The Pennsylvania State University

The Graduate School

College of Information Sciences and Technology

SUPPORTING PARTICIPATION AND MOBILE INTERACTIONS IN COMMUNITY EVENTS

A Thesis in

Information Sciences and Technology

by

Xiaoyan Xie

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

December 2009

The thesis of Xiaoyan Xie was reviewed and approved* by the following:

John M. Carroll
Edward M. Frymoyer Professor of Information Sciences and Technology
Thesis Advisor

Mary Beth Rosson
Professor of Information Sciences and Technology

Andrea Tapia
Assistant Professor of Information Sciences and Technology

John Yen
Associate Dean for Research and Graduate programs
College of Information Sciences and Technology

*Signatures are on file in the Graduate School

ABSTRACT

In the past ten years, the broadband wireless networks have been considerably developed. Many cities throughout the world have been investing in or are planning on a pervasive wireless infrastructure with the goal of making wireless access to the Internet a universal service. The development of local public network infrastructures has raised a new challenge for the community networking research tradition. How can we leverage the new capabilities of a pervasive wireless network, such as ubiquitous accessibility, interaction immediacy, mobility, and location sensibility, to support community-oriented goals? What are examples of effective civic applications of public wireless infrastructures?

Although some work has addressed leveraging wireless applications for the capacity building of geographically collocated communities (such as cities, towns, and other relatively populated areas), few of them investigate the wireless application paradigms for community-oriented goals by actual design, prototyping, and evaluation. The work reported in this thesis is a pilot study to address this gap, by which we explore what application features, leveraging the capacities of pervasive wireless infrastructures, can be used to facilitate and/or foster attendance of and interaction at community events, and how to design them. This thesis presents the design, implementation, and two field trials of a prototyping system supporting community event attendees and discusses design implications drawn from the field trials.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

First and foremost I offer my sincerest gratitude to my advisor, Dr. John Carroll, who gave me the opportunity to engage in this research project and has supported me throughout the past one and a half years with his patience and expertise while allowing me the room to work in my own way.

My thanks and appreciation also goes to my colleagues: Craig Ganoe, Umer Farooq , Jamika Burge, Blaine Hoffman, Louise M. Campbell, Honglu Du, Max Mendelsohn, Caitlin Ferro, and Harry Robinson. They all more or less contributed to this research project, which forms the basis of this thesis. I thank Craig Ganoe especially, who gave me much guidance to my work on this project.

I gratefully acknowledge Dr. Mary Beth Rosson and Dr. Andrea Tapia for being willing to serve on my thesis committee, and for giving me valuable advice in revising this thesis.

I wish to thank all those I have learned from over the years, whether professors, colleagues, fellow students or friends.

Finally, I would like to thank my husband, who has always been supporting me to seek my own dream.

Chapter 1

Introduction

Background

Many studies have been conducted to investigate how to leverage computers and digital networks to connect and empower residents of proximate communities. These have formed a research tradition known as “community networking”, which regards communitarian goals, such as social capital formation, community collective efficacy, social support, community engagement and attachment, and strong local democracy, as the most significant potential outcomes of local network infrastructures (Carroll and Ganoe 2008; Carroll 2005; Schuler 1996). Community network projects date back at least to the 1970’s Berkeley Community Memory (Farrington and Pine 1997), and were later exemplified by such projects as the Cleveland Free Net (Beamish 1995), the Santa Monica Public Electronic Network (PEN) (Rogers et al. 1994; Schmitz et al. 1995), and the Blacksburg Electronic Village (Carroll and Rosson 1996). A now dated study revealed that there were approximately 500 community network projects in the world (Carroll and Rosson 2001; Doctor and Ankem 1995). The majority of community network projects, especially all the iconic and influential work, were based on local cable network infrastructures.

In the past ten years, broadband wireless networks have been considerably developed. Many communities (cities, towns and other relatively populated areas) have been investing in or are planning pervasive wireless networking infrastructures, typically adopting Wi-Fi, with the intent of providing better Internet accessibility for their citizens and also of acting as an information technologies (IT) resource for civic services (Carroll and Ganoe 2008; Mandviwalla,

et al. 2008). In the United States, it is reported that around 350 citywide municipal Wi-Fi projects have been launched within the past few years (Wikipedia “Municipal broadband”). There are also a lot of municipal Wi-Fi projects launched in cities outside the United States, such as Taipei, Hong Kong, Toronto, Paris, Singapore, Bristol, etc. (Wikipedia “Municipal wireless network”). The analyst firm ABI predicts that 126,000 square miles in America will be covered by Wi-Fi in 2010 (ITAA 2006). Lately, WiMAX-based city wireless networks have been initiated. Baltimore and Portland became the first two WiMAX cities in the United States.

Compared to cable-based networks, pervasive wireless networks have their own advantages, which allow new design space for IT applications. The most direct benefit is the near-ubiquitous Internet access. People do not have to find a café and pay for a cup of coffee to get access to the Internet when out of their home. Instead, they can activate a wireless terminal device and access the Internet service almost anywhere in the city – at parks, streets, city halls, museums, etc. This means Internet applications can be extended to those activities that would happen at locations that the traditional cable networks cannot reach, especially outdoor spaces or public spaces. It also means the possibility of a significant improvement in the immediacy of interactions. Another benefit coming from pervasive wireless networks is mobility. Although earlier deployed mesh Wi-Fi based wireless networks only have supported fairly limited seamless mobility, e.g. mobility under walking speed, the mobile capability of mesh Wi-Fi is increasing. Many wireless network device providers have announced that their devices support mobility under dozens of miles per hour. This allows us to design broadband mobile applications for communitarian goals.

Different from traditional cable-based networks, wireless networks also provide new possibilities by supporting location-based (also called location-sensitive or location-aware) applications. Location-based applications represent an emerging class of applications where mobile device users are provided with information and functionality that is particular relevant at a

specific geographical location or within a specific distance (Christensen et al. 2007). That is, they exploit the position of a mobile terminal (OGC 2005). During the past ten years, a large body of research has been conducted with regards to the design and development of location-based systems and applications, which have been spread over many domains, such as tourism and navigation (e.g. Abowd et al. 1997; Reitmayr and Schmalstieg 2003; Cheverst et al. 2000; Nurminen 2006), games and entertainment (e.g. Bjork et al. 2001; Klante et al. 2004; Benford et al. 2005; Matyas et al. 2008), and people/friends finding (e.g. Burak and Sharon 2004; Paulos and Goodman 2004). Location-based technologies have a big potential to benefit activities in the proximate community context since they bridge the physical space with the digital space. Public Wi-Fi networks have been beginning to provide location-based information and services to targeted audiences (Rao and Minakakis 2003).

The development of local public network infrastructures has raised a new challenge for the community networking research line. How can we leverage the new capabilities of a pervasive wireless network, such as ubiquitous accessibility, interaction immediacy, mobility, location sensibility, to directly support community-oriented goals? What are examples of effective civic applications of public wireless infrastructures?

A few researchers have drafted wireless/mobile application scenarios that relate to community capacity building. For example, Ananny et al. described a system used by residents of an urban apartment complex who created captions for community photos with SMS texts as a way to deal with neighborhood change and to design new public spheres (Ananny et al. 2003). Lane and Thelwall described a system in which users could add their location-specific knowledge, memories and experiences to the places where they live and work, providing a sense of community memory and encouraging greater knowledge of and sense of ownership of an area (Lane and Thelwall 2005). Hirsch and Liu reported a project which improved an immigrant

community's access to social services by technically bridging immigrants and suitable multilingual volunteers (Hirsch and Liu 2004).

Although some work has addressed leveraging wireless applications for community capacity building, most of it is policy discussion or envisionment, rather than actual design, prototyping, and evaluation (Carroll and Ganoe 2008). This has motivated us to start the work of investigating the application paradigms for community-oriented goals by actual system design and development, with an emphasis on taking advantage of those new capabilities provided by a pervasive wireless infrastructure. The system reported in this thesis is our first prototyping system of this research, which aims at helping ordinary community members participate and engage in community events. The system allows users to announce daily community events, explore events nearby, share in situ experience, and interact with others attending. It provides a possibility for community members to be better aware of community events and to collaboratively author a community history base by capturing these events.

Community events, in this paper, refer to social gatherings in a geographically co-located community usually open to all or a large number of local residents. There are various types of community events, such as festivals, ceremonies, holiday parades, meetings, lectures, concerts, volunteer activities, and sporting events. Some events directly relate to civic engagement in community governance or policy-making. For example, a lecture can be held to help citizens better understand an issue important to the community and offer possible solutions, and then a further meeting can ask for citizens' input on this issue. Another set of events, though they might not be directly related to political affairs or community organizing, involve citizens in collective actions, usually voluntarily, to address some need or achieve some goal in the community. For instance, a senior center recruits volunteers to re-paint the walls of the center's buildings. Furthermore, many events are not organized intentionally for the goal of community change by taking collective actions. The typical examples of these are casual events like concerts and

sporting events. Ordinary residents attending this kind of event are often as spectators/audiences rather than as the performers.

Scholars have long studied all these kinds of events and commonly agreed that involving citizens in these events is important for community benefits, though political participation, civic volunteerism, and attendance in public casual events do not contribute to community capacity building in all the same ways. In addition to a stronger democracy resulting from public involvement in community management and direct community problem solving, one reason for the importance of involving people in public events is that it provides good chances for people to mingle and therefore would contribute to social network development, which benefits community sustainability (Berkowitz 1996). Researchers have suggested that involving in public events may encourage some recognition of the value of the larger community and reinforce the community sense (Kwak et al. 2004), promote community attachment, solidarity, pride, and unity (Berkowitz 1996), reinforce social and cultural identity of a community (Gursoy 2002; Getz 1993), generate common knowledge and build trust (Chwe 1998).

