above. Utilizing the raw data from the voice mail diaries, interviews, and phone call data, we identified "items": "events, behaviors, statements, or activities" [16] that were directly pertinent to answering our research questions. Because this was not an exploratory study, but instead a concept test, answers to the research questions could be discerned by pulling from the data all items that applied to one or another of the questions. Patterns within the answers to each research question were then identified using inductive analysis: creating groups of items that fit together, expressed a particular theme, or constituted a predictable and consistent set of behaviors. This was used to identify the nuance in the answers and explain variations.

IMPLEMENTATION

The Motion Presence application is implemented as a distributed peer-to-peer system using SMS as a delivery mechanism for presence status. The application is designed to run on a Motorola A780 or E680i phone and includes a native daemon process that computes the current status of the handset and handles messaging as well as a J2ME application that provides the user interface.

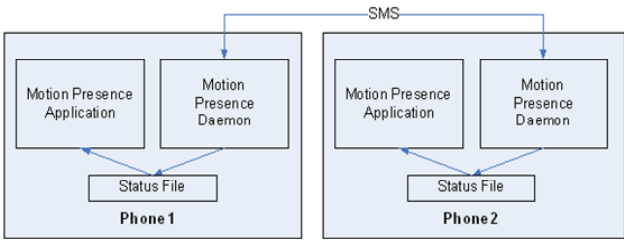

Figure 1. Architecture of the Motion Presence Application

Several system constraints led to the current design. The original design relied on a central presence server and used HTTP to post and get motion status updates. For several reasons, this design did not prove feasible for a field-able application. First, the A780 phone does not allow for incoming or outgoing calls while it is in GPRS data mode. This means that if the application was getting the status of another person or posting a change in its own status, any incoming call would be routed to voicemail which would not be acceptable for our users. Because we wanted participants to use this application on their main phone, we had to make sure that they would not miss any phone calls.

Also, we have discovered that it's quite difficult to explain to carriers how to add an unlimited GPRS data plan to an existing account. Most times, one ends up getting a WAP-based web subscription despite making it clear that they need a true internet plan. Because of these difficulties we wanted to make sure our users could add the appropriate service to their accounts without the possibility of not getting what they needed and seeing a large cell phone bill for all of the data that our application sends. Finally, a web transaction over GPRS currently takes about 10-15 seconds. Unless the application was continuously polling for updates to keep current, the resulting 10 second delay when a user opens the application to check status would not be acceptable.

Because of these constraints, we decided to implement the application using a peer-to-peer SMS based architecture as seen in Figure 1. There are two main components to the system, the daemon process and the Motion Presence application.

The daemon is written in C++ and runs natively in Linux. The phone is configured to automatically start the daemon on boot and the daemon runs continuously in the background the entire time the phone is on. This process is responsible for determining the current moving/not moving state of the phone as well as handling all incoming and outgoing status messages.

Every five seconds, the daemon process samples the current GSM Cell ID from the phone, which is a unique number identifying the current serving cell for a particular carrier and region. As the phone moves between cells, we claim that the phone is moving when it has seen two new cells in less than five minutes that were not visible in the previous fifteen minutes.

