Evaluation of a Location Linked Notes System

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ABSTRACT
We present a location-aware messaging system that lets users read and post notes tied to a particular location. We developed multiple clients (desktop, PDA and cell phone) so that users could choose the most contextually-appropriate device to interact with the system. We allowed remote access and authoring to avoid imposing artificial restrictions on users. We report on our initial evaluation of the system. The goal of the evaluation was to explore novel potential uses of the system and to identify users' preferences regarding the different system features. In our evaluation, we found that users were receptive of this system for leaving and receiving location-targeted reminders. They also overwhelmingly approved of the remote access and authoring capability, and suggested scenarios where these features would be crucial. We discuss our experiences building the system and our findings from the initial evaluation.

Author Keywords
location-based, annotation of location

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

INTRODUCTION

Before the advent of the digital age, communication consisted of writing down a message for another person and leaving it where he/she will know to look for it.

Most digital communication systems have focused on enabling communication between two persons, or among a group of persons without regard to the physical location of each of them. General opinion is that such an approach breaks barriers of location in communication, and opens the doors to direct interpersonal conversation among persons widely separated geographically. But such communication underestimates the importance of location in certain types of messages.

There is often a need to bind a message to a particular location, because it is highly relevant only at the chosen location and irrelevant otherwise. In the physical world, this factor is clearly evidenced by the ubiquitous presence of the Post-It™ note, handwritten notes placed on doors to community areas, informative write-ups about museum exhibits, etc.

The importance of location is also underestimated in current electronic reminder systems. A user can set reminders that go off at a particular time. Although a very handy tool to keep oneself updated with one's schedule, these systems (either hardware-only, e.g., digital watches, or software-based, e.g., calendaring tools) have the unfortunate side-effect of popping up ill-timed reminders in certain locations. Like other communication systems, they do not account for location, and would, for example, remind one to buy groceries while in a meeting with your boss.

Our system provides a way to annotate a given location or send messages to a group of people such that other users passing by that location will be able to see messages left by other people.

We conducted a preliminary survey to assess what users would expect from a system such as this; then we built the system, and finally invited participants from our target user group to use our application and evaluate it.

PREVIOUS WORK

There are many projects which explore annotation of location with digital information. In this section, we focus on applications used on college campuses. The E-Graffiti project [3] was initiated at Cornell University to explore the usability of location-based applications. Location was determined using the nearest wireless access point to indicate which building the user was in. An implementation was made available to a class of students using wireless laptops. Several problems were encountered with the system. The main issue was that the users perceived the system as a messaging or chat system to communicate between users, not a system that takes advantage of knowing the user's location. The E-Graffiti project allowed remote authoring of messages but did not allow remote access. The use of laptops inhibited the mobility and usability of the E-Graffiti application. In our system, users can use PDAs with wireless access, cell phones with HTML rendering capability, cell phones using VoiceXML or desktop clients running a web browser.

The lessons learned from the E-Graffiti project were implemented in Cornell's CampusAware project [4], a campus tour application. It allowed users to leave public notes about locations on the Cornell Campus. It was accepted and used more than the E-Graffiti project for several reasons: it had a well-defined purpose, it ran on Palm Pilots so it was truly mobile, and the private message functionality was removed to signify that it was not a

messaging application. It also included a Web client that allowed users to post and read notes about any location, so that staff and other users could add notes to the system without having to physically travel to the location. Like E-Graffiti, remote authoring was allowed but remote access of messages was not.

The GeoNotes system [8], which was location-aware and allowed the user to annotate a specific place, was much like the Campus Aware system. The goal of this system was to enable end-users to produce information, instead of just being passive readers of posted information. This project was mainly influenced by the E-Graffiti system developed in Cornell University but there were some fundamental differences: 1) E-Graffiti allowed remote authoring but not remote access. GeoNotes allowed neither as it was designed to be strictly location-aware. 2) GeoNotes allowed a much broader range of play with identity and anonymity. 3) GeoNotes allowed users to comment on content already present and distinguished original contents from comments. The system was used as a chat system and was compared to instant messaging systems like ICQ because of its interface, something which the researchers had not thought of when designing the system.

