

# Representing and supporting action on buried relationships in smart environments

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## ABSTRACT

Mutual relationships can provide springboards for conversations. Such relationships are built on common interests. Our goal is to make shared interests visible in order to support conversation and help build relationships. Our system looks for context common to one or more people present in a public space, and uses an ambient display to expose abstract representations of that context. More specific information can be viewed by users on a PDA, but is not displayed publicly in order to preserve privacy. Our hypothesis is that exposing those relationships will increase either virtual or physical dialogue amongst collocated users.

## Keywords

Ambient displays, context, recommender systems, PDA

## INTRODUCTION

Mutual relationships can provide springboards for conversations. Such relationships are built on common interests. Our goal is to make shared interests visible in order to support conversation and help build relationships. Our hypothesis is that exposing those relationships in a public setting will increase either virtual or physical dialogue amongst collocated users. We are particularly interested in the type, amount and particular aesthetics of information best displayed on personal versus public displays, and how to assess the change in the social dynamics of a space that a public display affects.

The system we will present in this paper includes two components, a public ambient display and a private PDA display, that work in conjunction to allow collocated users in informal spaces to discover and explore mutual relationships derived from their past interactions with smart environments. The system uses implicit sensing both to extract user interest and determine user identity near the ambient display. After both displays were developed, we conducted brief user studies of both interfaces. Users studies showed that the abstract representation of

relationships shown on the public display struck a balance between usefulness and privacy but that there should be a better mapping between the PDA interface and the public display. We intend to conduct a long term, in-use study, by deploying the system to labs at Berkeley and HP.

## Motivation

Conversations engender knowledge of one's community, which in turn encourages positive social change [18]. Conversations may arise out of a mutual relationship to a similar thing or event. Typical examples include the weather or the local sports team. However, more specific knowledge of another person or event may allow richer conversations.

In a ubiquitous computing environment wherein users and their subsequent interactions are sensed, a wealth of information is available. To present found relationships to users in an intelligent environment, we employ a composite system integrating a public ambient display that provides aggregate, abstract information and a PDA display that displays more specific information. The public ambient display notifies users in the space of the existence of relationships and the PDA supports inquiry and communication if participants are not co-located.

Ambient displays are designed to non-intrusively provide users with pertinent but usually non-critical information. They are especially appropriate for situations in which users are expected to focus on something else in the environment. Because they typically generalize or abstract information, they are also useful in situations in which an individual's privacy is a paramount concern, providing a gist of the relevant information without divulging detail. This property also allows them to effectively display data for which the details are uncertain or ambiguous.

PDAs provide a better interface to specific information because, unlike ambient displays, they support focal interaction. Therefore, in our prototype system, users interact with relationships through a PDA interface that allows them to discover more information about an entity as well as begin virtual dialogues with remote users to which they are related.

These two displays, public ambient and personal PDA, can work in tandem to provide a means of sharing personal

information. Public ambient displays can mitigate privacy issues derived from implicit context sensing by providing an overview of information rather than explicit detail.

Luff and Heath note in their work on paper-based medical records that there should be mechanisms in a work environment to support movement of data from “the individual and private” to the “collaborative and public” [12]. Furthermore, Greenberg recommends “against a rigid notion of personal versus public” and encourages research that allows “many gradations between” personal and public in “subtle and lightweight ways” [5]. An ambient display is a particular gradation wherein the contents of personal data are hinted at but not fully revealed.

### Overview

In this paper, we will first describe previous work in ambient displays, spontaneous interaction and conversation and community. Then we will layout system development, including the content discovery mechanism, sensor technology, context analysis and an initial iteration and follow that with a discussion of our user tests. We will then conclude and describe ongoing and future work.

## BACKGROUND AND RELATED WORK

### Public displays

Previous work has explored the use of context-aware public displays in generating spontaneous conversations. McCarthy’s Groupcast is a peripheral display that recognizes passers-by and posts content of interest to at least one of the users [13]. The work is similar to the system described here, but relied on users to enter specific and thematic interest categories rather than implicit sensing. Furthermore, McCarthy’s display was not specifically designed to present information to human peripheral senses and therefore was not ambient. Lastly, it did not have an interactive component.

Snowdon’s and Grasso’s CWall published articles captured from a community web site to an interactive public display [16]. The system had other interfaces as well, including a PDA version. However, the display did not use implicit sensing to determine user interest nor presence.

Other public peripheral displays have been developed and tested. Greenberg’s Notification Collage and Huang’s et al Awareness Module present items posted by users in a group to personal and public displays but neither use implicit sensing [6,9]. Finney’s FLUMP provides information on a public display after sensing presence (Active Badge), but does not use implicit sensing to determine user interest [4]. Information posted to Russell’s Blueboard is meant for explicit rather than spontaneous interaction [15].

### Conversation and community

Grice’s cooperative principle of conversation states that participants will tend not to make statements for which

they “lack adequate evidence” of being true and those that risk relevancy [7]. Evidence and relevancy can be supplied through the use of prompts, which, though are usually in the form of a spoken statement, may also be any shared experience. This shared background provides a context in which a conversation may develop [1].

## SYSTEM DEVELOPMENT

There are four critical pieces to our system – context awareness, content discovery, context analysis and interfaces.

### Context awareness

When users approach a public display they are automatically sensed by the system. Several breeds of sensor technologies exist that allow ID tracking, including direct haptic input, infrared and RFID [10,11,17]. In the current model, users explicitly point their PDA to a nearby infrared beacon, which then registers them with a space via a dialogue process involving user response. After completing this process, the space notifies the public display of the user’s presence. However, to best encourage spontaneous interaction, the technology used by this system should require minimal human interaction. The ambient quality of the public display is defeated if users have to explicitly tell the system of their presence in the room. Therefore, in ongoing work sensing technology is being developed to be as non-intrusive as possible.