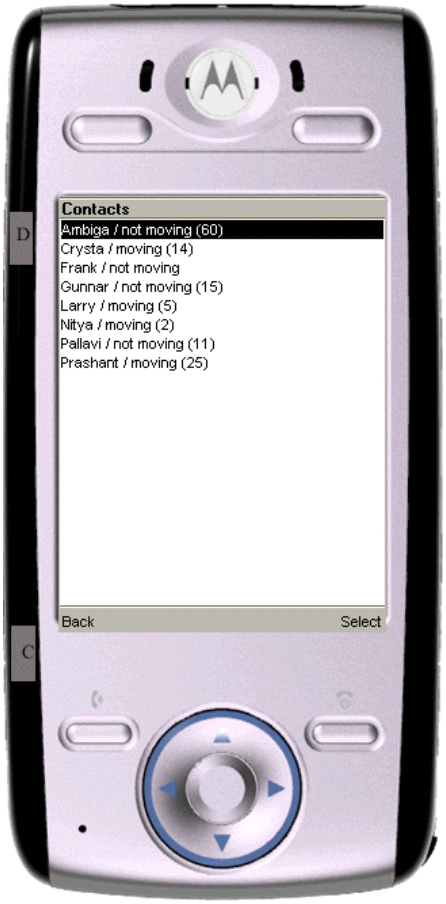

Figure 2. The Motion Presence Java Application

When a phone changes from the moving to not-moving state or back again, an SMS message is generated and sent to each person listed in the Motion Presence application.

The daemons on the other phones then receive these messages and save the results to a file that contains a mapping of buddy name to state and time in that state. The daemon also logs all state changes in status to a log file for analysis.

When the user opens the Motion Presence Java application, the current state is read in from the saved file and displayed to the user in the format shown in Figure 2. This status is re-read every minute or any time the application receives a start event (such as when the flip of the phone is closed and then reopened). Once in the application, the user can select a name and choose to contact that person via a voice call or text message. The first line of the application is the user's own status. This was included so that users would feel knowledgeable about the information that was being shared about them and as a reassurance that the system was operating properly. Users were asked to initiate all communication with the other participants in the study through our application as if it were their main phonebook. All interactions with the system are logged with a

timestamp including when communication is initiated from within the application.

Several limitations still exist in this implementation, the most important being battery life. Even with a larger 1450mAH battery, the a780 can only stay on for about 14 ½ hours. This is due to the fact that this application needs a new cell ID fix every five seconds and the phone's applications processor is not equipped to handle applications that need to continuously run. Another limitation is the use of SMS for delivery of messages. While this works fine for small scale studies like this one, any large scale deployment would need to look at the available bandwidth of existing networks for SMS traffic before choosing a solution like this one.

FINDINGS

Overall, our participants were able to infer many details about each others' location and activity using a combination of their existing knowledge and the simple motion information presented to them. While this information was used in a number of circumstances and purposes, they often asked for more data that was less abstract and more directly tied to the tasks that they needed to perform. In fact, our participants felt that they could infer a lot without the help of motion presence and that it mostly served to confirm what they already thought others were doing. However, we feel that this study demonstrates how a simple ambiguous piece of presence information can help people learn more about the lives of those close to them as well as mediate availability and help with micro-coordination tasks in meeting up. We feel that studying motion information is a good first step at understanding the types of information that would be useful for people to share in a mobile environment.

What was inferred from motion data?

While we were designing the application and using it internally, we hypothesized that people who are well aware of each other's daily routines might be able to infer location, activity, and availability from the motion data we provided. Our participants were, indeed, able to infer this information and they found a number of ways to apply the information.

On average our participants made the decision to call, text, or delay communications with the other(s) in the study based on the information they saw in the application three times over the two weeks of the study. In these circumstances, participants did not want to bother each other at work or in other situations when one might be busy, For example, Harold[1] delayed communication: "[George], I knew he was going to work, but I wasn't sure if he got there already and I saw that he was not moving for 12 minutes. So judging by that I'm getting that he was already at work so I didn't bother calling him." Likewise, Dana did not want to disturb her husband during a business meeting he was having during the day: "I knew he had, it was either a 10am or 11am meeting Cleveland time, so I was checking. I actually checked that application to see whether he was moving or not to know whether I should call. I didn't want to disturb him in his meeting so if it said 'not moving' I wasn't going to call." These participants used existing information about the patterns of others to turn motion information into meaningful places or activities so that they did not bother others with an interrupting phone call.

Other uses of the application for availability purposes involved trying to catch someone while they were engaged in a specific activity, like coming home from work. Ian was able to use time at the beginning of the day to catch his friends on the way to work. "I'm sitting at my desk between 7 and 8 and I can see when they're leaving. I have a general idea, but I could see exactly. And if I needed to talk to them, I could call them at that point."

