Exploring Personal Localization

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Abstract

We explored user attitudes toward personal indoor localization within the specific setting of UW CSE graduate students in the Allen Center. To do so, we used several HCI methodologies: Future Workshops, an online survey, a paper prototype, and user studies of the paper prototype. Taking inspiration from Value-Sensitive Design, we also identified values we wished to support. Fun and productivity were dual goals for the localization system, and we considered the privacy values of trust, plausible deniability, safety, calmness and social acceptance. Our contributions are the exploration of the wide range of user perspectives of the problem, and the development of a logging method that improves accountability and privacy in localization systems.

1 Introduction

Localization technology is emerging as a hot topic in ubiquitous computing [11]. Though its applications for elder care and activity recognition have been discussed [13, 19], we felt that personal localization, defined as letting users track each other, was under-explored. This project sought to quantify user opinions and attitudes towards personal localization and the values involved – how do users feel about locating others, and about being located? How can the system design affect these attitudes? We explored these questions using a variety of HCI techniques, taking inspiration from Value Sensitive Design [2], though we did not follows its method strictly. Our user population was the Computer Science & Engineering (CSE) graduate students at the University of Washington, in the context of the CSE building, the Paul Allen Center. We used Future Workshops [5] to brainstorm possibilities, and a survey to clarify user opinions of the matters raised in the workshops. Based on this data, we created a prototype system, on which we performed user testing. This wide variety of methods gave us a wide variety of perspectives on the problem. We feel that this range of data is our major contribution. As a secondary contribution, we also present a method for improved accountability and privacy in localization systems.

The remainder of this paper lays out the techniques we used, and what we learned from each of them. In Section 2 we describe the state of localization technology and the scope of our project and Section 3 describes our conceptual investigation of the values involved. Sections 4, 5, 6, and 7 describe the HCI techniques we used: Future Workshops, the online survey, a paper prototype system and the user studies on the prototype. We close with related work in Section 8 and our conclusions and future work in 9.

2 Localization Technology

A localization system allows a client device to determine its location. This can be done in a number of ways, including triangulating radio frequency signals from the environment and recognizing a sensor "signature." Systems can either rely on custom infrastructure or leverage existing infrastructure. A prominent example of the latter is the use of 802.11 (WiFi) network access point broadcasts, which has been shown to be accurate enough to determine a room in a building [8].

Location can be used for navigation tasks or by context-aware applications. In this project, we explore how graduate students in our department might use a system that enables the sharing of their locations to support collaboration or socializing. Although an integrated system has not yet been built, there have been prototype implementations of localization systems that work in the Allen Center.

To maximize its applicability to an actual implementation of such a system, we confine the area for potential localization to the UW CSE building. As a related restriction, our investigation only considered systems which could locate and be used by UW CSE graduate students. There was informal discussion of systems that included

professors or visitors, but we felt that these complications raised too many extra issues for a project of this scope. Expansion to buildings and users outside UW CSE are areas for future work.

3 Initial Exploration

Taking our cues from Value Sensitive Design, we started off our process with a conceptual investigation of the issues at hand. This consisted mostly of our impressions of our own current experiences in attempting to find people in the building, and of being found, and of our thoughts on what having the system would be like. Though we generated a large volume of material at this phase, we present only the most pertinent aspects here.

3.1 Stakeholders and Values

The direct stakeholders in a localization system are the users who are locating someone (the *finder*) and the users who are being located (the *findees*). Indirect stakeholders include anyone who does not use the system but is affected by its use, for example, department faculty, staff, visitors and undergraduate students, non-departmental friends, family or significant others of the building's inhabitants, as well as people who happen to be passing by or using the building. A variety of social issues could arise–will departmental indirect stakeholders be, or feel, left out? Perhaps a graduate student's spouse does not want location information revealed, but since he is always in the same room as the graduate student, people can infer the location of the spouse as well. One can imagine a host of other such questions regarding stakeholders.

We divided our values into two categories, *purpose* and *privacy*.

Purpose refers to the user's high-level goal while using the localization system. We identified two values, *productivity*, which is the accomplishment of academic work in an efficient manner, and *fun*, which includes socializing, group sports and games. As pre-quals students, our view of productivity is largely centered on courses. We realized that post-quals students would be likely to have a different view of productivity, and so we made an informal division between stakeholders, considering pre- and post-quals students separately throughout the project.

Privacy is the ability of individuals to control information about themselves. It is a value itself, but we divided it into five more specific values: trust, plausible deniability, safety, calmness and social acceptance.