The work reported in this thesis is a pilot study to explore ***what application features, leveraging the capacities of pervasive wireless infrastructures, can be used to benefit event attendees, and how to design them***. More specifically, we focus on ***facilitating event attendance and encouraging social interaction***. This emphasis makes our prototyping system quite different in functional features from those visitors/audience supporting systems which emphasize augmenting personal experience of, for example, the performance itself (e.g. Maynes-Aminzade 2002; Barkhuus and Jørgensen 2008; Reeves et al. 2005).

In our previous focus group interviews, we presented to the participants our initial application concept for our actual design work (Burge et al. 2008). Although the concept we described to the participants did not have exactly the same design as the prototype we later implemented and I will report here, they had common functionalities in terms of posting in situ

events, knowing “what is going on around me”, and discussing around the events. Participants thought this application concept represented an interesting and useful way to engage people in the community and to connect people with similar interests or experiences. Their positive feedback encouraged us to carry out further software design, implementation, and evaluation as described in the next few chapters.

Mobile Support for Event Attendees

Olsson and Nilsson designed a Media Event Platform (MEP), which provided users with various sources of event crucial information (Olsson and Nilsson 2002). Two things made the MEP special among the various efforts for event support. First, the MEP extended the duration for which an event was supported. It tried to keep users supplied with up-to-date information throughout all the phases of an event -- preparation before the event, traveling to the site, hectic time at the site, and all the way back to home, whereas other work tended to only focus on the visiting time at the site. Second, the MEP had an ambition to become a general event information platform with homogeneous information support, whereas many other systems were designed with an intention to support only a specific type of events. The information supported by the MEP was classified into two categories: static information and dynamic information. Static information could be viewed through WWW and/or WAP. Dynamic information was pushed to users through SMS, though it could also be viewed through WWW and WAP. The field trial showed users generally appreciated being kept updated; however, the SMS, as a pushing technique, sometimes brought some negative user experience, for example, disturbing users when they were engaging in the event itself or flooding users with notifications. Although not implemented on the MEP, personalized service based on location detection and communication support for forming a community were thought to be desirable functions for event attendees.

The TrottingPal (Nilsson 2004) was another mobile system developed for public events. It focused on supporting event information management and a seamless collaboration between spectators at trotting tracks. The system design was informed by the findings derived from an ethnographic study, during which it was found that spectators sought different sources of information at different places or among different people and thus interaction and collaboration occurred. Accordingly, two main components of the system were the event information pane and the collaborative message pane. The event information pane provided all kinds of static and dynamically updated information. The collaborative message pane allowed users to construct free-text messages and send them to the recipients they specified. An interesting finding from the system evaluation was that a majority (around 80%) of the collaborative messages were sent to the entire default recipient group each user had defined, rather than being targeted at one single individual. It seemed plausible that spectators generally were relatively open to sharing information with others at the event and less reluctant to share with all group members while using the technology. Also, the designer of the system also suggested providing personalizable cues, including intrusive cues, to inform users of information updates on the system.

Esbjörnsson et al. conducted an in-depth study of spectating behavior at sport events, drawn from field observation of car rallies (Esbjörnsson et al. 2006). They found that spectating was valuable for the rich experience due to being close to the action. Thus they suggested technology should not take spectators' attention away from what they can see and experience. In addition, spectators were observed to seek for more information of the event and more understanding of what they saw by talking with others. The event itself became a venue for sociability and provided rich topics for talk. The researchers argued new technology should give incentives for making it even more social. Based on these findings, the MySplitTime prototype was developed. By interacting with it, a user could receive automatic up-to-here statistics of a car and share the pictures and relevant statistical information with others by MMS or over infrared or

Bluetooth connections. A further work based on this ethnographic field work was an application concept presented in a paper authored by Engström et al. (Engström et al. 2007). Since a "viewing paradox" existed in spectating – i.e. being close to the action brought rich detail and emotional experience whereas it could also lead to a lack of the overall context and story – and audiences were observed seeking information to address the "viewing paradox", amateur collaborative TV production was considered for introduction to this situation. By collaboratively and timely producing and sharing video media materials with others within their peer group, users would supposedly get a dynamic overview of the event.

Jacucci et al. also reported a field investigation on spectatorship at a car rally (Jacucci et al. 2007b). Different from the other field ethnographic studies mentioned above, their work focused specifically on multimedia-mediated experience construction. Two participant groups being observed and analyzed were given cell phones with the capacity of taking pictures and videos, and they were able to use existing MMS service to share multimedia clips they created with others. No specific event support application was used. They witnessed various situations in which multimedia materials were created and shared, such as staging, competition, storytelling, joking, communicating presence, and portraying others, and concluded that multimedia was not just a means to record and later re-live experience but also a way for event attendees to socially construct experience.

In a later paper (Jacucci et al. 2007a), Jacucci et al. presented the CoMedia, an application to support people's activities and experience sharing in multi-day geographically distributed events, and reported the field trials of this application at a car rally and a music festival. The CoMedia was the first event support system that integrated the features selected from three application areas that would supposedly facilitate active spectatorship at events: event information applications, media-sharing applications, and awareness applications. Before the CoMedia, although a few event support systems had already addressed the event information

provision and/or media-sharing at events, as we can see above, most media-sharing applications and awareness applications had not been explicitly designed for event support, and there were no studies on integrated application that combined these three functions. The two field trials showed the CoMedia facilitated onsite reporting to offsite members, coordination of group actions, keeping up to date with others, spectating remotely, and joking, and in these activities, event information, media, and awareness cues were often used in concert. The main difference between the two field trials was that the rally users made more use of the Event Pamphlet module, which provided event information and supported group planning, and the festival users used the Media Stories more, which supported media sharing and collaborative storytelling.

From these studies, we can see it is generally accepted that mobile technologies would benefit event attendees, especially in information acquisition and co-experience during the event, and the user need for and behavior of these two aspects have been observed through some field investigations. During the whole period of an event, various types of information are needed, such as overview, context, location-specific, individual-specific, and latest information. Event information can be statically prepared before the event and/or dynamically updated throughout the whole event. It can be created by event organizers or mobile content providers, generated automatically via sensor-based technology, or shared among event attendees. Decisions concerning events, such as choosing an event to attend, planning trips, betting for a win, are made based on event information which people can gather. Co-experience in events is also not unusual for event attendees. By interaction with others, which may or may not be technologically mediated, they seek event information, share their opinions, construct an understanding of what they see, coordinate team activities, make jokes, and so on. And these are activities whereby they build their attendance experience socially with others. Mobile technologies, especially carefully designed mobile event support systems, have the potential to facilitate or foster information acquisition and co-experience at events. In addition to information acquisition and event co-

experience, awareness elements are considered to be an important supplementary feature for event support systems to facilitate information acquisition and foster social interactions. Awareness functions include, but are not limited to, an awareness of event information updates and an awareness of the location, the proximity, or the activity of friends.

While these studies provide insights for our design work, it should be noted that there are important differences in application context between these studies and our work. First, among these studies, except for the MEP, which did not support interactions among event attendees, all aimed at supporting interaction/coordination within an existing friend-like group. For example, CoMedia allowed group members to plan and negotiate group timetables to attend part of the events, create and share digital media among the group members during the events, and have awareness of other group members' rough location by cell-network-based location-sensing technology as well as who were nearby with whom by detecting nearby Bluetooth devices. However, our work does not have a friend-like group focus. We are concerned more with how community members, as an individual or accompanying associates, attend events and interact online with other people with whom they do not have to be friends. This would lead to some decisions for our design that do not exactly follow previous studies. For example, automatically revealing one's location or proximity to other people might not be appropriate due to privacy concerns after removing group elements. Second, the events these systems supported or these field studies investigated did not need to be community-oriented. For example, a couple of field studies/trials were conducted at car rallies. Spectators studied might not be local residents; rather, they formed groups and traveled to other cities to see the rallies. However, our application setting is focused on community-oriented events and we are concerned with how to facilitate local residents' attendance in these events. Thus some functions that previous systems supported, such as group planning for a long trip, would not be so relevant to our system.

According to the above research review and analysis, it would probably be wise to build our prototype system around two main aspects, i.e. event information acquisition and co-experience at events, and a supporting aspect, i.e. an awareness of others. However, the functional details and concrete software features for supporting these functionalities should be tailored with a community event orientation. Table **1-1** gives a brief comparison on these functionalities between CoMedia and our system. Our design rationales and details will be described in Chapter 2 and Chapter 3.

Table **1-1** A brief comparison of main functionality components

	CoMedia	**Our System**
Plans and information of events	Event information; Group schedule; Event list based on location or time	Events wiki Event list and map; Event search based on location, time, and event type
Co-Experience in events	Creating media stories together, not organized by events	Creating blogs/comments together, organized by events
Awareness	Awareness of a friend's rough location, what she is browsing online currently, when she used the phone previously, and who are in her Bluetooth range, all based on auto-detection	Awareness of other people's status, which could be anything – e.g. where they are; what they are doing; how they are feeling; etc. – they informed; Awareness of other people's online updates (posts)

Methodology

This study aims at figuring out how to design a system to support users' participation in community events. Iterative prototyping and field trials were used as research methods. We developed our initial prototyping system to demonstrate functional concepts we believed to be useful and important for event attending. We recruited participants to test it during an arts festival held locally. According to the field trial results, we improved the initial prototyping system, adding awareness elements. We then recruited participants to try the improved prototyping system during a New Year's Eve celebration of community activities. Design implications were drawn upon a combination and comparison of the results of these two field trials.

