

FriendGlass: A privacy preserving ambient location display

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ABSTRACT

Ambient displays are becoming popular forms of providing users with information in the periphery. Users are often interested in locations and activities that take place in a building. As a result, it is appropriate to create ambient displays to share the locations of users in a building. However, location systems are highly privacy-sensitive, so it is important to consider the privacy ramifications of such an ambient display. In this paper, we present an ambient location display called FriendGlass, which was designed with privacy support as a main feature. In this paper, we present the design process for FriendGlass, which included a small user survey which aided the designers in determining the needs of users for such a system. Finally, we present a discussion concerning the barriers to performing user tests for privacy sensitive ubiquitous systems such as FriendGlass.

Categories and Subject Descriptors: H.5.M [Information Interface and Presentation (e.g., HCI)]; K.4.1 [Computer and Society]: Public Policy Issues—*Privacy*

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INTRODUCTION

Ambient displays are becoming more common in social computing research. They can present information in the periphery that users might be interested to know, such as current activity or network traffic [3]. However, these displays are often counterintuitive. More than any other digital displays, the meaning of an ambient display should be immediately obvious. In [3], they present an example of an ambient display designed to present information on presence in a space. They use active wallpaper and create shadows on it to indicate when other persons are in some space. This space may or may not be obviously tied to the wall the information is being displayed on. While this display is fairly intuitive, it can only display a limited amount of information: for example, how many people are walking past one's cubicle. If this display is to be used to display presence in a remote space, it becomes less intuitive, and as a result, users would likely treat the information as just noise in the background. This paper presents FriendGlass, which is an ambient display of location information. FriendGlass uses a simple interface with dots on a map. This interface is effective and intuitive and can display presence information not only in the local space but also in remote spaces.

FriendGlass was designed for the Siebel Center for Computer Science. Because a location detection system is not currently available in the Siebel Center, FriendGlass dis-

plays a best guess location based on information that can be ascertained by the Building Automation System (BAS). More specifically, the Siebel Center is equipped with electronic door locks. When a user swipes into the door, the system registers these actions. FriendGlass uses these records to determine the user's location. Additionally, the BAS has occupancy sensors that are used to determine room occupancy so that lights can be shut off to preserve power. FriendGlass uses data from the sensors to detect if rooms are currently empty. In [1], the authors present more detail on how location is determined using these sensors. FriendGlass displays location information of individuals as dots on a map. Because accuracy is an issue, dots will fade from the map as time passes because it becomes more likely that the conjectured location is no longer accurate. Some users, however, may wish that the dots indicating their location do not fade. FriendGlass allows users to force their dots not to fade so as to increase the accuracy and in turn, the usefulness of the system.

When investigating presence displays, privacy becomes paramount. In [4], the authors found that users did not accept their connected kitchens because of privacy concerns. Because users are highly aware of the privacy implications of such applications, it is important to consider privacy in the design from the beginning. Because of this the privacy interface and infrastructure are a vital part of FriendGlass.

Privacy is protected by presence systems in a variety of different ways. The active wallpaper displays in [3] and the connected spaces in Telemurals [5] both mitigate users' privacy concerns by abstracting information. While the concept of abstraction is appropriate for assuage the privacy concerns of users, it also has the side effect of greatly reducing the amount of information that can be presented in the display. In FriendGlass, we chose to use an access control system which helps to find a balance between abstraction and displaying too much information. The access control system used in FriendGlass, discussed in greater detail in [1], allows users to create rules about who can see there their location based an environmental contexts such as their current location, or the time of day. Additionally, FriendGlass allows user to specify some amount of abstraction. Users are able to, for example, specify that their "dot" is shown, but not labeled.

This paper is organized as follows. In the following section, we present related work. We then present an initial design for the FriendGlass system. Following this discussion, we

describe a survey of potential users to ascertain the usefulness of the system as well as guide a re-design of the system. In the fifth section, we present an updated design based on the results of the survey. Following this section, we present a discussion on the barriers to performing a full user study on the FriendGlass system. We then conclude in the final section.

RELATED WORK

FriendGlass is not the first ambient display of location or presence. In this section we will survey several other projects that display location information in various ways.