### Content discovery

In order to determine relationships between users sensed near a public display, the system must have some knowledge of their interests. In the current system, relationships between individuals are ascertained from relationships between their associated content (Fig. 1).

Content may include descriptions of other participants or other smart environments as well as files. Users’ interactions with people, places and files in smart spaces

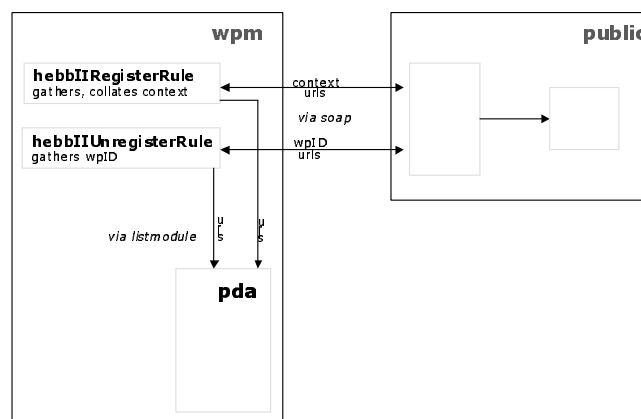


Figure 1. System design. On the left, code that is directly linked to the Web Presence Manager, including rules that fire when someone enters or leaves a space. On the right, the context analysis and public display components.



**Figure 2. Iconic public display (left), lexical public display (center) and PDA interface (right).**

are recorded via the Web Presence Manager infrastructure (WPM) [11].

In the WPM, users can view a web accessible interface for every person, place and thing known in the current context. Upon entering a WPM-enabled space, users can access their particular web interface to move their personal content to smart devices in the room (e.g. to send a PowerPoint presentation to a projector). The WPM records these interactions and furthermore extracts meta-information from those records. In this model, users must specify their personal content a priori. In ongoing work we are investigating the use of implicit content discovery.

### Context analysis

A separate system component analyzes user interest and makes the results available for different views. The current system uses object meta-information in the form of key-value pairs in determining relationships. Previous work has investigated the use of file content to augment the use of a current task [14], topic understanding from texts [8] and personalized document properties [3].

In addition to object meta-data, the system also integrates location and time in analyzing relationships. The WPM automatically records object meta-data, such as a file's name or mime type. Location and time are also recorded automatically when any event occurs in a smart space and both impact the strength of the calculated relationship between individuals. For example, if Joe meets Carla in 420 Soda and Dan in BID while Chris later also meets Carla in 420 but meets Dan at HP, when Joe and Chris meet their mutual relationship to Carla will rank slightly higher than that to Dan.

As some aspects of the system have not yet been implemented, such as implicit sensing and content discovery mechanisms, we concentrated our user studies on an analysis of the usability of the user interfaces.

### USER STUDIES

In user studies we evaluated the interface components of the public and private displays used in this system (Fig. 2). Specifically, on the public display we compared two different means of presenting relationship meta-data: lexical descriptions (e.g. file name, place description or the name of another person) and icons. To test the PDA interface we gave the users a specific task and monitored them as they attempted to complete it. We tested four users under nearly identical conditions. We presented two of the users with the version of the public display using lexical descriptions and the other two with the iconic version. All four users completed the same task on the PDA interface. Finally, we asked all users to comment on their privacy preferences with regards to public displays.

### RESULTS

We found that subjects were not able to peripherally monitor the public display and that they were able to recall more information (such as number of relationships presented) after glancing at an iconic display versus a lexical display. The former result follows from earlier findings that users tend not to perceive information on which they do not have reason to focus [2]. This implies that users should be made aware of the benefits of such displays before use. Furthermore, that users were able to ascertain more general information from the iconic display is not surprising given icons have larger screen representation than written text. However, as subjects were not able to accurately recall the content of the text we believe there is significant benefit to displaying iconic versus lexical data.

Subjects had a difficult time on the final task. It was apparent that the PDA interface was altogether too complex for the users to complete the task in a reasonable amount of time. Two issues that became clear from subject comments during the task is that there needs to be a clear

mapping between the personal device and the public display, and that the personal device should have a much simpler interface.

Subjects generally reported that they would feel uncomfortable having the full contents of their files displayed publicly, especially if those files were implicitly sensed. Iconic or textual displays seemed more appropriate, though one subject did not want files made public no matter how ambiguous the view.

## DISCUSSION

While a four subject study is hardly a rigorous enough basis on which to found design guidelines, we feel that the study nonetheless provides some direction for our work. Results from tests of the public display as well as the exploratory privacy question urge us to further explore iconic representations of relationships between collocated users. Furthermore, results from the test of the PDA interface show that care is needed to design simple interfaces to interactive mediums so that users can rapidly get to the business of communicating with each other rather than stuck navigating an interface.

## CONCLUSION AND FUTURE WORK

In this paper, we have outlined our work in facilitating spontaneous interaction amongst collocated users. Our hypothesis is that by exposing relationships amongst collocated users in a public setting we will increase either virtual or physical dialogues. User studies evaluating the effectiveness of the public and private displays to communicate relationship information have made apparent the importance of iconic public presentation and simple private access.

In future work, we intend to extend the composite system to different venues and evaluate *in situ* use of the system over an extended period of time.

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