Prototyping has been widely used in design-oriented research. Prototypes help users to better understand designers' design concepts and facilitate the conversations between designers and users. They can be used for exploring use patterns, finding user needs, evaluating design options, and testing usability. We developed a working prototype system, which, when deployed in the field, can support realistic use, therefore increasing the ecological validity of evaluation (Carter et al. 2008). Two issues concerning a working prototype are its time/labor cost and the robustness of the system. Usually developing a functionally working prototype costs much more in time/labor than low-fidelity (e.g. paper-based) prototypes. We addressed this problem by making use of existing open source software as much as possible. Since realistic use demands a robust system, we based our implementation on the Web, for easy bug-fixing anytime with no need for users to reinstall the application.

Our design of the prototyping system for event support was inspired by several sources, including the capacities of a pervasive wireless infrastructure (see the discussion in the "Background" section in this chapter), an analysis of previous event support systems as documented in the literature (see last section), and the developers' personal knowledge,

experience, and informal observations (such as those dispersed in the next chapter), and was encouraged by the positive feedback as to our initial application concept from the participants in our previous interview.

Our ultimate goal is to design a successful mobile event support system for community use in daily life. This requires long-time collection of field data concerning user requirements, use patterns, and so on, and a fairly stable system supporting the long-term field study. However, at the early stage of the development of our prototype system, when the functionalities, features, and user interfaces are still under pilot exploration, it is not very wise to conduct a field evaluation over a couple of months since this would probably not be productive in terms of the cost of time. Thus we took an expedient way; we tested the system use in special large-scale community events. Such events consisted of dozens of geographically distributed, independent, smaller events and all these smaller events were scheduled within a day or over a couple of days. We believe the compressed, event-condensed schedule provided an expedient method to look into system use for events that might be less frequent. Although such short-term use might not be the exactly same as use over time, we at least could start investigating users' general attitude to the system, the possibilities for how users would use it, further user requirements, and the basic usability of the system.

The field trials mainly focused on three sets of important features of our system – *event search* for event information acquisition, *event blogging* for in situ co-experience, and *user awareness*. The awareness cues features were only investigated at the second field trial since they had not been implemented before the first trial. We did not test *collaborative event information delivery by users* in these two field trials, though it was also an important design for our system (see Chapter 2). The main reason for this was that we wanted the system to be at least useful for event participants at the field trials. It was hard to imagine that an empty event repository would be useful to normal event participants. We did not want the users' possible activities on the

system to be restricted due to having no event information on it. Therefore we pre-populated event information on the system.

In both field trials, we used three methods to gather data. Post-interview was used to collect subjective data, such as a participant's intention, expectation, explanation and assessment of the system use. The interview questions were quite open, so as to encourage the participants to talk freely about the main system features and corresponding functional concepts. The system logs and the content users created on the system were collected as objective data to help understand how the system was actually used.

Though we hoped to understand how participants used the system spontaneously, we still encouraged them to do some tasks during the field trials, since otherwise the critical uses of the system we wanted to investigate might naturally occur only occasionally. This arrangement reduced realism in the trial process. More details of the processes of the field trials will be reported in Chapter 4 and Chapter 5.

This project involved team work. I was one of the main system designers and developers. I also participated in designing the interview questions and other preparation of the field trials. While I did not participate in training and post-interviewing participants, I conducted all the data (interviews, logs, and content) analysis reported in this thesis.

Chapter 2

Design Rationales

As stated in the last chapter, we considered how to design the event support system from three aspects: event information acquisition, in situ co-experience, and user awareness. In this chapter, the first two sections – “collaborative event information delivery by users” and “event information search” – are concerned with helping people acquire event information. They are followed by another two sections addressing in situ co-experience and user awareness respectively. The last section – “information structure” – explains how we integrated event information and experience sharing in developing software.

Collaborative Event Information Delivery by Users

The first thing to support participation in community activities is to let people know about these activities. Usually, important community events have their own website created by their organizers. However, they are often dispersed in different websites, and so people get a limited overview of what activities there are in their community. Moreover, numerous daily small events, such as an author signing a book in a bookstore, a nice band playing their new music in a bar, or a low-price book sale recruiting volunteers in a local school, do not have a relevant web site to publicize them. People often get to know community events only opportunistically from their family or friends or from local newspapers or news websites. This significantly restricts the capability for people to be aware of community events, and therefore would probably reduce the possibility they would participate in these events.

Previous mobile event support systems, other than the MEP (Olsson and Nilsson 2002), did not address this problem, since they all focused on users' information needs while they are already attending an event, rather than helping users become aware of what events are happening or going to happen before attending. The MEP did consider the users' information needs for preparing to attend, whereas the information delivery on the MEP relied on mobile service providers.

We considered dealing with this problem in another way, which is by so-called user-generation. The basic idea is that users are not just information consumers; they can become information generators and they can work together to produce artifacts of lasting value (Cosley et al. 2006). Information repositories based on user-generated content have become increasingly popular. Iconic examples include Wikipedia (www.wikipedia.org), del.icio.us (del.icio.us), Flickr (www.flickr.com), Digg (www.digg.com), and Youtube (www.youtube.com). They all have a mature mode to involve users in generating and maintaining content. The idea of user generation has also been used for community benefit. Lane and Thelwall designed a system that allowed users to author content about places in local communities, and they argued that engaging people with local geography has the potential to encourage a greater knowledge of and sense of ownership of an area (Lane and Thelwall 2005).

We envision that any community member could become an information generator to announce community events. They do not have to be the organizers of the events or news organizations; they can be ordinary community members. When they get to know an event from their family or friends, or when they pass by a place and happen to see some event being held there, they should be able to inform the community of this event. Mobile technology helps information delivery in more real-time; people can deliver the event information when they see it on the way and do not have to wait to go back home and sit at a desk.

When normal community members become information deliverers for their surrounding events, the accuracy and integrality of the information could become a problem. Different from the events organizers or news media, who have a great deal of accurate information about the events, a normal community member might just know some aspects about an event. For example, a person knows there is a donation event on his way home, but has no idea what the donation is exactly for. He posts the information that he knows. Another person who knows the goal of the donation or a contact telephone number for it should be allowed to edit the information the first person has already delivered. Therefore, some collaborative authoring mechanism should be introduced.

Collaborative authoring also helps deal with the issue of dynamic information delivery. As we learned from the previous studies of mobile event support, in many cases, event information needed to be dynamically updated. For example, the location of an event may change temporarily, or the number of attendees may have reached the quota so no more people are allowed in. By collaborative authoring, such kind of dynamic information does not depend only on event organizers to deliver; ordinary people can also help inform others.

Wiki is a simple and lightweight method for collaborative authoring (Schuler et al. 2007).We adopted wiki as the collaborative authoring engine used in our system, since it has already been a fairly mature mode for collaborative authoring with some very successful examples (e.g. Wikipedia; Louridas 2006; Chien-min and Turner 2004; etc.), and there were some existing open source Wiki engines we could use for saving development time. The wiki mode keeps all functionality within the web browser, which is very favorable for the early stage of a prototyping system since users do not need to download and install the software again and again as it is modified frequently.

Event Information Search

Information searching is a very important component for an information repository. Especially, the user generation mode can quickly generate a large amount of information, and therefore powerful searching becomes a necessity for a system to be useful (Lane and Thelwall 2005). Traditional information searching is content-based; search engines look for the content containing all or part of the query keywords and return the matched content with a rank by relevance or popularity. Such a searching mechanism is often not very effective or efficient for searching community events. We might have no idea about what keywords are appropriate for searching; for example, after having dinner in a restaurant, we just want to know what events are nearby so that we can choose one and spend the evening there. Also, event searching is often connected to actual physical actions, that is, we search events often because we want to find an event we can actually attend. If a movie will begin in the next 15 minutes but we cannot get to the theater until one hour later, this event information would probably be useless to us. Accordingly, we believe location range and time range are very important parameters for restricting the result events returned by the search engine.

In order to search events by location and time, the information about the event should be tagged by location and time. In other words, the location and time should be two kinds of metadata describing an event. They should be separated from event content in some way, for example, by storing them in different database fields or having them being represented in a special format. Since we use wiki as information delivery platform, geo-tagging can be achieved by adding metadata to wiki pages (Schuler et al. 2007), as well as tagging by time.

Many attempts have been done to attach user-generated content to geography. Location-based posting systems, such as E-Graffiti (Burrell and Gay 2002), GeoNotes (Espinoza et al. 2001), Locablog (Bamford et al. 2007), and Tagblogger (Hansen and Grønbæk 2008), are such

attempts commonly conducted. Location-based posting systems generally attach a post to the location where the post is generated. The advantage of such attaching is that the system would be able to automatically tag the posts geographically by location-sensing technologies, which can position where the device the user is using for posting lies. The disadvantage of this attaching is that the content of a post often has nothing to do with the location with which the post is tagged (Burrell and Gay 2002). Accordingly, these systems cannot provide effective searching about what things are happening nearby; rather, they tell us what are posted nearby. Although auto-geotagging is convenient for a person delivering event information at the locale, manual geo-tagging should also be used for people to deliver event information at any place. Likewise, although the time for posting an event can be automatically detected, we should allow users to tag with time manually.

In addition to location and time, we can also consider allowing users to tag an event with an event type so that users can further narrow the searching query by specifying the event type.

In Situ Experience Sharing

Everyday people share their life experience with families, friends, colleagues, or those with whom they are not well acquainted. They even share their experience publicly; in this case, they do not exactly know the persons with whom they share their experience. We attempted to provide people with a new space and means to do this. First, they should be able to share their experience while they are attending a community event. Such kind of in situ sharing keeps the experience shared fresh and lively, and presumably richer as it expresses more accurate and immediate reactions to an event. Moreover, sometimes people wish to express some thoughts in the context of still engaging in the event, whereas this motivation becomes much weaker after

they leave the context. Supporting in situ experience sharing provides a technical affordance to satisfy this wish.

Second, people should be able to share their experience about a community event with the whole community if they want, especially with those who may also be interested in this event or also attending this event, whether they are acquainted with them or not. Since moments of shared experience can be powerful connectors between people who have the same interests in similar scenarios (Blanchard 2004; Hourihan 2002), we can reasonably presume that a digital space for sharing experience around community events provides an opportunity to enhance the whole connectedness between community members.