In our survey and communication with participants, we referred to *trust*, or the absence of it, as "being lied to." How would users feel if they realized someone was lying to them about their whereabouts? *Plausible deniability* was "lying to others" – did users have the ability to deceive others as to their location if they needed to do so, to ignore or reject a request without upsetting social relationships, or at least to blur information (e.g. reveal floor rather than room location)? To what degree would they wish to do so and how comfortable would they feel doing so? *Safety* refers to the problem presented by location information in the hands of an attacker, stalker or thief. *Calmness* refers to the lack of what we called "creepiness" on our survey. It may be unsettling to know that you are being watched, or your location is being monitored, by someone else. We noted this in relation to the webcam in the department espresso lounge. While it is a great tool for enabling people to get together with colleagues, it's also creepy to imagine that someone you cannot see may be watching you.

3.2 Value Conflicts

The major conflict of values, and one of the major challenges of designing a personal localization system, is that privacy and purpose are at direct odds. If a user, concerned for her privacy, chooses to reveal as little information as possible, then it is accordingly more difficult to find her for purposes of fun and productivity. This gets more complicated as more users assert their privacy, and preventing this problem from bringing such a system to its knees is a major concern. Our prototype system includes a logging and accountability scheme which uses existing social pressures to enforce respect of privacy.

There are also lesser conflicts within the categories. Increased fun may reduce productivity, and lack of trust may affect social acceptance. Might peer-pressure force those who did not want to use this system to use it? If one chose not to use this system, would one be left out of social activities other students were planning? Some of these conflicts are already addressed, even without localization systems, for instance in the peer pressure to leave one's office door open. It may be impossible to create harmony between these values, but a design must be sensitive to them.

4 Brainstorming with the users

In order to get an initial idea of what the target population wanted, we held an abbreviated version of a Future

Workshop [5]. This section describes the workshop process and our conclusions from it.

4.1 Approach

A traditional Participatory Design Future Workshop has three phases: Critique, Fantasy and Implementation. Since implementation was outside the scope of this project, we only did the first two phases. For the same reason, and to save time, we used a more condensed version of the Critique and Fantasy phases than was presented by Bodker et al. [5]. We chose this technique as our first step for several reasons. First, as this is an exploratory study of our users, we wanted to include as many of them as possible in our first stage of design. A Future Workshop allows both gathering a large group of users together and getting their opinions all at once, as well as emphasizes everyone's participation by allowing everyone to get his or her turn to speak. Second, the Critique Phase is an effective way to get a good idea of the problems grad students currently have. Conducting a full ethnographic study would be would be too intense for this class project, and contextual inquiry would not have allowed us to get viewpoints from as many users in the same amount of time. At this early stage, we felt we should emphasize gathering as much data as possible, even if it's less detailed data, so that we'd have some idea where to direct the rest of our study. Third, because of the brainstorming nature of the Fantasy Phase, it would good as a first step in the design process. Finally, student involvement increases the chance of successful adoption of this system, should it be built.

We sent an email to the departmental graduate student mailing list asking for participants. We performed two Future Workshops, one for pre-quals students, with 4 women and 4 men, the other for post-quals, with 2 women and 6 men. Each lasted an hour and a half.

After explaining the procedure and the topic of our project to the participants, we began the Critique Phase. We posed two questions: (1) How and why do you currently find people in the building now? (2) What are your current problems with finding people and being found in the Allen Center? All the participants were given index cards on which to write their initial thoughts, after which every participant was asked to share a summary of his responses. We also asked for their office locations, to see how the placement of someone's office will affect their current localization practices.

In the Fantasy Phase, we asked the participants to brainstorm any solutions for personal localization that they wanted, no matter how fanciful. These ideas were grouped under categories, and in the post-quals workshop, participants divided into groups to develop their ideas and present them to the larger group, while in the other workshop, this phase consisted mostly of discussion as an entire group.

In the following subsections, we present the findings of the workshop.

4.2 Critique Phase: Current Practices

In the Critique Phase, students mentioned both social and work-related reasons for finding others in the department. Finding people for meals, to discuss homework or bouce research ideas around, or to gather a critical mass to play games like cricket. This exploration of goals led us to decide on *fun* and *productivity* as our "purpose" values.

We discovered that there did seem to be a general process most people followed for finding someone. The finder would first instant message (IM), email or telephone the findee, or possibly some combination of these things. Then, if there was no response and the reason was sufficiently urgent (either in terms of time or importance) the finder would walk to the findee's office. If the findee wasn't there, the finder might question the findee's officemates about their whereabouts, and then look in other common places for the findee might currently be in. Most of the pre-quals participants followed some fairly similar variation of this process. Some of the post-quals participants, however, tended to organize activities beforehand, and pre-arrange meetings, and so did not have quite as big a need to find people.