Another similar project is the ActiveCampus project at UCSD [6]. E-Graffiti is a function of their ActiveCampus Explorer application, which displays a map of nearby locations which is marked with nearby sites of interest, buddies and events. The ActiveCampus project does not support remote access or authoring of messages [5].

The choices that the system designers made about remote authoring and accessibility may have limited the possible uses of the system. To enforce the location-aware aspect, users were required to be physically located at a particular location to read a message. In our project, we decided not to impose any restrictions on our users and explore what functionality was desired by them rather than the alternative of providing a subset of features and examine usage [Pérez-Quiñones, personal communication].

RESEARCH QUESTIONS

There are many issues involved in location-linked applications regarding users' preferences for features such as: public or private messages, messages which expire after a given date and time, messages annotating a location vs. other types of messages, remote accessing and authoring, and push versus pull access strategies. Our purpose was twofold: first, to investigate the possible uses of location-linked systems and second, to focus on the usefulness of remote authoring and accessing of location-linked notes. Our hypothesis was that the users would prefer remote authoring and accessing of location linked messages. This conflicts with concerns raised by previous studies in this area, notably the GeoNotes system [8].

PRELIMINARY RESULTS

Survey

We began by considering various uses of the system to prepare a survey. We classified our potential users (in a predominantly university setting) as students, professors, teaching assistants and departmental administrative personnel who post items on department bulletin boards.

The first portion of the survey asked the users about current uses of public bulletin boards, cell phones, PDAs and their practices of leaving notes. We also asked about the most commonly used methods for communicating with students or co-workers, whether they advertised events and how. The second portion of the survey began with a brief description of the proposed system. The description was purposely kept short to keep the users' minds open to different possible uses of the system. The survey then described different scenarios in which the location-linked notes could be used. The description was followed with another set of questions asking the user more detailed questions about how they would consider using the system, including

- If they would use such a system at all
- Which device they thought would be most useful
- If they preferred active or passive notification of notes (push vs. pull)

The survey concluded by asking a few open-ended questions about whether they envisioned any other uses of the system and whether they had any concerns about the system. Finally, it asked if they would be interested in being a trial user of the system. This was partly to enlist them later, and partly to gauge their enthusiasm about such a system.

One of the things lacking in the original survey, that we later realized was an important factor, was whether users would prefer to be able to access their notes remotely, and whether they would be able to post notes remotely (that is, for a location other than their current physical location).

Our initial thoughts, partly influenced by the findings of similar projects, were that users would either not care for these features or would abuse them so that the system degenerates into an e-mail system with an additional field for location.

Despite this question not being asked in the initial survey, we implemented these features in the final version, hoping to gain valuable insight about this aspect when users evaluated our prototype.

Survey Results

All three user classes (students, professors and administrators) were equally divided as to whether such a system would be useful for private, public or for both types of messages. The CampusAware project had disabled private messaging capability because E-Graffiti found that

this feature led to the system being used as a chat application. However, we believe that such artificial restrictions do not respond to users' needs: if users believe that the private message feature is useful (albeit for a different purpose than the authors had imagined), the system should support it.

Most users expressed a preference for receiving alerts for individual messages rather than having to check for messages. In other words, they preferred a push approach to a pull approach. Our specific survey question about this aspect did not ask users' preference per device, and users seem to have ignored the fact that it might be too annoying to constantly keep receiving alerts on their cell phone while walking past various tagged locations on campus.

Many possible uses of the system were mentioned, including reminders for tasks to be done at a specific location, traffic information while driving, store promotions and identification of open parking spaces.