Various forms can be taken to share experience and exchange information digitally within a group of people. Oft-seen forms used on mobile devices include messaging services, email, mailing lists, and mobile blogging. Using messaging services or email usually requires the sender of content to already know recipients' cell phone numbers or email addresses, and thus is only appropriate for communication between close acquaintances. Using mailing lists does not require the content sender to know each recipient's contact information, but recipients have to explicitly join the mailing lists, and their mailbox is often flooded with messages from active mailing lists whether the messages are of their interest or not, which is especially inconvenient when using mobile handheld devices to check the mailbox.

In recent years, blogs became a popular form specifically for sharing thoughts and feelings. With the emergence of mobile blogging, life experience can be published to blog sites on the move via a mobile device such as a mobile phone or PDA (Cheng et al. 2007). Mobile blogging has been used for various purposes. For example, LocaBlog (Bamford et al. 2007) provides a space-time photo blogging service for travelers; Hall et al. proposed a concept *blogging by the dead* to allow memories to be saved and stored and later, after death, experienced by other people at the specific geographical locations where they are created (Hall et al. 2006).

Compared with messaging services, email and mailing lists, mobile blogging seems to be a more appropriate way to support "one-to-world interactions" (Beale 2005), since it does not require recipients' personal contact information, nor is it intrusive like using mailing lists. Therefore we attempted to introduce mobile blogging into our system to support community members in sharing in situ experience at events. Since there were open source blogging software packages, and even blogging modules on Wiki engines, using mobile blogging also helped us save our development time.

User Awareness

Awareness of other users' situations has been used to facilitate and foster social interactions. A typical example is Microsoft Windows Live Messenger, where a yellow star is shown beside the name of the buddy who has newly updated personal information or blog space, reminding the user to have a check. Facebook allows users to share their status, which often leads to a conversation around the status content. Holmquist et al. have tested a physical presence awareness device at a rock festival and in a conference and noted its usefulness in fostering a feeling of connectedness between friends and in finding opportunities to meet new people (Holmquist et al. 1999). Jacucci et al. became the first system designers who integrated into a mobile event support system the awareness of other users' physical status to augment media sharing (Jacucci et al. 2007a).

One of the findings from the first field trial of our system is that although the participants generally thought the blog was useful to capture and share experience, there was no noticeable interaction between them. The reason for this, in part, might be the problem of lacking awareness of other participants' existence and activities on the system during the very limited time when

they were actually using the system. Considering the positive impact of user awareness on social interactions, we introduced some mechanisms to the system to increase user awareness.

We attempted to achieve this from two aspects. First, users should be able to get an awareness of the most recent changes people have done online. We placed a line in the form of "[username] modified [page name]" near the top of every page, which was then a link to that page, so that the users would know the most recent change to the site immediately no matter which page they were at and would be able to easily navigate to the modified content. Second, users should be able to get aware of other users' current status in physical space. Thus we added a "Status Updates" feature to the system, which allowed users to share lightweight descriptive status information freely. We did not ask users to choose their status from a set of defined status possibilities since we wanted to know what users would write themselves as their status.

Information Structure

An information space should be imposed with a structure so that it would not become cluttered. A lesson taken from CoMedia (Jacucci et al. 2007a) is that an association between event descriptions and personal experience of events should be built. On CoMedia, the Event Pamphlet, which contained all event information, was not integrated with the Media Story, where personal experience was shared. Several users lamented the poor integration of these contents.

The information structure we proposed and used on our system is shown in Figure **2-1**. Each event has an event information page that can be collaboratively authored by all users. Each event allows being blogged by any user; however, these blog posts can only be altered by their creators. Blog posts about an event are all linked with the information of the event. All these event information pages can be accessed from default event indices or the result list/map of event

searching. Upon this structure, we grouped blog posts by event and associated the blog posts with a relevant event description.

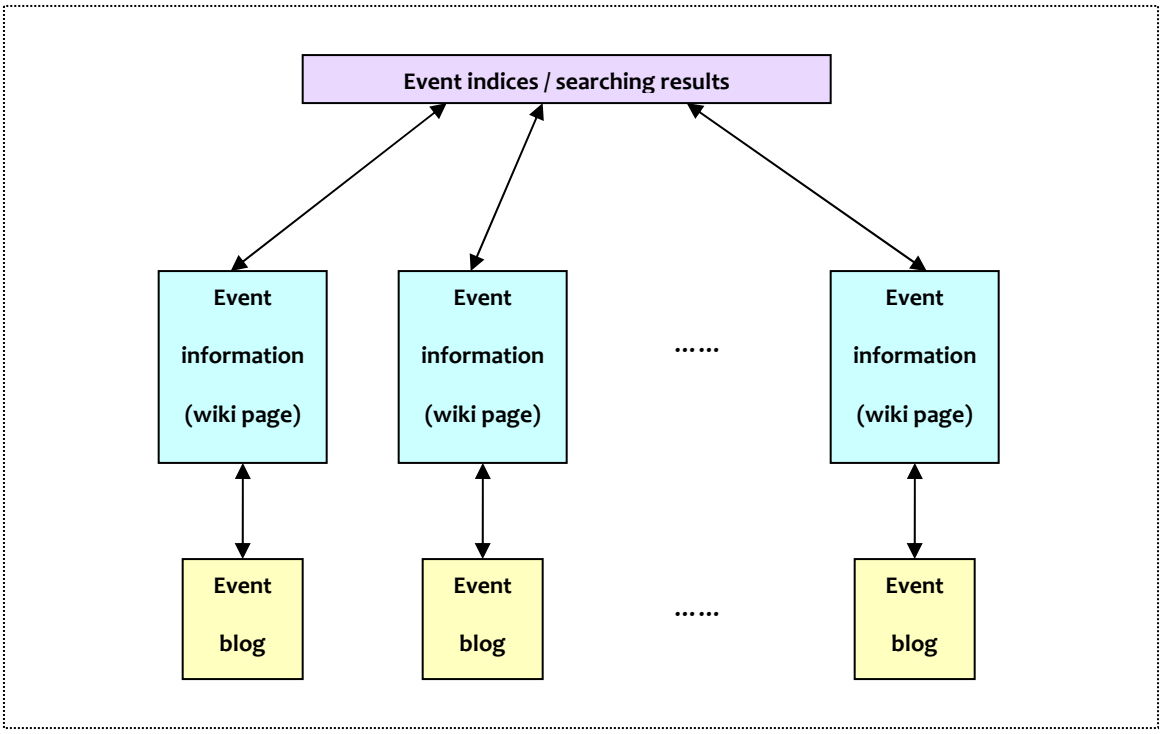

Figure 2-1 System information structure

One of the advantages of such integration is that the event description provides a discourse context for relevant blog posts. The bloggers do not have to introduce the event they are blogging, since the information structure has already put the event description aside with the blog posts. This is very important for mobile devices users. At the locale of an event, a user might not want to spend much time on writing long blog posts. And also typing on small mobile devices is usually not very convenient. The discourse context allows users to do less typing and still keep unambiguous references. This is kind of like how we use post-its as a communication way; if we write “do not shut down” on a post-it and place it on a computer, other people would not shut

down *this* computer since they know the post-it refers to it. Likewise, readers of a blog post can easily access the background information about this post.

In addition, grouping blogs by event provides a specific online space for each event where people who are interested in or also attending the same event can get together and interact with each other. It also provides a convenient way for event organizers to read all reactions about the event they organized and consider how to improve their work in organizing the next event. This is different from the normal blog format by which people's reactions about an event would be dispersed in different personal blog sites, so that it is not easy to find out which blog posts pertain to the same event.

Chapter 3

System Implementation

Based on our functional concepts and design rationales, the software features we chose to support include:

- a wiki platform for constructing content (wiki pages) that describes events with metadata such as date/time, location, and/or type;
- an event search tool for finding relevant event information based on event dates, types, and geospatial data, and displaying those results in a mobile convenient form;
- an event-based blog tool for community sharing around events;
- a status updates tool and site change monitor for enhancing awareness of other users' activities;
- and some auxiliary features such as a guide about where local wireless hot spots are located and a page where users can post personal information.

We chose JSPWiki (jspwiki.org) as the wiki engine for this work because JSPWiki is built around standard J2EE components – Servlets and Java Server Pages (JSP) – and can easily be extended by using plug-ins. Besides collaborative authoring of dynamic hypertext documents, it already has an implemented simple authentication mechanism, blogging plug-in, and file upload functionality.

Since JSPWiki is designed for desktop computer web browsers, we redesigned the wiki interface for better display and handling on mobile handheld devices. We removed any unnecessary buttons from the interface, and changed the horizontal design so that it would fit the

vertical web browsers on many mobile phones and PDAs. In order to support handheld devices with a finger touch screen, we increased the size of needed buttons so that they can be pressed with a finger. We also provided finger pressable tabs near the top of each page to easily navigate between related functionalities on a page (e.g. separate tabs for event wiki content vs. associated blog posts shown in figure **3-1** and **3-3**, and separate tabs for list and map views of event search results shown in figure **3-2**).

In the following sections, I will describe how we implemented the features listed at the beginning of this Chapter based on JSPWiki.