Another common use of the motion data was to aid in the task of micro-coordination. Ling and Yttri [17] describe micro-coordination as a set of coordination tasks that are required in daily life, for example, tasks like coordinating on a place or time to meet or coordinating transportation to a given location or locating someone else in a busy park. We found our participants utilizing the motion data for these tasks as well.

In four examples, our participants used the application to give themselves more time to spend in their current location. Ebony would check the status of her partner towards the end of the day to see if she had left work yet. "If she didn't leave yet, that means I can go do whatever I'm doing, like at work stay later." James also described using the application in this way: "If you knew someone was going to go pick you up or if someone was going to go someplace and you knew that and you know about what time, you could see if they were actually on their way or if they were running late. … Kind of lets you know when you should be ready or things like that."

Other participants used motion information to try to arrive at the same place at the same time. This was reported a total of seven times over the two weeks of the study. Harold and Ian were going to meet for lunch. Harold originally was going to call Ian when he was leaving, but then reconsidered: "I'll call you, or I'll just see that you're moving!" Later that week when they were actually getting together, Harold reported using that information: "I could tell when he was leaving work by when he went off of 'not moving.' … It was like, ok, I saw that he was already on his way and we'd get there about the same time."

Participants were also able to infer that others were following through with plans that they had made. Farisa said, "It was kind of nice to know that [Ebony] left when she said she was going to leave." Here, motion was inferred to mean that Ebony was on her way to do something she

[1] All participant names are replaced with pseudonyms

had promised her partner that she would do. Ebony also expressed this same feeling: "It kind of gives you a sense of security if the person says "hey, I'm going to Wal-Mart," and then you can kinda look on there and say ok, they're moving so that means they're in motion, they're kinda doing what they say they're doing."

However, in one instance this checking up on others was seen as going too far. Alejandro called his wife to see why she was moving in the middle of the afternoon. She said that she had left work and went to the store. The husband then said that she should be working and later noted that using the application like this to "check on" others could lead to potential relationship issues. We feel that due to the ambiguity of the data, there is plenty of room for plausible deniability, but recognize the problem of those that may wish to use this information for the wrong purposes.

A final area of use that was rather unexpected to us was using the motion data to request help from others. Seven instances of this type of activity were reported by our participants. Beatriz wanted her husband to get milk on the way home from work: "Oh, he's not in class, he's moving, he must be on his way home, I need milk!" Beatriz also used it to realize that her husband fell asleep instead of picking up their children at school: "I would mostly look at it around 2:30 because that's the time he needs to pick the kids up from school. And on one of the days he was napping and it said "not moving," so I had to call." In these instances our participants were able to correctly interpret the motion information to infer location or activity information for their significant others.

Overall, participants were almost always able to infer the locations and activities of others and developed many creative uses for determining availability as well as coordinating in person get-togethers.

How did motion data alter feelings of connectedness?

We found participants using the application in various ways to obtain feelings of connectedness with others and to maintain social awareness. We found that couples used the application for trying to feel a connection to the other person or for checking on one's safety while our group of friends mainly used the application as a way to maintain social awareness.

Two of our three couples reported looking at the application when they could not be with their significant other. In certain cases, seeing motion information gave them a virtual connection into the lives of their partners. Farisa said, "I've been working a lot and I'm not with [Ebony], so I've been looking at it just to see the motion on the phone." Dana reported checking the application when he had to work late to catch the time that his wife was walking their dog, an activity that they usually do together.