DESIGN ISSUES

Message Access: Push versus Pull

The choice between being alerted to messages automatically (the "push" mechanism) or manually retrieving messages (the "pull" mechanism) generated much discussion. Barkhuus and Dey [2] discusses several studies. Their own study on the user's perception of control revealed that even though users felt less control using applications that automatically reacted to the user's context, they still preferred it. Likewise, our initial survey results indicated that users strongly preferred being alerted to new messages.

Other systems, such as E-Graffiti, GeoNotes and ActiveCampus, did not support pushing of new messages, even though the GeoNotes system did include a configurable query feature that would alert users when notes were posted to a location that matched their query. The designers of the ActiveCampus system supported push functionality on just the ActiveClass portion of the project, but chose not to push E-Graffiti messages.

Since true location-determination was not implemented in our initial prototype, we did not use location to trigger alerts to new messages. Push capability needs to be implemented with careful thought to configuration and physicalities of the device under use, because alerting a user to a large number of new messages could be irritating and interrupt the user [10]. In this application, instead of alerting users to all new messages, it may be best to allow, a configurable option for notification alerts for private messages (directed to a particular user) or messages for user-selected locations.

Remote vs. In-situ Access and Authoring of Notes

Previous works in this area, like GeoNotes or E-Graffiti did not allow remote accessing of messages; users could not check for messages at locations other than their current physical location. Also, GeoNotes did not allow for remote authoring of messages (leaving a message for a location from a physically different location); while the E-Graffiti project did. In order to explore what users preferred, we decided to have our system support remote as well as in-situ accessing and authoring of messages. Accordingly, the users could select their location from a list displayed to them and check or leave notes to any location. In addition, they could also check or leave messages at their current physical location (which was the default action). We included tasks in our experiment that explore both of these accessing and authoring options and got the opinion of the user as to what they preferred in each scenario.

The Concept of Channels

The Wireless Graffiti project, implemented at the Aware Home [1] at Georgia Institute of Technology, explored the concept of channels. A channel is an arbitrary identifier for a group of messages such that users can selectively publish and subscribe to certain channels. The recipients of the messages would thus be only those users who would know to which channel to subscribe. Alternatively the sender of the message could use "Public" as the channel name, in which case all users would get the messages for that location. Thus the concept of channels introduced a new medium for sending and receiving location linked multicast messages.

However some of the problems with this included people having to know the specific channels in advance; unless certain channels were well-known, there would need to be an out-of-band technique for distribution of channel information. Another issue to be considered was whether people needed to register to use these channels or if knowledge of a valid channel would suffice. Due to such varied factors, we decided not to implement channels in our current version of location linked notes though this concept is definitely worthy of research in the future.

Granularity of Location

One issue with location-based systems is the decision for how to present location to the user. Perhaps the application doesn't need to know the user's exact location, but instead a zone [9]. We explored different representations for indicating and storing location information such that its usage in our application would be easy for the user. The two alternatives were a flat location model, where a user can be in exactly one location (identified by a number, and indexed by a string representation) and a hierarchical representation. The hierarchical representation closely models the real world scenario, where a user can be inside a room, a building, a university campus and a city at the same time. The Aura Location Identifier system from CMU provides such a hierarchical representation that can be layered on top of a purely geographical (co-ordinate-based) approach. [7]

However, for the limited scope of our experiment (user evaluation on a university campus), we found hierarchical names to be too difficult to remember, and an unnecessary hindrance to the actual task of obtaining user feedback about the system at large. Considering that some of our users had not used a personal digital assistant (PDA) in the past, we decided to use a very simple flat naming scheme.