In [2], the authors present a few ideas to show presence, such as the presence light and intentional presence lamp. Similar to FriendGlass, the authors of Casablanca found that privacy was a vital issue in their ambient displays of location so in intentional presence lamp they gave the user the ability to "turn off" presence detection in order to preserve their privacy.

In [8], the authors present a design of a series of ambient displays including a presence indicator. They call this display active wallpaper which has light shining on it to indicate the presence of individuals either in a remote space or the local space. This display is akin to shadows on the wall.

Ubisense [7] is a highly accurate location detection system that is designed for use in business and buildings like the Siebel Center. Unlike the detection system for FriendGlass, it is expensive and requires difficult calibration. It is, however, packaged with an application similar to FriendGlass in which users are able to see the location of their co-workers on a map. However, unlike FriendGlass, Ubisense offers no privacy protection and does not make use of colors and dot size to indicate information about the users on a map. Any additional information one may wish to infer about a user must be inferred only from their location.

Mankoff et. al. [6] also gives an example of a location display in their paper on heuristic evaluation, although their display focuses on tracking busses while our display focuses on tracking people. Bus Mobile displays the location of busses by varying markers distances from a cap, which represents the building the mobile was located in.

In [5], the authors present a virtual portal which displays presence of other people. The Telemurals display is, however, designed more as a social catalyst than a static ambient display.

INITIAL DESIGN

The design of FriendGlass proceeded in two phases, separated by a user survey. In this section, we will present the initial design of FriendGlass.

Initially, the main focus of FriendGlass was to notify individuals when someone had entered their room. When a person swiped into their office, their face would fade in, hiding the map and then fade out again. The map had dots indicat-

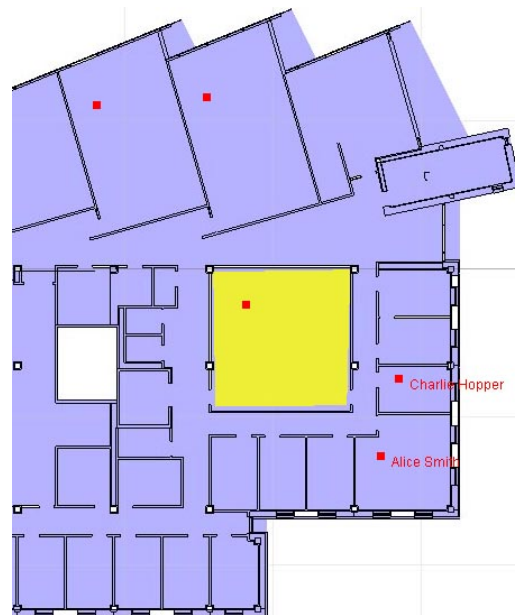


Figure 1: A screen shot of the initial design of FriendGlass. Labeled dots are the dots of individuals the map owner has subscribed to. The yellow box indicates the room in which the display is currently located.

ing the users' locations in the building, with color indicating their role. Additionally, dots could be labeled on the map with a name so that an observer would know who that particular individual was. A screen shot of this map is shown in Figure 1.

However, in such an application, privacy is of paramount importance. FriendGlass was built on top of a system designed for The Siebel Center for Computer Science called Janus's Map [1]. Janus's Map is a privacy-sensitive location information system. Using the electronic door locks and occupancy sensors, Janus's map is able to conjecture user's locations in the building. Additionally, Janus's Map allows users to define a privacy policy that limits what information can be used to determine location as well as who may view such information. Because of this, FriendGlass is designed to be used by a single individual. One could imagine, for example, that FriendGlass would run on a PDA or tablet P.C. that sat on a user's desk in the periphery to their main work station. This design decision is important because people may often allow some people to know their locations but not others, so each FriendGlass display needs to be tied to a specific individual.