Couples also reported using the application to check on each other's safety a total of seven times. Chris said, "I'd be worried, like if it was late and she was coming home from a client in Wisconsin. If I knew she should be coming home and she wasn't [moving]." Ebony explained that she moves around a lot at her job, so her partner should be worried if she's ever not moving for a long period of time while she's at work. Beatriz's husband was stopping after work to pick up some medicine for their sick child. Beatriz was comforted to know that the medicine was on its way: "I did feel relieved that he was moving. It meant he was on his way home with the medicine that I needed." Farisa summed up the safety aspect, "We've been together five years. We've never been concerned about it, but it was kinda like nice to know. I didn't know where she was at, but I knew she was moving." Often just knowing this simple information without any inferences is enough for couples to be reassured about each other's safety.

The group of four friends in our study used the application in a different way to maintain social awareness in their group. By using the application for several days, or looking into the history of updates over time, our participants were able to learn a lot about each other's lives. George reported about finding when his friends left for work: "I'd be like, oh, this guy actually left for work at 7:30 and then I felt bad for him. I knew he went to work way earlier than I ever woke up, but I never knew exactly when. When it hit the same time everyday, I was like, that's kinda cool." Ian, the friend that got up early, also used the application to check on patterns of his friends: "I get up really early so I knew when everyone was going to work and everything. I checked it all the time."

Participants also used the information to infer specific activities and maintain an awareness of what their friends were doing. "You could see like if we were meeting at a bar or whatever, like if they're at two different apartments if they start moving they're probably all going there." George reported checking the application to see which of his friends were going out at night: "I checked it when I got out of work and before I went out just to see what everyone else was doing." James also discussed using the application to see which of his friends were going out at night. At one point, James used the application to see if a friend of his was stuck in the same traffic he was. As traffic was so congested that cars were not moving for several minutes, his friend's status reported "not moving" and he knew that his friend must be in traffic as well.

We hypothesize that such incidents of social awareness can help to bring people closer together because they are more knowledgeable about each other's lives. In some cases, this knowledge was used in later conversation and could serve as a conversation starter as well as helping people to know more about those close to them.

When was the application used?

Our participants looked at the Motion Presence application on average five times per day. The group of friends tended to check it more often; however, they also had two additional contacts in the application. Other than the

specific instances mentioned above, where users have specific purposes to check the application, our users often looked at the application in idle moments. In previous work on Music Presence [4], it was noted that looking at the application tended to be something that was done when participants were bored, or just had a spare few seconds to kill. We noted two main classes of "boredom" times that people used the Motion Presence application.

Participants often needed a distraction from their current task and saw the Motion Presence application as a potential source of diversion. Harold reported looking at the application "at work when I don't feel like doing my actual work." Other users saw the application as a game and would try to catch each other moving or not moving throughout the day. Chris: "I looked at it mainly out of curiosity, mostly it was a game for me this afternoon to see if I could find a time when I could see her moving." George reported checking for his "own amusement."

We also noticed our participants checking the application when they were bored and had nothing else to do. Participants who lived in the city mentioned checking on the train on the way home and wished that it would work in the subway where they had no GSM signal. Almost all participants mentioned looking at the application for "no particular reason" several times throughout the study. We believe that these glances at ambiguous information, over time, might help to bring out the rich social awareness as mentioned above.

Participants mentioned that on days when they were extremely busy, they hardly ever checked the application. Also during the workday, it was less important to see when people were moving or not as participants were often stuck at work for the duration of the day. On weekends, our participants often used the application less frequently, as they were either spending large amounts of time with their significant others and thus did not need to check the motion status or because they were mainly sleeping or busy with other commitments on the weekends. Harold: "I only used it a few times [today], mainly because I was lying in bed all day." Ian: "I knew where my friends were going to be all day. So I had no reason to know where they were or what they were doing or to contact them."

Participants also checked the application to look at their own status. Especially at the beginning of the study, participants reported checking on the accuracy of the application. Dana: "I wanted to see what I had done before…so I knew it was right." Alejandro: "I was looking at it to see if it was working like it was supposed to work. It was working fine for me."