We also discovered that the layout of the building has a large impact on current practices of finding people. The CSE department moved from the cramped Sieg Hall into the spacious Allen Center two years ago. Our division of pre- and post-quals students happened to exactly land on the pre- and post-Sieg line, which we initially hadn't realized, and this gave us the opportunity to discover how the new building affected personal localization practices. In Sieg Hall, there were a handful of offices with large numbers of people in each, and the offices were laid out in a way that made it easy to visit all the offices by walking in a relatively straight, simple path through each floor. In the Allen Center, there are a large number of offices on more floors and each office holds far fewer people. Additionally, offices are more spread out and there are about three main corridors of offices on each floor. Hence, gathering a group of students takes a lot more legwork than in Sieg.

However, at the same time, there are some features of

the Allen Center that make it easier to find people. For instance, several students noted that they made use of the Atrium-window offices for finding people by walking out on the main staircase or catwalk and looking to see which offices were occupied or had their lights on. One student said he merely looked down at a hallway's floor to tell whether an office was occupied, because he could see the light from the office shining on the hallway floor, thus prevented him from having to walk down the entire hallway. We assume that this method is more useful in Allen Center since there are now fewer people per office, and so knowing that one office is occupied gives more information about whether a specific person is present than if the office contained a large number of people.

Other differences between the pre- and post-quals groups included the fact that the older group had less of a need to find people because they already had an established group of friends and tended to come to school less and only for planned activities, whereas younger students spent more time in the building, were still making friends and still had to work on class homeworks and projects with a variety of other students.

4.3 Critique Phase: Current Problems

Workshop participants brought up a variety of problems with their current practices. They did not like having to waste time or energy by playing a physical, office version of phone tag. Unless the finder was familiar with the findee's habits, it would be hard to know where to look for the findee if she weren't in her office. Would she tend to be in the lab, or in a breakout area, or some other favorite spot? Many mentioned that they wished there were an easy way to know if the findee was in class, or to have some idea of the findee's schedule. Also, students on floors with fewer grad student offices, or in less trafficked areas of the building, complained that they felt lonelier and more disconnected from the rest of their fellow students. Several students mentioned that cell phones were ineffective in the building because of spotty reception. For roles of both the findee and the finder, students were concerned with bothering the findee's officemates if the findee wasn't in her office.

On the other hand, people also mentioned being found when they didn't wish to be found. Sometimes students would be concentrating on work and not want to be disturbed, or they might be working on a Friday night, instead of going out, and not want other students to know. (Or the other way around, they're working on a Friday night, and would like to know that other students are around so that they feel a sense of camaraderie.)

4.4 Fantasy Phase

A variety of solutions were suggested, from the familiar ("glorified IM") to the wacky (firepoles to facilitate traveling through the building, the Mauraders' map from the Harry Potter books, etc). We grouped the suggestions into coherent solutions and ask the participants to elaborate on what they wanted out of each kind of solution. From these, we generalized that the type of application desired were of three types: interactive, passive, and peripheral. An *interactive* application is one in which the finder sends a request to the findee asking for their location. The findee then accepts or rejects the request and optionally selects how much information to reveal about their location. A *passive* application would be akin to the current IM model, where a list of a user's "buddies" and their locations appear on a continuously updated list that the user can check periodically or keep running all the time. A *peripheral* application is like current "task tray notifications" in the Windows OS, where a finder can set notifications, for example, when at least three people in her algorithms class have gathered in a breakout area in the building, and be alerted to this event via a blinking task tray icon or perhaps a dialog box, etc. when this event occurs. We also discussed whether people would like to be notified when someone was searching for them. Some felt this might annoy the findee, some felt that this would be a good idea akin to leaving an answering machine message asking for a call when the other person returns.

Secondly, from the discussion in the Future Workshops, we identified the types of targets, or findees. A finder could search for (1) a specific person (e.g. your friend Joe), (2) a person from within a group (e.g. anyone in your HCI class), (3) or a group of people (e.g. everyone in your HCI project group). We also identified the question of whether this should be a desktop/web application or one carried on a device like a cell phone or PDA. Finally, we identified several values that were important to the participants, which are detailed in Section 3.1.

Questions that came up during the Fantasy Phase regarding these solutions were, what if the findee did not want to be found? What features of the solution could support that? Some participants also thought it might be socially harmful if, for instance, a findee claims to a finder to be somewhere he's not, and then he runs into the finder. There were also concerns about being found in sensitive locations, like the bathroom.

5 Quantifying user opinions of the design space

To gauge user interest in various attributes of the hypothetical localization system, we conducted an online survey. This part of the project is equivalent to the empirical investigation phase of VSD.

5.1 Methodology

Our survey asked users to share their opinions of the desiribility of various aspects of the design space, and asked them explicitly about their attitudes towards the values we had identified, as listed in section 3.1. Questions about the design space generally took the form of this example:

> There are three types of targets which users may want to find. These are
>
> 1. *Specific person.* Bob wants to find Alice.
> 2. *Anybody in a group.* Bob wants to find anybody in his research group.
> 3. *A subset of a group, of certain size.* Bob wants to find enough of his Cribbage buddies for a game of Cribbage.
>
> Please consider how often you find yourself in these situations, for either work or for social activities. How desirable would you find a system that could do that kind of localization?