Rules for Janus's Map and, subsequently, FriendGlass, consist of 3 parts: targets, data access, and visibility. The targets of a rule are the users to whom the rule applies. The data access portion defines which events can be used to determine a user's location, by limiting, for example, the time during which events may be used. Finally, the visibility section of a rule allows writers to specify how much of their location should be revealed, for example, they may wish to only reveal their floor instead of their room. Alice might define, for example, a rule that states Bob can only know her location between 9am and 5pm Monday through Friday. Unfortu-

Topic	Response
General Use	2.6 (Average out of 4)
Use of Color	6 Availability, 6 Role
Should dots fade	8 yes, 6 tunable
Being notified of persons entering your current room	2.4
Using multiple rules	3.2
Time as a feature of rules	2.9
Location as a feature of rules	3.1
Controlling whether your dot is labeled	2.9
Event type as a feature of rules	2.5
Should invalid swipes be used to determine locations	2.7
Location granularity as a feature of rules	2.3

Table 1: Survey Results. Numerical responses were on a scale of 1-4 (Strongly agree to Strongly disagree). Elements following the double line concern what should be considered in rules.

nately, showing a user as on a floor would be very confusing in the map visualization so the visibility portion of a rule has been removed in FriendGlass.

Once this design was completed, we surveyed potential users of the FriendGlass application. The purpose of this survey was to determine which features would be most useful and also to gauge how much users might use such an application.

SURVEY

In order to ascertain users' expectations from a system such as FriendGlass, we performed a survey of potential users. We asked graduate students in Computer Science to participate in the survey as they would be the most likely users for the FriendGlass system.

The goal of the survey was to determine what users expected from FriendGlass. More specifically, the survey included questions to determine whether users would use this system, how color ought to be used in the map, whether dots should fade based on confidence in a user's location, and finally, what parts of a rule would be most useful. The survey was 4 questions long. The first 3 questions each had 2 parts, a multiple choice question and an open-ended question. The final question, which focused on how users would write rules for specifying their privacy requirements, was broken into 15 statements. Participants were asked how much they agreed with these statements on a 4 point scale, from strongly agree to strongly disagree. These statements dealt with the importance of different aspects of privacy rules as well as different potential features of the FriendGlass application. These topics, as well as the results of the survey, are listed in Table 1. 15 students participated in the survey.

One of the most important things we learned from the survey was that privacy and accuracy were the greatest concerns of users surveyed. In fact, some survey participants were very concerned that the system would not be useful because most people wouldn't bother to configure the system to show their location because of their privacy concerns. Additionally, because there are many rooms in the building that users do not need to use the e-locks to enter during business hours, they

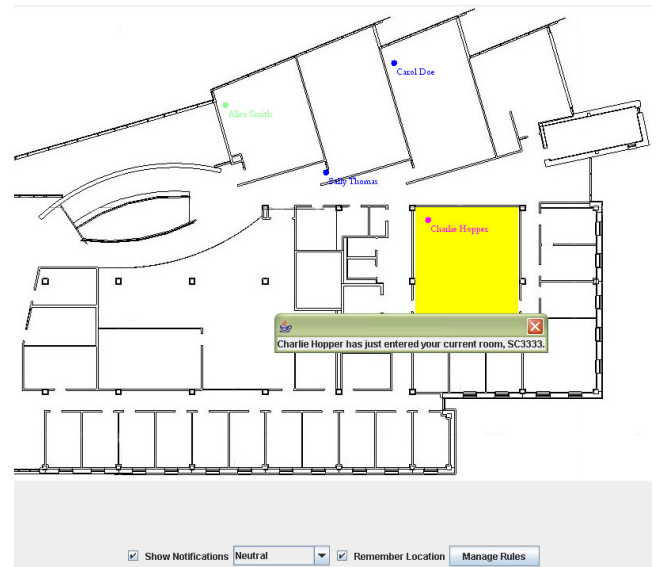


Figure 2: The second version of FriendGlass. Take note of the notification as well as the fact that Alice's dot is hard to notice. This is because she waited until her dot faded before asking for her location to be remembered.

feared that, most of the time, the people they were most interested in finding would not appear on the map even if they had configured it.

We also learned the location and time were the most important parts of a rule. Additionally, users would like to have control over whether their dot has a label associated with it. This allows users to indicate their presence while not necessarily having to reveal that it is them.

POST SURVEY RE-DESIGN

Using the survey results, we went back to the original design and tweaked a few things in order to complete the FriendGlass design. The most interesting result of the survey, design-wise, was the split decision on how to use color in the map. From these results, we elected to use color to indicate role in the building (i.e. graduate student, staff, professor, etc.) and dot size to indicate availability. Additionally, we elected to add a small configuration panel to the bottom of the map display. This configuration panel would allow users to set their availability as well as request that their location is "remembered", meaning that their dot would not fade. One feature of the "remember" switch was that users could allow their dot to fade before flipping the remember switch. This would then hold their dot at the transparency it was when the switch was activated, effectively giving users the ability to make their dot harder to notice at first glance. Figure 2 shows the newly designed map display.