Event Construction with Metadata

In order to make the event wiki pages searchable by date/time, event type and location, the wiki engine needed to be able to recognize the specific types of information, metadata, about the events. Accordingly, a mechanism was introduced to allow wiki editors to input the metadata. We provided a wiki-like syntax with special formatting rules to specify the metadata. For example, the following five lines represent that the event name is *Johnathan Burns*, the event type is *Comedy (Stage/Theatre)*, the starting time is *19:30 on July 12th, 2008*, and the geospatial coordinates of the event location are latitude *40.791183092935434* and *longitude* -*77.85914182662964*.

```
[{SET eLat='40.791183092935434'}]
[{SET eLng='-77.85914182662964'}]
[{SET eStart='2008-07-12 19:30'}]
[{SET eType='Comedy (Stage/Theatre)'}]
[{SET eName='Johnathan Burns'}]
```

These metadata for an event can be inserted into the wiki page describing more detailed information about the event in the wiki page editing mode. They are only used to inform the wiki engine and therefore are invisible in the wiki page view mode (see Figure 3-1). Each wiki page is allowed to be embedded with only one set of event metadata; in other words, one wiki page currently allows the metadata of only one event. Currently, these metadata are stored as readable text files, one set of metadata per file. We are planning to store the event metadata in a database capable of handling geospatial searches in the later phase to more efficiently handle searching around a location.

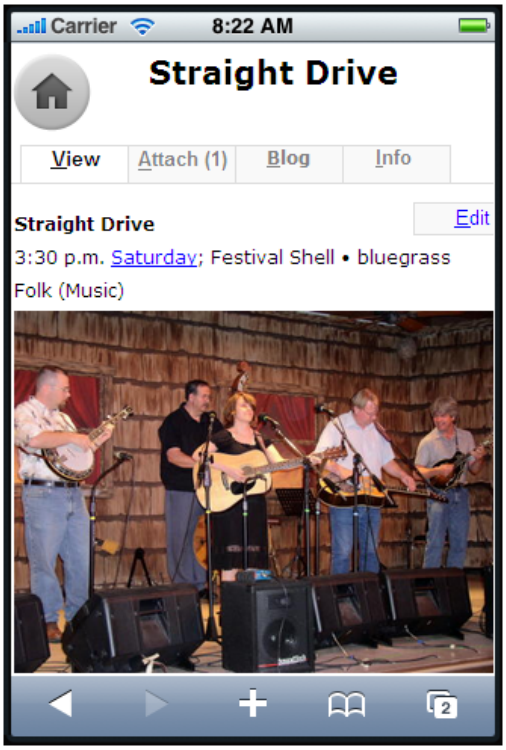

Figure 3-1 View mode of a wiki page from the festival showing an event. A brief textual description of the event following the picture can be seen by scrolling down the content.

Event Search

The events can be searched through a 3-tab page which is implemented through a set of nested special JSP files and is not user-editable (see Figure 3-2).

The Search tab (Figure 3-2 top) allows users to provide query conditions, including the range of the event starting time, the specific event type or all types, and a geographic location range. The location range is effectively a circle where users can specify the central geographic coordinates and a radius length. If a particular query parameter is not specified, the query will not consider it. The event query results can be displayed as a list or a map.

Since users usually do not know the geospatial coordinates of a place, the "Get my location" button can help them get the geospatial coordinates of the place where they are and automatically fill in the "Center latitude" field and the "Center longitude" field automatically so that they can easily find the events nearby. This locating function is implemented based on the Loki JavaScript API and supported by the Loki locating service (http://loki.com).

The other two tabs (Figure 3-2 bottom) are Events, which shows a list of events, and Map It, which displays a Google map with markers indicating the events by their location. By default, these two tabs show upcoming events which will begin in the next six hours, which are actually the results of a special event query with a fixed parameter (starting time within the next six hours). When an event query is made through the Search tab by a user, these two tabs will show the query results. In this case, there is a Show Recent Events button (which should be renamed as Show Upcoming Events) in each of these tabs. Users can click this button to switch to the default views.

The hyperlinks of the event names in these two tabs can be used to navigate to the detailed wiki content pages. On the map, the events with proximate geospatial coordinates are indicated by only one marker, with a bubble label to show the metadata of all these events, to

avoid markers overlaying one another. The granularity of detecting overlaid latitude and longitude of the markers is set to 0.00005.

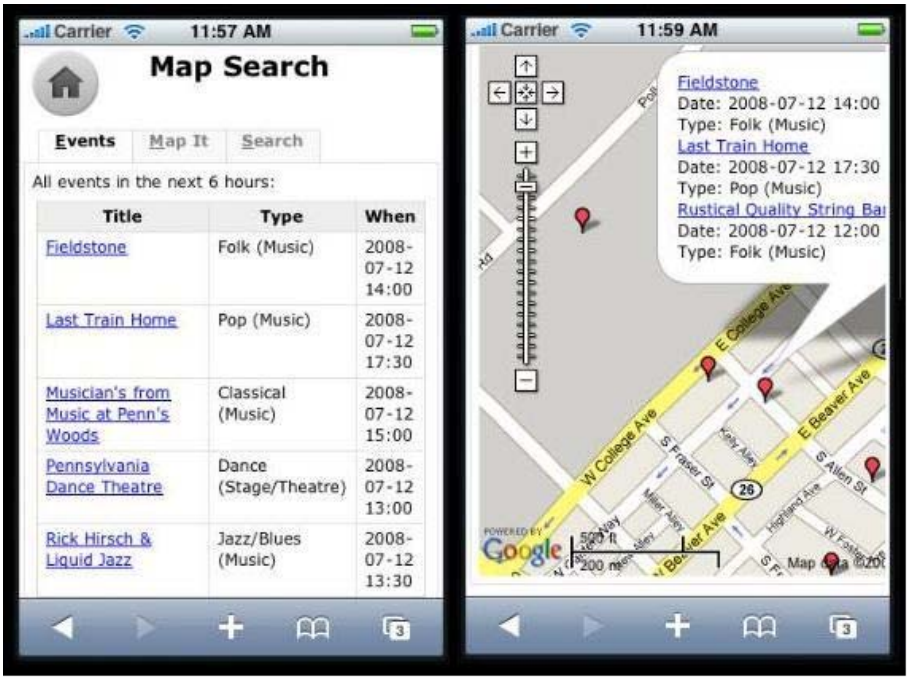

Figure 3-2 Three-tab page for event search and displaying search results.

Event Blogging

In addition to allowing users to create and collaboratively edit event wiki pages with special event descriptive tags, we also wanted to include the ability for users to post their individual experiences at the events, comment on them, exchange information regarding them, and participate in discussion around them. Also, the manipulation of the wiki page content and the manipulation of users' posts around events should be separate enough so that editing or altering one does not lead to a misoperation on the other.

Thus we introduced an event-based blog feature to achieve this ability with enough separation from wiki content. JSPWiki has an included plug-in enabling the use of blog on created wiki pages. This plug-in allows users to easily create their blog posts and post blog entries which will be archived automatically by month. What we needed to do was to add this plug-in into our system and relate it to wiki content in some way.

The backend of JSPWiki renders pages upon a template, separating wiki page content and page appearance. We altered the template to include an instance of the blog plug-in on each article page in the wiki. By doing so, we achieved the separation between wiki page content and blog posts. We also added a Blog tab to the existing tabs for users to access blog entries. Thus for every wiki page, there are four tabs (see Figure **3-3**): the View tab for viewing the event content; the Attach tab for uploading files, such as images and videos; the Blog tab for accessing and creating blog posts related to the event described in the View tab; and the Info tab displaying the revision history and other information about the page. Users can easily switch between event content and related blog space by tapping the tabs.

Figure 3-3 Blog tab for a festival wiki page for the event Matt Santry band play.

User Awareness

Some mechanisms have been introduced to help users become aware of the other users using the system. First, a Status Updates tool was created that allows individual users to post lightweight messages about their personal status. Users are allowed to write anything they like as their status. Everyone's latest status can be checked from a specific page where all these statuses are listed along with their usernames (see Figure 3-4). A link to this page has been placed near the top of all pages.

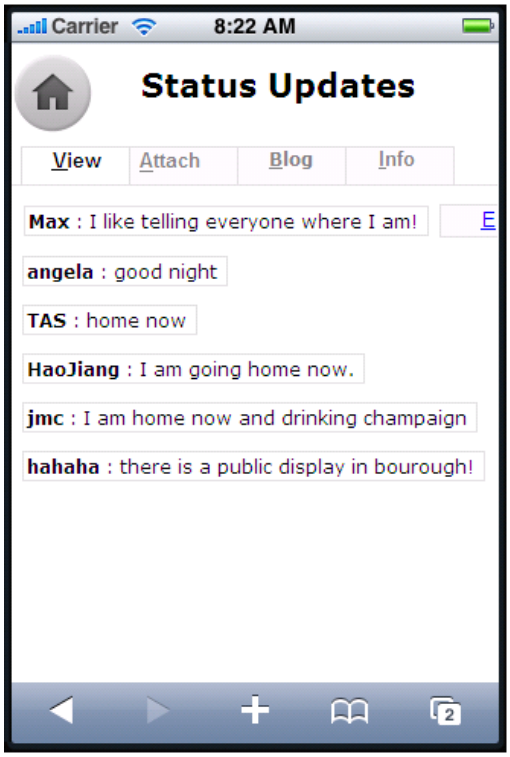

Figure 3-4 Status list page

Along with the link to the status list page, we also added a link at the top of site pages in the form "[username] modified [page name]" that allows users to know what the most recent change to the site was. Users can easily navigate to *that* "page" (which included the status list page and blog posts) through this link.

JSPWiki provides a plug-in that allows a page to include recent changes to the wiki, including blog entries. We constructed a fixed Recent Changes page within the wiki to list all pages that were changed during the last 10 days, as well as the users and date/time with regards to these changes. This would help users quickly find changes to the site and easily navigate to the relevant pages. A link to this Recent Changes page is also available in the header of all pages.