Users were then asked to rate the options for desireableness, on a scale of 1 to 5.

We asked similar questions about type of application, type of target, and about the desirability of a handheld device versus a desktop application, as described in section 4.4. After each of these rating questions was a free-response box in which users could share comments, and in which we asked them to disambiguate any items which they rated the same level. The objective of this part of the survey was to find the most preferred part of the design space.

We also attempted to gauge opinions about the values at play. We asked participants to rate how concerned they were about each of the values. The survey asked for the participants' gender and pre/post-quals status, but did not identify users. We posted the URL of the survey, with a request for participation to the graduate student mailing list. [1]

[1]Though we have no assurances that the respondents were all UW CSE graduate students, it is unlikely that anyone else would have encountered the URL of the survey, and the survey itself included text that asked that it only be taken by graduate students in CSE.

5.2 Results and discussion

We had 20 respondents to the survey. 12 were men and 7 women, 9 were pre-quals, 5 post-quals, and 5 post-generals. One respondant did not report gender or status. Raw data is listed in appendix A, and in this section we summarize the highlights.

Generally in line with our expectations, survey participants indicated that they would prefer a system that allowed a single individual as a target, that used passive localization, and that was available as both a mobile device and a desktop application. The model we had in mind, and which we described in the survey, was similar to an IM "buddy list", which names the users "buddies" (users of interest), and presents information about their locations.

What surprised us was how much more strongly users preferred a mobile device interface alone to a desktop application alone. We had postulated that the superior readability of a large screen would be more useful than the ability to locate others while not at one's desk (or laptop).

Participant responses about values were unsurprising. Users were generally unconcerned about lying to others, and were only mildly concerned about being lied to. They were more concerned with safety and creepiness, and consistently only somewhat concerned about social acceptance.

When asked about the importance of fun and productivity, users rated them almost identically. Some of the users also noted on this question that their "productivity" activities are usually scheduled, whereas "fun" activities are more free-form, making the system considerably less relevant for productivity.

The value conflict between privacy and purpose showed up in a couple of the participants' comments. One respondant said

> On one hand I think it would be nice to find others, but at the same time I would not want to participate in a system that could find me.

However, not all users commented on this, and one participant in the user study (described in section 7). In order to get at this issue, and to ask users to consider the tradeoff between knowing others' information and maintianing their own privacy, we asked

> For the system type and target type you preferred, think about the relative creepiness of

> others knowing your location with a certain specificity, and the usefulness of knowing others' location with the same specificity. Tell us the desiribility of each of these possible systems.

The *room* level was rated at an average desirability of 3.22, while *floor* and *building* averaged 2.77 and 3.94, respectively. Two respondants ranked *room* more desireable overall than *building*. This shows that, though room level is overall less desirable than building level (presumably for privacy reasons), it is not entirely undesirable, and is in fact preferred over another level which hides more information.

Gender had a few slight effects on response. On the majority of all of the questions, men and women responded the same way. However, opinions on three of the values were slightly different. On a scale that mapped amount of concern to the numbers from 1 to 5, women were slightly more concerned than men about safety (mean 3.5 vs 2.72) and about the creepiness of being locatable (4.14 vs 2.8), and slightly less concerned about the social acceptance factor (2.7 vs 3.18). Though the first two of these differences is consistent with stereotypes, the third is not.

We asked users to think of scenarios in which they would want to use the kind of system we propose. We took inspiration from these suggestions when chosing scenarios for the user studies, described in the next section.

6 Prototype design

Having explored the design space and refined our focus, we made a paper prototype of the system, based on the expressed preferences of the survey participants. The goal was to make our ideas concrete, so that users could be asked to evaluate them. In the parlance of VSD, this section of the project was a technical investigation, the proactive design of systems to support values identified in the conceptual investigation.

A major question at this phase was how to deal with the issue of privacy and the unsettling nature of being locatable by any other users. To address this, we developed a logging system that would let users to find out who had been looking for them, allowing normal social pressure to discourage excessive attention to any other user's location. One option would have been to actively ping the user being located any time there was a request for that information. The benefit of a pinging system would be that users would always know who had been looking for them, but the survey respondants agreed with our intuition that this would be annoying, for both the finder and the findee. At the opposite extreme, the system could passively display all of the available information all of the time, however, this leaves the privacy issues wide open.

In an attempt to get the best of both of these worlds, we developed a privacy and logging system, which leverages three different granularity levels of location information: *building* , *floor* and *room*. A user, let's call him Bob, sets a *default* level of information, for example, whether or not he is in the building. This is the information that the system displays at all times. In addition, Bob sets a *maximum* level of information, typically which room he is in. When another user, Alice, wishes to locate Bob, she actively queries the system, by clicking on his name. It shows her what room he is in, but adds logs that query. If Alice is querying for Bob with inappropriate frequency, he will know that if he checks his logs. If he wishes, he can make the log visible at all times, and see in real time when he is being looked for.