Additionally, from the survey results, it was apparent that time was an important factor in writing rules. As a result, we developed a time-centric rule manager, which is shown in Figure 3.

Users are able to select times and then create rules that apply during those times of a week. All rules repeat week to week. By using a calendar-like rule manager, users are able to get a

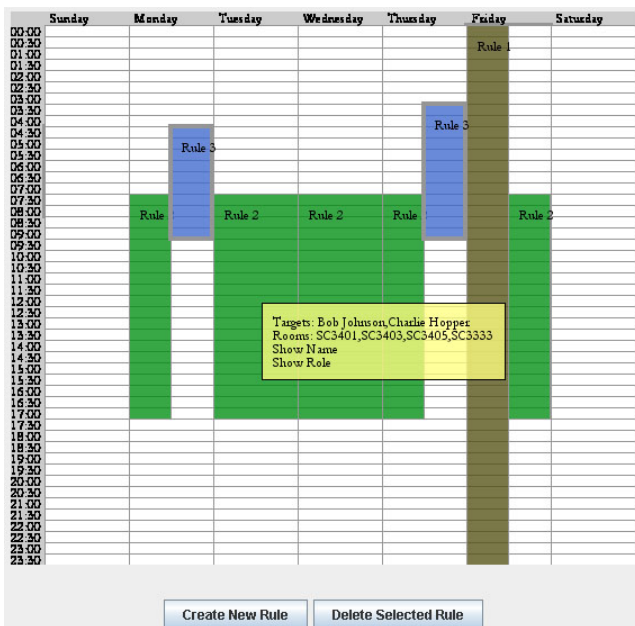


Figure 3: The rule manager for FriendGlass

good idea of when their locations are visible at first glance. It is also important to note that rules are written concerning when a location can be seen. If, at any particular time, no rule is specified with a certain user as the target, that user will not be able to see the dot associated with the rule writer.

The results of the survey also indicated that users were not terribly excited about using granularity or event types in rules. As a result, they have been removed from the rule system for FriendGlass. Additionally, we elected to always hide invalid events. Unfortunately, this information could be useful if users want to indicate their location to someone by sliding their card in a nearby door to which they do not have access: for example, the employee door of the coffee shop in the Siebel Center.

BARRIERS TO A FULL USER STUDY

One of the most difficult things about developing privacy-sensitive, ubiquitous systems such as FriendGlass is that it is problematic to deploy a full system. While with some systems, working with prototypes is appropriate, this is not the case with a system such as FriendGlass. This is because no matter how many surveys are performed, it is hard to predict how people will actually use the system. This is also true of the privacy management framework for FriendGlass.

People have difficulty fathoming a system as far-fetched as FriendGlass, which makes standard short term user studies inaccurate and inappropriate. With an application such as FriendGlass, it is more appropriate to fully implement the system and then perform ethnographic studies on how it is used. Once users in a building are used to the system, one can begin to do more complete investigations on interfaces both for displaying location information and for managing privacy.

Unfortunately, some of the same things this project ad-

resses are also barriers to implementing it in a building. In working with the building managers to implement the location system used in FriendGlass, we were met with some resistance due to the sensitive nature of the door lock logs used to determine the location of people. Specifically, the building managers were concerned about the privacy of the information being released. It is vital to successfully studying the FriendGlass system “in the wild” that the security and privacy systems are well developed and trustworthy.

CONCLUSIONS AND FUTURE WORK

In this paper, we present a system called FriendGlass for displaying location in a building equipped with a BAS. After presenting an initial design, we presented the results of a user survey. These results were fairly positive and bode well for a system such as FriendGlass. The key results from the survey were that users were most concerned about privacy and accuracy. The system underlying FriendGlass, Janus’s Map, aims to address privacy for a location system that uses BAS sensors and can be extended to include other pieces of building infrastructure to improve the accuracy of the system. Following the user survey, FriendGlass was redesigned to take user feedback into account. Finally, we have presented a discussion on the barriers to doing a full user study for a system like FriendGlass.

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