Most novelty effects (e.g. the game of seeing when someone was moving) seemed to wear off quickly in the first few days. Use in later days was more focused on task-based interaction or on checking status in idle times.

How were ambiguities/errors dealt with?

We initially thought that designing the application so that the information was ambiguous would allow for a great deal of plausible deniability. However, we noticed that people were truthful with each other almost all of the time and did not appear to actively lie about their actual locations even when they were not doing what they should have been doing.

One participant (Chris) made it clear that the motion information was only meaningful if he knew about his wife's schedule for the day: "It didn't really tell me anything unless I kind of knew in my mind, I had some theory in my mind about what she was doing." We found that our participants most often had the necessary information to make inferences from the motion data. This was the main reason that we selected participants already in strong-tie relationships for the study. We hoped that the information would be meaningful to those who already knew each other's patterns fairly well and we observed that in most cases this is true, but precisely because they already knew each others' patterns the motion information was less useful than it could otherwise have been.

Although most times, participants were able to infer the information that they needed, on a few occasions participants reported needing more information. Instead of relying on the application, one set of participants, Alejandro and Beatriz still called each other many times per day to tell each other where they were, a practice they had been doing for years. In one case, Ian reported misinterpreting the motion data. "He was supposed to be at home and it said he wasn't moving. But he ended up not being at home. So it didn't really help me."

While most participants thought that the motion information was always accurate and reflected what they were currently doing, some reported issues in certain situations. One participant worked in a large warehouse that was about ½ square mile in area. When he walked to one end of the warehouse, it said he was in motion while he considered himself "stationary" as he was in the same building. Another participant lived on the edge of a GSM cell, so he could walk about six blocks in one direction before it said that he was moving, but one block in the other direction set him into the moving state. For the most part, these errors did not cause any issues with the use of the system, but James reported that he was uneasy that others could make incorrect assumptions about his activities while at work. "Maybe they thought I was going to lunch at like 10:00 or whatever but I was still at the warehouse working."

Participants also had different notions of what "moving" meant and the times that were listed for people being in a given state. Chris was on a road trip and stopped for about ten minutes for gas and a snack. A few minutes later, he looked at the application to call his wife and saw his own status in the process: "It was obviously a wrong number of

minutes in motion. I had been on the road for about four hours and it said 14 minutes." He didn't consider the gas stop as a reason why he might have stopped moving and for the moving counter to be "reset." This illustrates the need for a short history or a way to represent what has happened recently with a given person. One of our participants mentioned wanting this very thing: a history of the other person's movement. Several other users wanted to see what happened just before the current status. This could also help with the perception issues in the case of James above where it could be shown that from 7-10am he was not moving and then only moving for a few minutes.

Privacy Concerns

While we had hoped that choosing strong-tie social networks would help reduce privacy issues, we did expect privacy concerns to arise. However, we were pleasantly surprised at the small number of concerns over privacy that our participants raised. Our participants did not take advantage of the plausible deniability provided by the vagueness of the motion data that was provided. As our participants were in trusting relationships, for the most part they wanted to share and receive even more information with each other.

It was clear that users saw this application on a different level of intrusiveness than a location tracking service. George said that "putting it up against a map would be cool. But then you get that whole big brother thing." However, he did not see issues with the motion data being shared.

Still, there were instances when our participants thought that this application could get them into trouble. Alejandro saw potential relationship issues evolving, "I think it would be a situation in which the other person, you could be checking on the other person and it would create conflicts." Farisa also saw that it could be an invasion of privacy in some situations, but stated it in a very abstract way: "The movement, that's scary. I'm sure there's privacy issues." However, in the two weeks that she used the application, she did not report any times when specific privacy issues arose. When asked if they would ever turn it off, Farisa said that "as a couple we wouldn't turn it off."

Despite a few users seeing potential issues with sharing this information all the time, others like Dana said that "I was fine with it… It wouldn't worry me that [my boyfriend] knew."