Auxiliary Features: Hot Spots, User Pages

In addition to the non-editable search results map, a kind of user editable map was also needed to display Wi-Fi hot spot location information. We provided this because there was not universal Wi-Fi coverage across the entire Arts Festival at which we conducted our first field trial. This user editable map is supported by a JSPWiki plug-in, the Google Maps plug-in (http://www.jspwiki.org/wiki/GoogleMapsPlugin). Users may add Google maps onto any wiki page while in the wiki page editing mode. Specifically for our field trials, we added a guide page about wireless accessing which contained a Wi-Fi hot spots map. A link to this guide page is placed in the footer of all pages.

Here is an example adding a Google Map plug-in with three wireless hot spots in a wiki page (see the wiki-style syntax following this paragraph). The map is 600 pixels wide and 400 pixels high with the center coordinates of latitude 40.794326524533965 and longitude -77.86144852638245 and with a zoom level 16. There are three markers on this map to indicate the spots of the wireless hot spots. The corresponding geospatial coordinates are specified for each marker. Each marker also has a short description: *Dunkin' Donuts* for marker p1, *The Corner Room's Free Wi-Fi* for one hour for marker p2, and *Webster's Coffee Free Wi-Fi* for marker p3. When a marker is clicked, a bubble label will appear to show the short description of the marker.

```
[{GoogleMaps lat='40.794326524533965'
             lng='-77.86144852638245'
             zoom='16'
             width='600'
             height='400'
```

```
                type='map'

Marker p1: 40.79337620044377, -77.86276817321777
Dunkin' Donuts

Marker p2: 40.7943671363715, -77.86173820495605
The Corner Room's Free Wi-Fi for one hour

Marker p3: 40.79369703787554, -77.86075115203857
Webster's Coffee Free Wi-Fi

}]
```

Though the Google Maps plug-in has only been used to present wireless hot spots in this project, it is a general mechanism to enabling users to add maps on wiki pages. We have also enhanced the Google Maps plug-in to allow a map to be centered in the user's location that is sensed by Loki. In order to do this, users need to specify a new parameter service='myloc' to their googlemaps plug-in like this:

```
[{GoogleMaps service='myloc' zoom='16' width= … }]
```

Besides, we also adjusted the backend of JSPWiki to automatically create a user page using the user account name as the page title upon account registration. This allows all the user’s automatic signatures on the posts or comments they created to become links to their user page where they can post personal information.

Chapter 4

Field Study: Arts Festival

Procedure and Task

We partnered with the Central Pennsylvania Festival of the Arts, held in State College, PA to deploy and test our wireless application. The software was tested within the context of the Arts Festival, over a period of 4 days (Thursday to Sunday, the main days of the festival). The mobile website link was highlighted in the Arts Festival official printed program and also was posted on the Penn State's official news website the Monday before the start of the festival.

Before the field test, we created wiki pages for scheduled events, including dances, comedies, music shows, and talent competitions, but not including the crafts exhibitions that lasted throughout the whole festival. A total of 73 events were pre-populated on the wiki. Each event wiki page provided a short description about the event and, if available, a picture relevant to the event. A web link was inserted at the bottom of an event wiki page to allow users to open a Google map with a marker pointing to the location of the event. Every event wiki page was tagged with an event's geographic location, type, start time, and title, so that the system can search events by using these metadata (except the event title). We also created a map, by using the user-editable map feature, to display the Wi-Fi hot spots around the campus and downtown that we had tested and confirmed to be available and free for the public.

Five participants were recruited among our colleagues, friends, and family members. All of them had already planned to attend the festival. Each of them was given either an Apple iPod Touch or a Samsung UMPC (Ultra-mobile PC) (see Figure **4-1**). Both devices allowed the users to access the Internet through Wi-Fi and surf the web pages within a web browser. The UMPC

had both a hard keypad and a soft keypad for typing, along with a stylus; whereas the iPod Touch only provided a soft keypad which was designed for tapping by a finger. Also, the UMPC had an embedded camera for taking pictures; whereas the iPod Touch did not include such functionality. Three participants were assigned iPod Touch devices, and the other two were assigned UMPCs. None of them had prior experience in using the iPod Touch or the UMPC.

Figure **4-1** Samsung UMPC (left) and Apple iPod Touch (right) devices used by the participants.

Each participant received a training lasting 30-45 minutes. The training content included how to use the devices, how to find and connect to a wireless hot spot, how to create a user account, and how to access the event search and blogging features. The UMPC users were also trained to take and upload pictures. The participants were encouraged to use the event search feature to find the events they were interested in, and were asked to author at least three blog posts. Since we were also interested in their general attitudes to mobile devices and mobile applications, they were allowed to keep the devices for as long as they desired during the Arts Festival and were encouraged to try any other functions the devices provided for any other personal purposes.

Data Collection

The data was collected in three ways. The first data source was interviews. Each participant was engaged in a semi-structured interview lasting around 15-20 minutes. The interview questions focused on design features, such as event search and event blogging. The participants were asked if they used these features, how they used them, and how helpful or problematic they thought they were. Also, they were encouraged to talk freely about any other practical uses they could think of for the wireless devices and general mobile applications, although this was not our central concern and will not be reported in this thesis. All the interviews were audio-recorded and transcribed for further analysis.

The second data source was the access log file stored on the web server. It collected the information as to when and how the website was accessed. The data included, but was not limited in, these fields:

- The IP addresses from which users visited the website
- The date/time when users visited the web pages
- The web page URLs along with the query parameters in the URL that users used to access web pages.

The log file provided a detailed record of the actual visits to the website by the users, which could not be obtained simply through interviews.

The log file recorded all the visits to our website, not only including those by the participants, but also including those of the investigators and other visitors during the Arts Festival. However, we cannot really know how many visitors there were totally since the user names were not recorded in the log file. Although the IP addresses of the visitors were recorded, each visitor did not have to be corresponding to one unique IP address.

The third data source was the blog entries posted by the participants. There were a total of 9 blog entries posted by three participants. The other two participants did not do it. A descriptive analysis of these posts provided a pilot understanding about what users would author when using mobile event blogging.

The data collected will be organized and analyzed around event searching and event blogging in the following sections. As mentioned in the "Methodology" part in Chapter 1, we did not try event authoring in the field trials.

Results

Event Search

Interview Analysis

Almost all the participants agreed that searching events was useful in preparing event attendance. One participant mentioned her experience, "*And the other day um when I wanted to (go to) the Arts Festival and I didn't bring the device but that time what I really wanted to do was give me the schedule or the nearby, say, if you know where I am and it rendered to get surrounding just like the Google map there is a search nearby and it can detect where you are and it gave me surrounding what happens right now or maybe in a half hour*." Another participant said, "*I don't want to go anywhere fast. Actually I usually know where I am, and I search about 500 meters away…It should be very near and according to time I will decide my way.*" Another one emphasized that event search by time was critical to him, "*I searched type and I used time… if I searched for an event tomorrow, it meant nothing to me that afternoon. So I*

would choose the day and the time, say, after 2pm and before 7pm." He also took the distance into consideration as he chose the closest event from the query result to attend.

Although we did not have a large number of interviewees, we still can see that the event start time and location were important to users in the process of making a choice about which event to attend. Moreover, this decision making process depended not only upon the absolute time or location of an event but also upon the relationship between the time or location of an event and the user's current context. For example, a participant cared "*what happens right now or maybe in a half hour*" and another looked for an event that "*should be very near*". If such kinds of relationships are not made explicit, users would have to build them by mentally computing, which could be inconvenient and even troublesome. Accordingly, making such a relationship explicit to help planning event attendance can be identified as a user requirement. Our design of the event search feature attempted to meet this requirement, and from the above reflection of interviewees, it seemed the event search feature (the three tabs of the *Map Search* page as a whole) met this requirement in the context of the Arts Festival.

Here, it should be noted that users did not have to build such a kind of time/location relationship by making use of customized event searching through the Search tab. The list view of the default event index would help build time relationship since it only lists upcoming events. Moreover, the map view of the default event index would help build location relationship by visualization of the geographic distribution of events, as well as a time relationship since it also only shows the upcoming events. In fact, two of the interviewees did check this map in making a decision on which events they were going to participate in. However, we did not know whether the other three interviewees used this map since we did not target the question explicitly in the interviews.

Content-based event search can also be identified as a requirement. One participant said he wanted to improve the search terms in the Search tab but failed. When a user has a basic idea

of what event she wants to search for, content-based search might help pinpoint the event more quickly. Content-based event search can be implemented, for example, by asking users to input keywords and then matching the keywords with the text in event titles and/or event descriptions.

One participant said he preferred just a casual browse. In fact, since the default event list was designed to only show the events that are about to start within the next six hours, and only the Arts Festival events were included in the system, there would not be a large number of events on the default list. This might be part of the reason the participant did not use a customized event search. However, this might also suggest that the default event list, as a special event search result, had the default query parameter (start time <= current time + 6 hours) set appropriately, and the number of the default result events (no more than 20) was not too many for browsing.

One participant suggested replacing text typing with calendar picking for the convenience of restricting date/time when searching events. This is a helpful suggestion; it should always be kept in mind that typing in small handheld devices is much more difficult than desktop devices for most people.

Log Analysis

The main page for the website which was publicized to the press was accessed 213 times. The main page was redirected to the *Map Search* page automatically where the default event list tab was activated. The *Map Search* page was accessed an additional 445 times without an auto-redirection from the main page. This means there was a total of 658 accesses to the event search and/or its results (note the default event list/map is also a kind of event search result). Among the 658 accesses, only 26 (4%) were requested with event query parameters being input by users, and the other 632 (96%) were only requested for default event results that contained all the events that would start within the next 6 hours. From these numbers, it seems 1) that the 3-tab *Map Search*

page for event search was overwhelmingly used, and 2) that the default event query parameters had been set appropriately and effectively to satisfy most of the requests for an event index, at least in the context of the Arts Festival.