An extention of the privacy/logging system would allow users to set the default and maximum to apply differently to different other users. That is, Bob can set the default and max to *building* and *room* for his labmate Alice, but sets the default at *room* for his best friend Clive. He can also avoid his arch-enemy Denny by setting the maximum for Denny to *floor*.

The paper prototype has two list views, separated into tabs. The "People" view lists all locatable buddies, while the "Place" view shows a hierarchically arranged list of buddies grouped by their location at default granularity. The latter is useful for determining, for instance, if one's friends have gathered in their normal meeting place for lunch. Clicking on a buddy performs a query operation and displays her location on a map. A search box at the bottom of both views can be used to locate a specific person or list all people whose default granularity location reveals that they are at that location.

7 User Studies

Having made our prototype, we performed a user study to elicit feedback, paying particular attention to the reactions to our privacy/logging mechanism. We also used the opportunity to gather data on users' attitudes to the implications of a localization system. Whereas the survey had asked directly about user attitudes towards the values at play, this investigation explored those attitudes implicitly.

7.1 Methodology

We had a total of 5 participants in our user study: 1 pre-quals woman, 1 pre-quals man, and 3 post-quals men. All but one of the participants had taken our online survey, which had asked for volunteers for the study. We ran our first study as a pilot, after which we made slight changes to the questionnaire wording. We treat results from the first study the same as our other studies, except for differing questionnaire answers. The raw data from the questionnaire is presented in appendix B.

7.2 Procedure

Each user study consisted of 4 phases: introduction and disclaimer, demo, scenario, and questionnaire. One group member acted as the primary liaison to the participant, a second member took notes on a laptop, and a third acted as the "computer," responding to the participant's interactions with the prototype.

In the introduction phase, the liaison explained that the study was meant to learn how members of the UW CSE graduate student community might use localization technology to find other UW CSE graduate students. The participant was also told to assume that the technology would be highly accurate, down to the granularity of a specific room in the Allen Center. As a disclaimer, participants were told that we were testing the design of the system and not them, that there was no correct or incorrect answer that we expected from them, and that they could stop at any time.

In the demo phase, we presented the paper prototype, describing and demonstrating its features. The liaison explained that the interface is meant to be used on a desktop machine, and that a companion mobile interface is future work.

In the scenario phase, the liaison presented four scenarios to the participant. Each scenario involved finding one or more people for a specific purpose. When presenting a scenario, the liason encouraged the participant to alter it to match a similar situation that happened to them in the past, in order to get them to think about the concrete details involved in the process of finding people.

For two scenarios, the participant was asked to use the system while thinking aloud, and for the other two, the participant was asked to describe the steps that he or she would take if the system did not exist. We randomized the scenario order for each participant to reduce priming effects, and chose two scenarios to be with-system and two to be without-system, allowing us to compare current practices with the practices that might result from the existence of the localization system.

After going through a scenario, the participant was asked to imagine being one of the people being located by someone using the system in the same scenario. We asked what default and maximum granularity settings the participant would specify, given that someone would want to find them in that situation, and we asked for any opinions or feelings about that decision.

Scenario 1. Problem-solving: It's 9 PM and you have a paper deadline at midnight. However, you are getting a compile error in LaTeX that you can't figure out. You've had no luck with a search on the web, and you could post to cs-grads, but who knows if it'll get read in time? So you decide to find a fellow LaTeX-knowledgable student in the Allen Center to ask for help. How would you use this application to do so?

Scenario 2. Appointment no-show: You have made an appointment to meet with Alice, another grad student at 2:30 in, you think you recall, CSE 678, but it's 2:40 PM already, and she isn't here yet. Perhaps the meeting place has gotten mixed up and they're in another meeting room? Perhaps they forgot and they're sitting in their office or in their lab, or they could be somewhere else entirely. If you leave the room, though, this person might be on their way, and just miss you. How would you use this application to solve your dilemma?

Scenario 3. Lunch mates: It's lunch time, and you're looking for some company to head up to the Ave for food. How would you do so using this application?

Scenario 4. Project/Group discussion: You are working in a group of four people three other and yourself on a project. A big question related to the project has come up, and you'd like to talk it over with your teammates as soon as possible, preferably now. How would you use this application to meet with your teammates?

After all the scenerios were completed, we administered a questionnaire with questions regarding the participant's attitude towards the scenarios and the system. The liaison offered to clarify any confusion regarding question wording.

7.3 Results and discussion

The results for most participants were quite varied. All but one participant said that the system would be useful in at least two of the four scenarios. The "project/group discussion" scenario averaged a slightly higher usefulness rating, but all scenarios were deemed useful or very useful by at least one participant. This suggests that a general-purpose localization system could be useful to a range of people and their needs, even if its usage varies.