For the most part, our participants wanted more data about each other. They were disappointed that the application "doesn't really do much," as Harold stated. Participants requested absolute location, or at least the ability to share a name of a location in a similar way to an AIM away message so that friends or family could know for sure exactly where they were. Other participants thought that compass information along with motion would provide more useful information and better allow them to determine if others were coming home or heading away. James wanted to know how far away his friends were: "Like if you're meeting up with someone for lunch and you could see, hey, they're 0.4 miles away. That would be useful." One participant also mentioned wanting to be able to get directions from his location to his friend's.

Having a history of data again returned as a useful feature. Dana stated that "it would be helpful if there was a line in there saying, kind of, what the last batch of moving was, so that you kind of knew that this was the next segment." George found a way to see the history in the messaging application in the phone and would look in the history to find out when his friends got up or went to work. None of his friends saw this as an invasion of their privacy and some of them also looked back at the "hidden" logs.

Participants also stated that it would be a useful application for families to be able to know where their children are and that they are ok. While none of our participants' children participated in the study, it would be useful future work to study the use of this application in families with children of different ages to learn about the potential privacy issues involved with this different demographic.

DISCUSSION

The creation and evaluation of this system has taught us a great deal about how ambiguous presence cues can be used in real-world situations. We believe that privacy concerns in mobile presence applications are an important consideration and new applications must strike a balance between the amount and type of information shared and the potential privacy implications of sharing that data. This application has shown that our participants can infer quite a bit of useful information from a very simple ambiguous source.

Palen and Dourish [20] discuss how privacy on networked systems is a continual, dynamic process and not a simple set of definable rules. In actually using digital systems as a part of their everyday lives, people's privacy concerns involve a tension between what people need and want to share and their own needs of protecting themselves from embarrassment or feel in control of their lives. Our system supports this in a simple way since people close to the user will likely be able to interpret the motion information and infer rich information while people who know less about the user's schedule most likely will not be able to infer more information. This performs a type of implicit recipient design [20] without active involvement from the user allowing different people to be able to infer different information based on their closeness to the user.

While we do not think that applications that constantly share precise location are acceptable to most consumers because of the extreme lack of privacy that these types of systems entail, this study has shown us several examples of situations where sharing precise location would be important. Systems such as this one can easily be augmented to "push" location information to other clients

when a user decides that it is acceptable to share their current location, for example when at a public event or location where they would like friends to meet them. This would allow for a system closer to what Palen and Dourish argue for as a continually evolving and personal way to approach privacy.

FUTURE WORK

Future work lies in three main areas: improving the motion detection algorithm, studying other types of presence information, and studying combinations of presence information.

The current motion detecting algorithm is not perfect, and while some participants never noticed a problem, others found themselves in situations where the data was at times incorrect. One simple way to improve the algorithm is by using neighbor cells in a similar way to Sohn et al.'s work on motion detection [22]. The parameters of our current algorithm could also be improved to meet a broader range of situations. Our current algorithm also requires that the phones application's processor run for a small time every few seconds. This leads to a large battery drain if power management is not fully implemented on the device. A commercial version of this application would likely want to implement the location determination on the baseband side or in the network so that the application processor can sleep and conserve power.

We are also interested in how different presence information can be used for the same or different purposes. Earlier work in our lab [4] involved a preliminary investigation into the way that currently playing music information could be used to infer location as well as to use as a conversation starter. Further work into the usage of music presence or an investigation of sharing other data like TV shows or photos taken could help to maintain a sense of social awareness. Other applications such as using lights [5] or the idle screen of the phone to convey simple presence (home/not at home), similar to Tollmar's work in Scandinavian homes [23], could also be worth investigating.

Finally, we are interested in how the fusion of presence information can create richer experiences than any of the presence data taken alone. For example if a user knows that music is being played and a friend is in motion, perhaps they could then infer that the friend is working out and therefore not interruptible. Rich combinations of data could also work together to create a richer sense of social awareness and potential conversation starters.