Factors Affecting the Design

During our discussions of a design for this system, we found several factors affecting its use. In order to understand the inter-relationship of these factors, we created a matrix of their inter-relationships. The factors considered here and listed in Table 1 are:

Design Issue	Messages which expire vs. messages which do not expire	Location-Placeholder (Messages *to a person* at a location) vs. Object of Interest (Messages *about* a location)	Remote vs. In-situ (local) authoring of messages	Remote vs. In-situ (local) accessing of messages	Push vs. Pull
Domain (Public vs. private messages)	System would be more likely used for private rather than public messages.	Messages about a location are more likely to be public messages.	Authoring messages from a specific location is more likely for public messages.	Both public and private messages would likely be accessed in-situ or remotely.	Users would probably preferred that private messages from a known source be pushed and public messages pulled.
Messages which expire		Messages that are left for a particular person are more likely to use an expiration time. Messages about a location are more likely to never expire.	Remote use more likely for messages which expire	Both methods of accessing messages would be used regardless of message expiration.	Not applicable
Location-Placeholder vs. Object of Interest			Messages about a location are more likely to be left by a user at that location (In situ) - more for Object of Interest	Both types of access would be used for either type of message.	Depends on domain more than anything else (and also who is sending it)
Remote vs. In situ annotation				NA	NA
Remote vs. In situ accessing					Depends on domain more than anything else (and also who is sending it)

Table 1: Inter-relationship of Different Design Factors

- Domain (public vs. private)
- Messages which expire vs. messages which never expire

- Location as a placeholder of information (information is not about that location) rather than an object of interest (information is about that location)
- Remote versus in-situ access
- Remote versus in-situ annotation
- Push versus pull access strategy

In Table 1, we see the effect of each factor on every other factor. These are the effects that we hypothesize to exist between each pair of factors. We tried to confirm our hypotheses through actual implementation of the system, by designing benchmark tasks and obtaining qualitative feedback from the users who performed them.

Due to the high number of factors involved, we decided to limit our scope to examine the effect of all other factors on two factors, namely: remote authoring/access, and in-situ authoring/access. Tasks were designed accordingly, to study the correlation between the factors selected for study.

IMPLEMENTATION

Architecture

From a software engineering standpoint, it is obvious that an application that runs on multiple platforms will have certain common elements that need not be duplicated in each individual implementation. We factored out the common functionality across all platforms into a single layer, which provides services to the upper platform-dependent layers.

The middleware was implemented using web services: the client application on each platform makes calls to a web service to receive and update information such as the current location and messages for the current location.

Multiple location systems can communicate with the web service to account for the fact that a single location system may be inadequate to track the user at all times. For example, the global positioning system (GPS) lacks enough granularity and signal strength to track a user within a building, whereas wiring a large space using RFID is economically and logistically infeasible.

Special care was taken to design the interface so it does not mimic an instant messaging (IM) application. Previous experiments on location-based messaging systems have reported that these systems were regarded by several users as enhanced IM applications; this ultimately led to a mismatch of expectations of the users and the researchers about the objectives of the system.

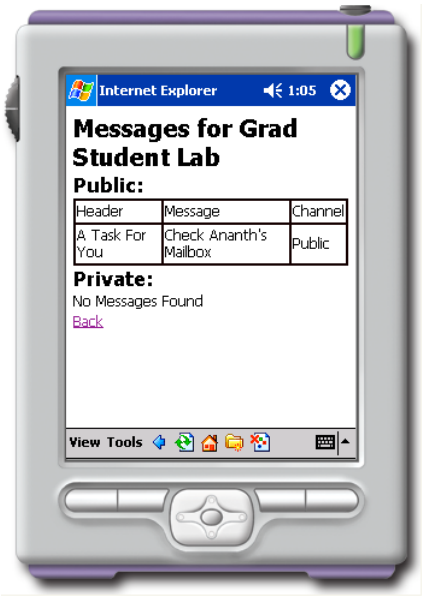

Figure 1: PDA

Figure 2: Cell phone

EVALUATION

User Tasks

Initially, we wanted to design scenarios that would exercise each of the features listed in Table 1, but later realized that the result would be a long list of tasks which would seem contrived and not realistic to a new user. We then narrowed the scope of our evaluation to explore the aspect of the system that generated the most discussion - whether or not remote access and authoring is an important feature to a system that is location-based. We wanted to see whether allowing the user to use the system from any location made the application seem like e-mail with an extra step required to specify a location, or whether the possibility of being able to read and post messages from a different location would open up unexpected uses for the system.