Though we gathered information about current practices, we found it to be largely redundant with the information gathered in the critique phase of the Future Workshop (see section 4.2).

7.3.1 Attitudes towards location disclosure

Perhaps surprisingly, most participants preferred to have their location granularity settings apply to all of the other users, rather than having per-buddy settings. Some of the participants felt that they could trust their peers, while others felt that having per-buddy settings might lead to socially awkard situations, if buddies with on different settings found out they were not trusted to the same degree.

One participant wanted to have a way to define granularities on a group basis, allowing him to put buddies into the appropriate group rather than individually tailor settings for each person. The group that a buddy would be assigned to would be based on familiarity (friend vs. stranger) or expected level of interaction (project partner vs. passing acquaintance).

Four of the five participants said that they would set their maximum granularity to *room.* Two of those participants wanted their default granularity to be *building,* because they wanted to know who might be querying for their specific location. The third participant had no preference between *building* and *room,* while the fourth chose *room* – the former disliked the idea of having queries logged while the latter did not care.

The response to the privacy/logging scheme was generally positive, and in one case very positive. Three participant indicated they would find the log useful. Conversely, one participant indicated he would be unlikely ever to query for more specific information about any other user, since he did not want his actions to be logged.

The woman participant was the only one to set her maximum level to *floor* when she was on the system. Her comments regarding the system were centered around not wanting to be interrupted when she was busy, e.g., in a meeting or class. She also mentioned that she would not want people to know when she did not come to school, which is why even the *building* setting would be disclosing too much information if she were to be logged in often.

7.4 Features

In this section we present several features which the participants suggested.

Interruptibility. Several participants commented that knowing the interruptibility of a findee was as important as knowing his or her location. When finding another user, participants often used that person's location to infer if they were busy, in a meeting or available. One participant expressed concern over the possibility that someone finding her might wrongly assume that she was interruptible given her location. A system that could convey interruptibility could be used to address these issues, although such a system might be very difficult to implement.

Subsets of people or places. Several participants asked for the ability to create groups of other users, to facilitate locating individuals. One participant mentioned that he would want the ability to apply filters to narrow down either the buddies or the locations displayed, because there might be too many people that might show up and make locating specific people more difficult.

Time. One participant mentioned that he might like to have a way to configure his maximum and default settings to automatically chage after a certain time of day.

8 Related Work

There are several existing personal localization systems, though none in the same context as ours. In the commercial arena, many mobile phone service providers have been offering location-based services. Both DoCoMo [18] and AT&T Wireless [9] have such services available for their customers. DoCoMo's service consists of websites for their mobile internet service augmented with personal localization information. AT&T's Find People Nearby allows users build a list of other AT&T subscribers whom they would like to locate. Their system works much like the "interactive" solution we described in our paper, with a finder requesting information and a findee accepting or rejecting the request, and the system automatically discloses the location in the form of urban coordinates. This detracts from the tool's flexibility and hampers control and denial practices. Location-tracking services for children or the elderly have also been developed [16, 17].

As for localization services in a smaller, organizational setting, KDDI.corp's [7] cell phone location service is designed for a corporate environment, to aid transport management, sales and marketing activities. In terms of indoor tracking, the Active Location Badge system [22, 10] uses small badges attached to users to ascertain their location. We envision a future system where

a small badge can be localized. Unlike Active Badge, which requires that a centralized server determine the badge location, we envision a system that supports a more privacy-friendly scheme that allows location to be computed locally on a client, as can currently be done using WiFi [8] and/or ultrasound [6].

There have also been studies on the specific question of what users would want out of a personal localization system and how they would use such a system. Work on Sun Valley [12], a location-enhanced messaging service for cell phones, confirms the need for plausible deniability, which our system supports, and stresses the need for activity-based, rather than place-based, locations, which we also discovered evidence of in our user study. Aoki and Woodruff [1] touch on plausible deniablity in terms of the need for ambiguity in the design of personal communication systems. Consolvo et al. [21] studied what users are willing to disclose about their location to social relations. Their work is very similar to ours but is more general in that they included outdoor localization and family, friends and co-workers. They found that the important factors in determining whether a user reveals her location information are: who the requester is, why he wants the location information, what level of information would be most useful to the user, and whether they are willing to disclose that information. Lederer et al. [15] also found that findees provide the level of information perceived to be most useful to the finder, or not at all. In our study, however, we discovered that for a small population like the graduate students of a specific university department, these factors were not as big a deal, perhaps because in limited group of users and a single building location, the possibilities of "who", "why" and "what" are fairly narrow. What appeared to be more important to the graduate students was their own perceived interruptiblity, whether they were busy doing work or were looking for company. However, in accordance with Barkhuus and Dey [3], our data shows that people are willing to give up some control over their personal location information if the application is useful to them[3].