Table **4-1** A summary of user customized event search requests

Specialized Search Type	# Requests	# IP Addresses
Including date/time	13	6
Including type of event	13	7
Including location	8	2

Table 4-1 lists the numbers of user customized event search requests, by types of query parameters specified, and the numbers of unique IP addresses of users who did these searches. Note a search request might include more than one type of query parameter. From this table we can see that the event type and date/time range were used more often for customized search, whereas the location range was rarely used (only the users from two unique IP addresses used it). Considering the interview results which suggested location/distance was an important factor when the participants chose an event to attend, we should not conclude that the software feature to support event search by location was unnecessary; rather, this result would probably suggest that the customized event search by location had not been well designed or implemented. In fact, this feature had only been fully implemented upon specific web browsers with a specific plug-in downloaded from loki.com, thus the devices most people used would not be ready for an event search by specifying the location range parameter. In addition, since the Arts Festival events were distributed in a relatively small area, so their geographical locations were easily explored by the map view of the default event index, this might also mitigate the need for a customized location-based search.

Summary

In the process of choosing an event to attend, the event start time and location were important factors people would consider. Moreover, this decision making process depended not only upon the absolute time or location of an event but also upon the relationship between the time or location of an event and one's current context. Computing and creating such a kind of relationship by software would make this decision-making process easier for people.

Users at the Arts Festival seemed more interested in the events that were going to start very soon and/or close to their location. Users were generally satisfied with an index (list view or map view) of events that would start within the next 6 hours and did not require a further customized event search.

Event search by location needed to be implemented on more devices. Sometimes exploration on a simple location relationship was through a map showing event distribution rather than a search by specifying the location parameter explicitly.

Event search by type or content can also be considered as a requirement.

The number of events, when it was less than 20, was usually not too much to browse and did not need to be narrower.

Event Blogging

Interview Analysis

The event-based blog was one of the focuses for this field trial. Event search was designed to support the activities of individual users, whereas, event-based blog was designed as a channel for people to share interesting live experiences and enhance social interaction.

Overall, the interviewees had motivation to post blogs, not just because we asked them to do so. However, hard typing on small handheld devices seemed the main barrier discouraging them from writing blog posts. Two interviewees actually did not write anything due to this problem, and one used the laptop which he always carried to write blog posts, instead of using the assigned UMPC. Although most interviewees agreed that the typing was a problem, still one interviewee thought it was very easy to use the iPod Touch to input blog posts. This discrepancy could be considered from two facets. First, all these participants had never used the assigned devices before, so they definitely needed some time to get used to them. It is not rare to see that some people text message very fluently on their own cell phone. We can also assume that the users would find it to be easier to type after some time of use. What we need to further ask then is whether the motivation to blog could be strong enough to overcome the mitigated typing problem. Second, are there more convenient ways to help users create expressions? This is also an issue waiting for investigation. For example, can we provide some commentary phrases or content templates for users to choose or customize?

Although the participants generally thought the blog was useful to capture and share experience, there was no noticeable interaction between them. Two of them did not read others' posts; one said he read some; and the other two did not mention whether they did or not. None of the nine blog posts got a comment from others on the system. Such kind of self-expression without audience was not exactly like what we had envisioned. We had expected community members to get benefits from the event blog function by obtaining in situ information, building conversation, or even developing social relationships, in addition to expressing their feelings. Although interaction based on events does not have to happen while the events are going on, we were especially interested in the in situ experience exchange around events between people who might or might not be acquainted with each other. Part of the reason that made our envisioned in situ experience exchange become self-expression without an audience could be the problem of

lacking an awareness of other participants' existence and activities on the system during the very limited time when they were actually using the system. Therefore some awareness feature should be considered to enhance social interaction.

Two participants did not find a suitable place on the system to post something they created. One of them attached a blog post to a random event since he did not find an event relevant to his post (his post was about a booth exhibition, whereas we only had created other types of events, such as music, shows, etc.). The other one took some pictures which did not specifically belong to any events and so he did not know where to post them. These cases, on the one hand, suggested that one of our design decisions – allowing users to create events for better contributing to community content (our system had already supported it, but we did not test it during the Arts Festival) – was accordant with users' requirement. On the other hand, they also suggested that the information structure on our system might need a recheck. For example, if a user just took a picture capturing the general climate of the Arts Festival, rather than a specific event, where would be the best place for him or her to post the picture? Is some hierarchical structure needed to organize on our system a set of relevant events such as those for the Arts Festival?

Log Analysis

Nine blog entries were accessed 22 times in total, with an average of 2.4 hits per post. Since at least 1 hit was from the author of the post, every blog post, on average, received at most 1.4 hits from other readers. The average hit rate was relatively low. This is consistent with the interview result.

Posts Analysis

Of the 9 blog posts, a total of 7 were related to experiences about specific events at the Arts Festival, including 3 textual blog posts and 4 pictorial posts. The other 2 blog posts were not related to the Arts Festival activities and instead talked about the functionality of the wireless device.

The three textual event blog posts typically contained the authors' comments on the relevant events and/or authors' activities at the events. In addition, one of them provided interesting event relevant information which the author obtained from the host of the event at the locale. Here is an example of a textual event-relevant blog post:

"We heard Kelly's music before we found her. She is a graceful lady. And graceful music. Very focused player. Got immerged in her own European style music. I can feel that there is a music in her heart. The crowded audiences burst in to applauses for many times."

The picture event blog posts were of two types. One included pictures of the Arts Festival events, and the other included pictures of participants to convey their presence at the Arts Festival.

From this brief content analysis, we can roughly see what the users used the event blogging feature for and what they wanted to share, though the answer might be incomplete due to the small number of blog posts being analyzed.

Summary

Overall, the participants thought the event blogging feature was useful to capture and share their experience at events. They had a motivation to share their experience publicly, not just because they were asked to do so. By event blogging, they commented on the events they

attended, described their activities at the events, shared event information, captured event scenes, and conveyed their presence.

On the other hand, the participants' motivation to author blog posts was challenged by the difficulties they had in typing on small handheld devices. While it can be assumed that the users would find it easier to type after some time of use, more convenient ways to help users create mobile content they want to convey at events are still waiting for investigation.

There was no noticeable interaction between the participants at the Arts Festival. The blog posts lacked readers and respondents. Some feature to help users to be aware of other participants' existence and activities on the system might be needed to increase in situ social interaction.

The information structure on our system might need a recheck. A series of relevant events can form a large event (or in other words, an event can consist of a number of sub-events). It might be necessary to introduce some hierarchical structure for better organizing events on the system.

Users might want to blog events that were not announced on our system. Allowing users to create events on the system was accordant with the user requirement.

Chapter 5

Field Study: First Night

Procedure and Task

The second field trial, in which we tested our revised software, was conducted within the context of First Night, a New Year's Eve celebration of community activities - from concerts to ice sculpture exhibits - taking place mainly in the afternoon and evening of December 31st. The whole procedure was quite similar with the field trial during the Arts Festival. Approximately 30 scheduled events during the day were pre-populated on the system. Each event corresponded to an event wiki page which included the event information and was also tagged with event geographic location, event type, event start time, and event title. The site was also open to public use and publicized through the "A.M. Briefing" of the local newspaper (including its online edition) and Penn State's official news website before the start of the festival.

Five participants were recruited from among the IST graduate student population. All of them were already planning to attend First Night. Two of the participants were a married couple and we assume they attended all events together. The other three participants attended the festival separately, though some of them attended with other friends/family. The participants were given either an Apple iPod Touch or a Samsung UMPC (see Figure **4-1**). Three of them were assigned UMPCs and the other two iPod Touches. A very brief introduction to these two types of WiFi-enabled devices can be found in the "Procedure and Task" section of Chapter 4.

At the start of the study (6:00 p.m., Dec. 31), the participants were trained on how to use the devices, how to find and connect a wireless hot spot, how to create a user account, and how to

access the event search and blogging features. The UMPC users accepted additional training on how to take pictures and attach them to their blog posts.

We encouraged each participant to use the search feature to find at least two events of interest to him or her and post their personal status. We also asked them to author at least two blog posts. They were allowed to keep the devices for as long as they desired through the duration of First Night.

Data Collection

Similar to the first field trial during the Arts Festival, in the second field trial we also collected data in three ways: post-interviews, the server-end access log, and the content posted on the website (including blog posts and status posts).

Upon returning the device, four (including the couple) among the five participants were engaged in a semi-structured interview conducted by one of the investigators. The fifth participant did not respond to the request for an interview. During the semi-structured interviews, we asked each participant about his or her experiences using the device and the software provided, as well as what they envisioned as possibilities for other uses. The designed interview questions were almost the same as those used for the Arts Festival, since we wanted to see whether the findings from the first field study could be stronger through reflections from more participants. We also added a question to ask participants if they were aware of other people using the system. Interviews were audio-recorded and transcribed before being analyzed.

The server-end access log file contained, but was not limited in, these items:

- The IP addresses from which users visited the website
- The date/time when users visited the web pages

- The web page URLs along with the query parameters in the URL that users used to access web pages.
- The client terminal information, such as device types, operating system types, web browser types and versions, etc. This information was not saved in the access log during the Arts Festival.

The participants can be recognized from the log file through the information of the devices they used. However, the married couple used exactly the same devices with the same operating system and web browser, so their data cannot be separated.

Results

Event Search

Interview Analysis

The participants rarely used a customized event search (i.e. the Search tab on the *Map Search* page) at First Night, which was consistent with what we had found at the Arts Festival where the users usually only used the default event indices to find an event to attend. The reason why they did not use the customized event search could probably be like what one of the participants said, "*(we did not use it) because we know the name of the events and there are few events we can handle.*" There were actually only 23 events which would start that night after our field trial began. This enhanced our finding at the Arts Festival that approximately 20 events were not too many for just browsing.