Four tasks were designed, two that would involve the user being physically located at the location in question, and two tasks which could be done remotely, from any (physical) location. We also chose tasks that involved reading messages (both at a location and remotely) and leaving messages. The user evaluations took place at the Graduate Student Lab in the Computer Science building, which was the specified location for the first two tasks. The first task required the user to read a location-linked note posted at the door which instructed them to check a certain mailbox in the graduate student mail room located adjacent to the lab. The second task asked them to pretend that they were a TA leaving a note at the lab that they were going out for a quick lunch.

The second set of two tasks used the remote access and authoring features of the system. The third task asked the user to check for reminders at the Student Center and to leave himself/herself a reminder for something he/she needed to do the next time he/she was physically present at the Student Center. The fourth and final task asked them to check the availability of a professor they wanted to visit, who had previously posted his status on his office door using a location-linked note.

Evaluation of the System with a Prototype

Topiary [10] is a prototyping tool for testing location-aware applications. It allows a developer to include a map of the test area and indicate relevant places. Users are then added to the system, and links can be added to the application to create scenarios. For example, one scenario could be "When Bob is in the library and clicks on the 'Get Info' button, display the info for the library. When Bob is in the bookstore and clicks on the 'Get Info' button, display the information for the bookstore." Topiary allows the user to simply sketch the user interface with electronic ink, which is displayed on the PDA. As the user interacts with the sketched version of the user interface, the tester can move an iconic representation of the user on a laptop running Topiary and the corresponding links will be automatically activated on the device controlled by the user under study.

We decided not to use Topiary for our user evaluation, because Topiary did not support rich interaction: for example, entering text data via a PDA into a form specified by our application was not supported. For this major reason, we preferred to use a working prototype, rather than sketched buttons and icons. The second reason was that in the tasks that required the user to read and post messages for a remote location, Topiary provided no way for the user to select the location.

We did, however, find value in the Wizard of Oz technique underlying Topiary: it allows a straight-forward method to change the user's location. We used a Wizard of Oz prototyping approach by implementing a special administrative interface to inform the system of the changes in location of the user currently logged on.

The user evaluations were conducted with one experimenter acting as the puppeteer, updating the user's location as needed. Initially, we disabled the remote access feature of the system, so that the user would have to be physically present at the location at which he/she wanted to read or leave messages. The user's location (in the Grad Student Lab or the TA office) was set by the experimenter and the user never had to specifically enter her location. After the first two tasks were completed, the remote access and authoring features were enabled, and the user was free to enter any location on the PDA application, regardless of where he/she was physically located.

Questionnaire

After each task, the user was asked to stop and fill out one section of a questionnaire. The task-specific question queried the user as to whether he/she felt that location-linked notes was a better method for accomplishing the given task than the traditional methods of leaving a paper note or sending an e-mail.

Once all four tasks were complete, a set of general questions were posed to the user. The first two questions asked if the user felt that a user should be physically located at a given location to read or write the messages posted there or whether remote access or authoring would be preferable. Users were asked how often they saw themselves using the system and if they could think of other uses of the system. We also wanted to consider the social aspects of the system, so the final question asked them to rank who they saw themselves communicating with: themselves, friends, peers, professors or the public.

RESULTS

Our evaluation was conducted with eight users, consisting of five males and three females. Five of the users were Computer Science graduate students. The rest of the group consisted of a Professor, one high-school student, and one middle school student.

The users unanimously agreed that remote authoring and remote access are necessary.

All but one user indicated that if such a system were in widespread use, he/she would use it daily. The other user stated that it would be used weekly. (Other options were monthly, or not at all.)