9 Conclusions and Future Work

We have presented an exploration of user attitudes towards personal localization systems that can allow users to locate each other in the Paul Allen Center. Based on Future Workshops, an online survey, and user studies, we believe that a personal localization system has the potential to benefit UW CSE graduate students. Our proposed design supports a range of uses for locating people, while providing mechanisms to address their privacy concerns. Feedback from our user study participants provides evidence that there are people who would use such a system with some changes to its current design, provided there were enough other users.

One concern that might impede the adoption of such a system is the large variability in user preference and the resulting usefulness all users. It may be that the desire not to be localized is greater than the desire to find others, and that this may keep away too many users. A logical next step would be to study a larger group of graduate students using a working prototype system for an extended period of time. From such a study, we can get a better idea of the system adoption rate and how usage actually varies. More use would also uncover more social and privacy implications that could be due to design, not only to the target users, but to other groups such as faculty, staff, and undergraduates. Another area to pursue is designing a mobile application for users to locate others when not at a personal computer.

A basic issue with personal localization systems is the difficulty of getting the users to wear or carry the device that does the localization. Though this is less of a problem in corporate settings where active badges can be required [22], it could be an extremely difficult one in academic settings like this one. A future direction would be to perform a study of current habits in carrying small devices for communication (for instance, how often do people carry their cell phones with them?). It would also be useful to explore the possibilities of a tag that knows when it is on the user or not – in such a case, the user could leave the tag somewhere when she doesn't want to be located. Casual observation shows that users currently do this with cellular telephones – would it extend to localization devices? Would the tags be left separate from their users for so much time that the system became useless?

The restriction that localization only be available within the UW CSE building made a large difference in our data. As the world moves towards more ubiquitous systems, it makes sense to examine attitudes towards a system that included multiple buildings, perhaps all on the UW campus, or including users' homes. Plainly, a more expansive system would raise more and more complex issues of privacy and safety.

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A Survey Data

Online Survey (Statistics by Participant)

ID number:		92764	93716	94059	94165	94199	94234	93236	93299	93544	93646
Gender:		*N/A*	*man*	*man*	*woman*	*man*	*man*	*man*	*man*	*woman*	*man*
Status:		*N/A*	*P-G*	*P-G*	*P-G*	*P-G*	*P-G*	*P-Q*	*P-Q*	*P-Q*	*P-Q*
Type of Target	specific person	3	4	5	4	4	5	4	2	4	2
	anyone in a group	4	4	4	2	2	4	3	3	2	4
	subset of a group	4	5	3	3	5	3	4	4	2	5
Type of Solutions	interactive (ping)	*N/A*	2	3	4	2	3	3	3	2	1
	passive	*N/A*	4	4	3	4	5	3	2	3	5
	alerts	*N/A*	3	2	1	4	3	4	2	4	4
Interface Options	mobile device	*N/A*	4	4	4	4	4	4	2	2	2
	desktop/webapp	*N/A*	4	3	3	4	4	2	2	3	4
	combination	*N/A*	5	5	5	5	5	2	2	2	3
Purposes	fun	*N/A*	4	3	3	5	4	4	4	3	5
	productivity	*N/A*	3	5	4	3	4	2	3	3	4
Values	lying to others	*N/A*	1	1	2	5	1	3	3	1	1
	being lied to	*N/A*	1	2	2	4	1	2	2	1	2
	safety	*N/A*	1	1	2	1	2	5	4	4	5
	social acceptance	*N/A*	3	3	2	1	3	4	4	1	4
	creepiness	*N/A*	3	2	4	1	1	5	5	3	3
Granularity	room	*N/A*	5	4	2	4	4	4	2	3	3
	floor	*N/A*	4	3	3	1	3	1	2	2	4
	building	*N/A*	4	2	4	5	4	5	2	4	4

ID number:		96391	100378	102379	93179	93422	93459	94303	94475	94785	95262
Gender		*woman*	*man*	*man*	*man*	*man*	*man*	*woman*	*woman*	*woman*	*woman*
Status:		*P-Q*	*Pre-Q*	*Pre-Q*	*Pre-Q*	*Pre-Q*	*Pre-Q*	*Pre-Q*	*Pre-Q*	*Pre-Q*	*Pre-Q*
Type of Target	specific person	4	4	5	1	5	4	5	4	3	1
	anyone in a group	2	3	3	3	3	4	5	4	5	1
	subset of a group	1	4	3	2	4	4	5	3	4	1
Type of Solutions	interactive (ping)	4	2	5	2	2	4	4	5	4	1
	passive	2	5	3	2	4	4	5	4	5	3
	alerts	3	4	4	2	5	4	3	3	3	1
Interface Options	mobile device	4	4	*N/A*	2	4	5	3	4	4	3
	desktop/webapp	2	3	*N/A*	2	2	4	4	4	5	1
	combination	3	5	4	2	3	5	5	5	4	1
Purposes	fun	4	4	5	2	5	*N/A*	4	4	4	2
	productivity	2	5	4	2	3	*N/A*	5	5	5	2
Values	lying to others	3	1	2	3	3	*N/A*	2	4	1	1
	being lied to	3	1	5	3	3	*N/A*	2	4	2	2
	safety	2	4	3	3	1	*N/A*	5	3	4	5
	social acceptance	4	3	4	3	3	*N/A*	3	3	4	2
	creepiness	4	3	3	3	2	*N/A*	4	5	4	5
Granularity	room	1	4	5	2	3	*N/A*	4	3	3	2
	floor	2	1	3	2	4	*N/A*	5	5	3	2
	building	4	5	5	2	5	*N/A*	4	5	4	3