CONCLUSION

We observed that people can infer useful location and activity information from motion data of close friends and family. Participants did not need detailed information on origins, destinations, arrival times, or absolute locations to infer where close friends and family were located and what they were doing. While our participants used this information for many of the same purposes that they used location and activity information spoken over the phone, our participants did not report to us that getting this information out of band provided much of an advantage to just calling the other person. They did not see the inconvenience of calling someone to be great enough to warrant the use of an application like this one on a regular basis. It would be interesting to see how use would continue if participants were able to use the phones for a longer period of time; however, improvements in battery life would have to be made to reduce the burden on participants. One hypothesis is that this sort of application is not something that one would find "useful" on a regular basis, but would provide lasting value over a longer time span as one can learn patterns and better plan communication and in person get-togethers which might be more infrequent activities.

We are quite interested in how other presence information is perceived in a mobile setting and in finding a collection of presence attributes and an appropriate presentation of these attributes that will meet the needs of mobile phone users and provide them with a meaningful way to build their existing strong-tie relationships and stay connected to family and friends. Our work will continue to this end in investigating how different types of information are used in the mobile context.

REFERENCES

1. Anderson, I., Muller, H. "Exploring GSM Signal Strength Levels in Pervasive Environments," aina, pp. 87-91, 20th International Conference on Advanced Information Networking and Applications - Volume 2 (AINA'06), 2006.
2. Aoki, P. M. and Woodruff, A. 2005. Making space for stories: ambiguity in the design of personal communication systems. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (Portland, Oregon, USA, April 02 - 07, 2005). CHI '05. ACM Press, New York, NY, 181-190.
3. Arminen, I. (2003) Location: a Socially Dynamic Property - A Study of Location Telling in Mobile Phone Calls. In L. Haddon et al. (Eds) The Good, the Bad and the Irrelevant: The User and the Future of Information and Communication Technologies, Conference Proceedings, Helsinki.
4. Bentley, F., Kaushik, P., Narasimhan, N. and Dhirah, A. 2006. Ambient Mobile Communications. CHI 2006 Workshop on Mobile Social Software. April, 2006.
5. Bentley, F., Tollmar, K. , Demirdjian, D. , Koile, K. and Darrell, T. 2003. Perceptive Presence, IEEE Computer Graphics and Applications, v.23 n.5, p.26-36, September 2003
6. Consolvo, S., Smith, I. E., Matthews, T., LaMarca, A., Tabert, J., and Powledge, P. 2005. Location disclosure to social relations: why, when, & what people want to share.

In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (Portland, Oregon, USA, April 02 - 07, 2005). CHI '05. ACM Press, New York, NY, 81-90.