Checking for Messages at the User's Physical Location

Task Description

This task required the users to check for messages in the Computer Science Graduate Student Lab while they were in it.

Results

The majority of the users felt that the system was useful for such tasks, though some of them had concerns regarding the actual implementation of such a system. One user was concerned about the feasibility of practical location-determination on a college campus. Another user felt that the system would be useful only if he were prompted automatically about messages. One user felt that e-mail was preferred for such notifications in locations such as the Grad Lab, which contains several public access computers.

Leaving a Message at the User's Physical Location

Task Description

This task asked each user to pretend he/she was a Teaching Assistant leaving a note at his/her office indicating that he/she was leaving for a 30 minute lunch. The message included an expiration time, after which the message would be no longer displayed.

Results

All of the users felt that leaving a note like this was a very good use of the location-linked notes system. Even though this task involved being physically at the location, 2 of 8 users recognized that being able to check the TA's availability from a remote location would be very useful and would save users the time and effort involved in walking over to the TA's office. Other users expressed concerns that such notes are only available to students who have PDAs and notes would most likely only be read if the PDA alerted the reader to read the note.

Leaving Notes at a Remote Location

Task Description

The second portion of the user evaluation allowed the user to author and access notes from any location. The first task in this section involved reading a reminder left at the Student Center and leaving a note to himself/herself to be retrieved the next time the user was in the same place.

Results

A majority of the users felt that the location-linked notes system was better than e-mail or paper for leaving a reminder. However, three users felt that it is most useful if the user is automatically alerted that a message is available when the user is in that location. One user felt that using location-linked notes as reminders is only useful when leaving reminders for others, not self, and one user suggested changes in the user interface to reduce the effort necessary to leave and check notes. One user also suggested making the messages both location- and time-dependent, so that reminders to oneself would appear when needed.

At this point in the evaluation, we asked the users whether they wanted to check for messages themselves or be alerted when a message for them was present. Half of the users selected 'automatically reminded', while the other half wanted configurable and changeable alerts. No one selected the option to check for reminders manually. It is interesting that none of the users mentioned the possibility of frequent interruptions if too many alerts arise.

Checking a Message from a Remote Location

Task Description

The final task involved checking a professor's status remotely by checking to see if he had left any location-linked notes on his office door. The message left there stated that the professor was in a conference call and didn't want to be disturbed.

Results

Six out of eight users felt that this task was a good use of location-linked notes, with three enthusiastically supporting this use. Two users felt that the same intention could be accomplished using some other method. Potential pitfalls about this use of location-linked notes included the concern that it was only useful if the user (the professor) was consistent in updating his status. Another user pointed out that such location-linked notes are only useful if students are carrying a mobile device.

Social Aspects

Users were asked whom they would mostly send messages to and to rank their responses. The results are shown in Table 2, where each dot represents one user.

Opinion was divided among our users about the usefulness of our system for leaving personal reminders (i.e. messages for themselves.) More than half ranked leaving notes for themselves as their primary use of the system, whereas two others considered this the least useful aspect of the system. Table 2 shows the ranking of the most-likely recipients of messages.

From Table 2, we infer that a majority of people see this location-linked application first as a reminder system, second as a system for social interaction, and third as a system for collaborating with professors and colleagues. They seem to prefer it more for private messaging than posting public messages.

Ranking	1st	2nd	3rd	4th	5th
Yourself	●●●●		●		●●
Peers	●●	●●	●	●●	
Friends	●	●●●●		●●	
Professors		●●	●●●●		●
Public			●	●●	●●●

Table 2 Rankings of Likely Recipients of Location-Linked Notes (Each dot represents one user.)

Other Suggested Uses of the System

Other suggestions promoted by the users included:

- Ordering food at a restaurant by placing your order straight to the kitchen from the dining room (or the car, if at a drive-through window) was suggested by two users.