Online Survey (Average Statistics)

		Gender		Status			All Participants			
		dude	lady	pre-quals	post-quals	post-generals	mean	median	max	min
Number of Attendance:		12	7	9	5	5	20	20	20	20
Type of Target	specific person	3.75	3.57	3.56	3.20	4.40	3.65	4	5	1
	anyone in a group	3.33	3.00	3.44	2.80	3.20	3.25	3	5	1
	subset of a group	3.83	2.74	3.33	3.20	3.80	3.45	4	5	1
Type of Solutions	interactive (ping)	2.67	3.43	3.22	2.60	2.80	2.95	3	5	1
	passive	3.75	3.57	3.89	3.00	4.00	3.68	4	5	2
	alerts	3.42	2.57	3.22	3.40	2.60	3.11	3	5	1
Interface Options	mobile device	3.25	3.43	3.63	2.80	4.00	3.5	4	5	2
	desktop/webapp	2.83	3.14	3.13	2.60	3.60	3.11	3	5	1
	combination	3.83	3.57	3.78	2.40	5.00	3.74	4	5	1
Purposes	fun	3.75	3.43	3.75	4.00	3.80	3.83	4	5	2
	productivity	3.17	3.71	3.88	2.80	3.80	3.56	3.5	5	2
Values	lying to others	2.00	2.00	2.13	2.20	2.00	2.11	2	5	1
	being lied to	2.17	2.29	2.75	2.00	2.00	2.33	2	5	1
	safety	2.50	3.57	3.50	4.00	1.40	3.06	3	5	1
	social acceptance	2.92	2.71	3.13	3.40	2.40	3.00	3	4	1
	creepiness	2.58	4.14	3.63	4.00	2.20	3.33	3	5	1
Granularity	room	3.33	2.57	3.25	2.60	3.80	3.22	3	5	1
	floor	2.33	3.14	3.125	2.20	2.80	2.78	3	5	1
	building	3.58	4.00	4.13	3.80	3.80	3.94	4	5	2

Note 1: the statistics were based on the following scale: 1: really undesirable, 2: undesirable, 3: neutral, 4: desirable, 5: really desirable.
Note 2: P-G means post post-general, P-Q means post-quals, and Pre-Q means pre-quals.

B User Study Questionnaire data

1. How useful would the system be, for each of the scenarios?

	$P0$	$P1$	$P2$	$P3$	$P4$	average
problem-solving	3	5	3	2	5	3.6
appointment no-show	4	4	4	2	4	3.6
lunch mates	5	3	3	3	3	3.4
group discussion	5	4	4	3	4	4.0

2. Per-user or everyone setting

	$P0$	$P1$	$P2$	$P3$	$P4$
rating	4	4	3	3	2 (groups defined)

3. Default and maximum? (Building:1, Floor: 2, Room: 3)

	$P0$	$P1$	$P2$	$P3$	$P4$
default	1	1	1/3/doesn't matter	2	2
maximum	3	3	3	2	3

4. Separate default and max levels, or one level?

	$P0$	$P1$	$P2$	$P3$	$P4$
Have both	N/A	5	3	3	2
One default	N/A	1	3	4	4
One max	N/A	4	3	1	2

5. Usefulness of query log

	$P0$	$P1$	$P2$	$P3$	$P4$
having a log	N/A	4	1	5	2
having visible log	N/A	2	1	5	2

6. How often would you use system to find people $(1:0\%, 5:100\%)$

	$P0$	$P1$	$P2$	$P3$	$P4$
rating	4	4	5	3	3

7. How frequently would you be logged on $(1:0\%, 5:100\%)$

	$P0$	$P1$	$P2$	$P3$	$P4$
rating	4	5	4	2 (interrupts)	4

8. Percentage of people necessary for system to be useful $(1:0\%, 5:100\%)$

	$P0$	$P1$	$P2$	$P3$	$P4$
rating	3	3	4	N/A	2

C Paper Prototype Images