7. DeUafera, C., Eichin, M., French, R.,. Jedlinsky, D., Kohl, J., and Sommerfeld, W. 1988. The Zephyr Notification Service. In Proceedings on USENIX 1998.
8. Dey, A. K. and de Guzman, E. 2006. From awareness to connectedness: the design and deployment of presence displays. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (Montréal, Québec, Canada, April 22 - 27, 2006). CHI '06. ACM Press, New York, NY, 899-908.
9. Dourish, P. and Bly, S. 1992. Portholes: supporting awareness in a distributed work group. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (Monterey, California, United States, May 03 - 07, 1992). P. Bauersfeld, J. Bennett, and G. Lynch, Eds. CHI '92. ACM Press, New York, NY, 541-547.
10. Grinter, R. E. and Palen, L. 2002. Instant messaging in teen life. In Proceedings of the 2002 ACM Conference on Computer Supported Cooperative Work (New Orleans, Louisiana, USA, November 16 - 20, 2002). CSCW '02. ACM Press, New York, NY, 21-30.
11. Hightower, J., Consolvo, S., LaMarca, A., Smith, I. and Hughes, J., "Learning and Recognizing the Places We Go," in Proceedings of the Seventh International Conference on Ubiquitous Computing (Ubicomp 2005), pp. 159-176, Sep. 2005.
12. Ho, J. and Intille, S. S. 2005. Using context-aware computing to reduce the perceived burden of interruptions from mobile devices. In Proc. CHI '05. ACM Press, New York, NY, 909-918.
13. Iachello, G., Smith, I., Consolvo, S., Abowd, G., Hughes, G., Howard, J., Potter, F., Scott, J., Sohn, T., Hightower, J., and LaMarca, A. Control, Deception, and Communication: Evaluating the Deployment of a Location-Enhanced Messaging Service. In Proceedings of Ubicomp 2005, Tokyo, Japan. September 2005.
14. Laasonen K., Raento, M., Toivonen., H. Adaptive On-device Location Recognition, Pervasive Computing: Second International Conference, PERVASIVE 2004, LNCS 3001, Springer Verlag (2004), 287-304.
15. Laurier, E. (2001) Why people say where they are during mobile phone calls. In Environment and Planning D: Society & Space, pp. 485--504.
16. LeCompte, M. and Schensul, J. (1999) Designing and Conducting Ethnographic Research. Walnut Creek, CA: Altamira Press.
17. Ling, R. and Yttri, B. (1999): Nobody sits at home and waits for the telephone to ring: Micro and hyper-coordination through the use of the mobile phone. Report No. 30/99, Telenor Research and Development, Oslo.
18. Marmasse, N., Schmandt, C., and Spectre, D. (2004). Watchme: Communication and Awareness between Members of a Closely-Knit Group. In Proceedings of UbiComp, Nottingham, UK.
19. Otasson, V. Varshavsky, A., LaMarca, A., deLara, E. 2006. Accurate GSM Indoor Localization. Ubicomp 2006. Tokyo, Japan.
20. Palen, L. and Dourish, P. 2003. Unpacking "privacy" for a networked world. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (Ft. Lauderdale, Florida, USA, April 05 - 10, 2003). CHI '03. ACM Press, New York, NY, 129-136.
21. Smith, I., Consolvo, S., Lamarca, A., Hightower, J., Scott, J., Sohn, T., Hughes, J., Iachello, G. and Abowd, G., Social Disclosure of Place: From Location Technology to Communication Practices, Lecture Notes in Computer Science, Volume 3468, Jan 2005, Pages 134 – 151.
22. Sohn, T., Varshavsky, A., LaMarca, A., Chen, M., Choudhury, T., Smith, I., Consolvo, S., Hightower, J., Griswold, W., and de Lara, E. 2006. Mobility Detection Using Everyday GSM Traces, in Proceedings of the Eighth International Conference on Ubiquitous Computing (Ubicomp 2006), pp. 212-224, Sep. 2006.
23. Tollmar, K. and Persson, J. 2002. Understanding remote presence. In Proceedings of the Second Nordic Conference on Human-Computer interaction (Aarhus, Denmark, October 19 - 23, 2002). NordiCHI '02, vol. 31. ACM Press, New York, NY, 41-50.
24. Vetere, F. , Gibbs, M. , Kjeldskov J., Howard , S., Mueller , F., Pedell , S., Mecoles , K. and Bunyan, M. Mediating intimacy: designing technologies to support strong-tie relationships, Proceedings of the SIGCHI conference on Human factors in computing systems, April 02-07, 2005, Portland, Oregon, USA
25. Weilenmann, A. H. and Leuchovius, P. 2004. "I'm waiting where we met last time": exploring everyday positioning practices to inform design. In Proceedings of NordiCHI '04, vol. 82. ACM Press, 33-42.
26. Weilenmann, A. (2003) "I can't talk now, I'm in a fitting room": Availability and Location in Mobile Phone Conversations. In Environment and Planning A volume 35, (9) September, pp. 1589 - 1605, special issue on Technology and Mobility, (Ed.) E. Laurier.