- Notification of store hours, reminders for oneself to buy certain items while at a particular grocery store were also mentioned (electronic grocery list).
- Notes at home for family members.
- Directed advertisements.
- Leaving notes for project group members when one member might be late.

IMPLICATIONS FOR FUTURE WORK

Sending Messages to a Category of Locations

We realized while creating the scenarios for the user evaluation that certain notes are specific to a generalized class of locations rather than a specific member of this class. For example, a location-linked note to buy milk and groceries applies in the real world to all locations of type "grocery store", not just one grocery store.

The system could be meaningfully extended to support this in the following manner: each location known to the system is part of one or more location types. These location types occupy the same address space as the locations themselves, so from the point of view of the user, it is completely transparent whether a message is sent to a single location or a group of locations. When a message is sent to a location group, it will be displayed whenever the user is known to be in any one of those locations. It will be shown successively in more than one location till it expires (or is deleted by the system).

Blending Applications

In the past, applications like Instant Messaging and e-mail each had their own independent use. Now, they are starting to blend. For example, Apple Mail program on the Macintosh shows the online presence of people you may wish to e-mail. There exists a plug-in for the Yahoo Messenger instant messaging application that shows the song being played in WinAmp, a media player application for Windows. Location-Linked Notes have a limited domain of possible uses, but combining the capabilities of Location-Linked Notes with other applications would enhance those applications. For example, when a user changes his/her status on the Instant Messaging program, the same status could show up in a location-linked note located on the user's office door.

CONCLUSIONS

Location can be an excellent source of context, and location-based applications will become more prevalent in the future. The design aspects of location-based application need to be considered, both how location information can be used to enhance an application and how to best communicate the locative aspect of the application to the user.

Previous systems specifically restricted users from remotely accessing notes and some restricted remote authoring. Our results show that users actually prefer the ability to access and author notes remotely and that this feature can enable new uses of location-based messaging systems, such as reminders or checking someone's status remotely

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REFERENCES

1. Aware Home Research Initiative Website, http://www.awarehome.gatech.edu/. Last access December 2004.
2. Barkhuus, L, Dey, A.K. Is context-aware computing taking control away from the user? Three levels of interactivity examined. *UBICOMP 2003, 5th International Symposium on Ubiquitous Computing*, October 12-15, 2003, pp. 149-156.
3. Burrell, J., Gay, G, E-graffiti: evaluating real-world use of a context-aware system, *Interacting with Computers*, Volume 14, Issue 4, 1 July 2002, pp 301-312..
4. Burrell, J., Gay, G., Kubo, K., Farina, N. Context-aware computing: a test case. *Lecture Notes in Computer Science*, Vol.2498. Springer-Verlag. 2002, pp.1-15.
5. Casterton, D. Tutorial on ActiveCampus, http://activecampus-dev.ucsd.edu/ntutorial/index.htm, 2003. last accessed December 14, 2004.
6. Griswold, W., Shanahan, P., Brown, S., Ratto, M., Shapiro, R., Truong, T. ActiveCampus: Experiments in Community-Oriented Ubiquitous Computing, *IEEE Computer*, Volume 37, Number 10, October 2004, pp. 73-81.
7. Jiang, C. Steenkiste, P. A Hybrid Location Model with Computable Location Identifier for Ubiquitous Computing, Carnegie Mellon University, Submitted to *UbiComp 2002*.
8. Persson, P., Fagerberg, P. GeoNotes: a real-use study of a public location-aware community system. *Technical Report,(T2002:27).*

9. Schilit, W., Adams, N. and Want, R., `Context-aware computing applications', *Proceedings of the Workshop on Mobile Computing Systems and Applications*, pp. 85-90, Santa Cruz, California, IEEE Computer Society Press, 1994,

10. Yang Li, J., Hong, I., Landay, J. Topiary: A Tool for Prototyping Location-Enhanced Applications, To Appear in *Symposium on User Interface Software and Technology - UIST'2004*, Santa Fe, New Mexico.