A problem was found with regard to finding a specific event that had already started. Since the default event list only listed events that would *start* within the next six hours, rather

than that would *be going on* within the next six hours, when users wanted to blog an event that had already started or just finished, they were not able to find an entry from the default event list. For example, those ice sculpture display events for which First Night was well known started from noon on December 31st until midnight. If a user wanted to blog these events while she was enjoying these art works in the evening of that day, she could not get into the blog space of these events easily from the default event list as they did not show up there. Although she was able to find these events by searching them with a time restriction to include these events or without any time restriction, this was still problematic as well as inconvenient. Searching with a time restriction to find a specific event required that the user already knew the start time of the event, but this was often not the case for the user who attended an event that was already going on. Searching without a time restriction would probably return too many events, necessitating browsing a long event list to seek the one she wanted to find. Certainly she could add more search parameters, such as event type or location, but this was inconvenient for a user who just wanted to find a specific event to blog, especially the event she was attending.

There could be a couple of solutions to this problem. First, as described in Chapter 3, with the current implementation, an event can be tagged with their geographic location, type, and start date/time. However, there is no metadata designed for the end date/time or the duration for the event, and therefore it is impossible for the system to recognize which event is still *going on*. A solution is obviously to add such kind of metadata and then adjust the way to display the default event list and allow users to search more easily for the events that are still going on or just finished. Second, as we had found from the field study at the Arts Festival, a content-based search should be considered to be integrated into the current event search to facilitate pinpointing a specific event for which a user wants to blog. In addition, we can also consider adding on the default event list page a hyperlink that can navigate to earlier events.

Log Analysis

The Map Search page (3 tabs: Events/Map It/Search) was requested 164 times, including those redirected from the Main page automatically. Only 4% (7 out of 164) of these requests contained parameters. This percentage was exactly the same as the use of this page during the Arts Festival. In addition, all these 7 requests were submitted by the same user. No other parameters were used except time range. The rare use of customized event search by users corresponded to what the interviewees responded in the interviews.

Summary

The participants rarely used the customized event search at First Night, which was consistent with what we had found at the Arts Festival. Also similar to our finding at the Arts Festival, a list of approximately 20 events was still fine for just browsing.

Finding a specific event that has already started is not very easy on our system. This should be improved; otherwise, mobile blogging during an event would be inconvenient since it requires finding the event first. There are several solutions, such as using a content-based search, using a hyperlink to navigate to earlier started events, or also displaying ongoing events on the default event list.

Event Blogging

Interview Analysis

The event-based blog was generally thought as a useful function. All participants created blog posts and read other users' posts. One blog post received comments from participants. This

situation was quite different from the Arts Festival, at which we found participants rarely read others' posts. This difference might in part be a result from our change to the design – we placed a line in the form of "[username] modified [page name]" near the top of every page, which was then a link to that page, so that the users would know the most recent change to the site immediately no matter which page they were at and would be able to easily navigate to the modified page (including blog posts and comments).

Typing difficulty, which had been emphasized by most of the participants and had made two participants not write a single blog post during the Arts Festival, did not seem to be a focus at First Night. Only one participant using the UMPC mentioned that input was not convenient, but this did not make him give up writing blog posts, comments, and status. Another participant thought typing messages on an iPod Touch was quite easy. Most of the participants suggested making better use of multimedia, e.g. capturing and uploading pictures or videos. Since the iPod Touch was not embedded with a digital camera, those participants using iPod Touch could not take pictures or videos.

Similar to the first field trial, a participant put forward the suggestion to create new event pages so that people can blog around them. "*I mean*," the participant said, "*there were some events on there, but those were only scheduled events but there's a lot of else, other stuff going on too like we went to the ice sled, right? So it would have been nice to either make a page for that or somehow blog about it because somebody even saw our status. Because we said 'Going to ice sled now', somebody would be like 'What's that?' you know, and then they wouldn't know how to go figure out what that was or something.*" From this response, as well as the interview result from the last field trial, we can safely assume that some ordinary people, other than event organizers or news reporters, do want to help publicize events that they are interested in. This finding is a support for one of our design rationales – allowing user generation of event information.

Log Analysis

There were a total of 21 blog posts and 2 blog comments posted by all visitors, including 17 blog posts and 2 blog comments posted by the field trial participants. The total number of these posts was much more than that of the Arts Festival (9 blog posts). These blog posts were hit 103 times in total, with an average of 4.9 times for each. The comments were hit 16 times, with an average of 8 times for each.

It seemed that two of the participants each accessed almost all these posts (one requested blog posts 17 times and blog comments 4 times; the other requested blog posts 21 times and blog comments 2 times), supposing most posts were accessed only once. The married couple accessed the blog posts 20 times in total, with an average of 10 times each person, and accessed the comments 3 times in total. The fifth participant only accessed blog posts 3 times.

Overall, users' posts were commonly read. This was consistent with the interview result and quite different from the situation at the Arts Festival. It would in part be attributed to the adding of the awareness feature, as explained in the above interview part.

Posts Analysis

The participants posted 17 blog entries to the system, as well as 2 additional comments responding to the same blog post. Most of the blog entries were longer than the posted status update messages. Most blog entries ranged from 1-2 sentences and two posts were full paragraphs. A total of 11 blog entries described a specific event that the participants were currently attending, had attended, or had tried to attend.

Except for one pictorial blog entry that captured the scene of an event, the other blog posts were all textual posts. The picture was not clear since the event was held outdoors in the dark night. This might be part of the reason why there were so few pictorial blog entries.

Table 5-1 summarizes the basic functions of the 16 textual blog posts created by the participants. Some entries had more than one function. As with those textual blog posts created during the Arts Festival, the main functions of the blog posts at First Night were also describing personal activities at events and commenting on events. Sharing event information was also a function of the blog posts, but it was sometimes an indirect function instead of the author's direct purpose. Some blog posts were used for greeting or asking a question during First Night, whereas these two functions were not found from the Arts Festival blog posts. These results reinforced and supplemented the corresponding findings from the first field trial; the latter were rather weak since they derived from only 3 textual blog posts concerning events.

Table 5-1 Functions of blog posts and corresponding numbers of the blog posts having these functions

Function	**Number**	**Example(s)**
Describing personal activities at events	9	"… I bought 2 of their CDs: under the covers and in lake ECG."
Commenting on events	7	"The idea of burning man is interesting. He gave us much on his short journey."
Sharing event information	4	"I saw 4 horse carriages pretty close!!!"
Greeting	4	"… Happy new year, everyone." "… Have fun, everybody!"
Asking a question	2	"Anyone going to this?"

There were two blog comments in total. One of them replied to a blog post and later it was replied to by the other one which was created by the author of the blog post. In result, these three posts (two blog comments and the initial blog entry) formed a dialog between two participants. This kind of dialog needs further investigation with more consideration of the preexisting social relationships between users.

Echoing what we envisioned, the specific event wiki pages provided a better context for blogging so users did not have to explain too much about which event they were talking about. For example, sometimes participants simply used “this” to designate the event, e.g. “this should be fun”, “anyone going to this”, and did not lead to vagueness of the meaning.

Summary

The event-based blog was generally thought to be a useful function. All participants created blog posts. They used blog posts to describe personal activities at events, comment on events, share event information, greet other users, and ask questions. They also used blog posts/comments for conversation. It has been observed that the event wiki pages provided a better context to facilitate blogging.

Overall, users’ posts were commonly read. This was quite different from the situation at the Arts Festival. It would in part be attributed to the adding of an awareness line that allowed users to know the most recent change to the site immediately and to be able to easily navigate to the modified content from any page.

Similar to the first field trial, there was a requirement to allow creating new event pages so that people can blog around them. We can safely assume that some ordinary people do want to help publicize events that they are interested in. This finding is a support for one of our design rationales – allowing user generation of event information.

Typing difficulty did not seem to be a focus at First Night, though it was regarded as a big barrier for blogging at the Arts Festival. Most of the participants suggested making better use of multimedia for blogging.

User Awareness

Interview Analysis

All of the interviewees updated their status and looked in other people's status at the events or even right after they were back home. By checking status, they were aware of who were using the system and where they were. One of the participants assured us of the user need of the awareness function: "*I actually went in and checked people's statuses, especially after I got home I was checking people's statuses and seeing what they were doing and where they were gone and stuff like that. That was fun to see people still out there doing stuff even though it wasn't that exciting.*"

Three interviewees suggested two improvements as to how to present status on the system. One suggestion was making status scrollable so that not only current status but also previous status could be read. She was also interested in what people had done or where people had been even after they had gone away. It is not very clear now how other people's status history could be useful; whether it could serve as one of the references for people to decide which events they would attend next, or as a topic that triggers a later chat between a person who informed about what she did in her status and another person who is interested in or also experienced what the former person has done. At least, some people did care about this information. The other suggestion was allowing users to create their buddy list so that they can check only their buddies' status if they like. This should be a good suggestion, because 1) there should be some users (e.g.

the interviewees who made this suggestion) who only care about particular persons, and 2) if there are many more people using the system simultaneously, some ways (including using a buddy list) to narrow down the status list a user wants to check would probably be needed.

There were also two suggestions as to increasing interpersonal interaction based on an awareness of other people's status. One participant thought commenting on others' status would be useful. He wanted to do so at the trial, but the system did not provide a way for him to do so. Another participant thought "*it would have been nice to connect directly to certain people*." She said excitedly: "*So (during the fireworks) I could be like 'How was out there at the fireworks?'…' What are you doing?*'" We can see that the awareness function did bring about more desire of interacting with other people that would probably not be generated without this function.

Log Analysis

Table **5-2** lists the access numbers of the Status Updates page and the Recent Changes page from Dec 31st 6pm (the start of the study) to Jan 1st 5am. The numbers in the "All visitors" column include the access requests from all site visitors, including the five participants, investigators, and some other people. The A, B, C, and D&E four column list the numbers with regard to each participant, with the exception that the D&E column contains the sum-up data from the couple. Note that all these numbers in the table correspond to the requests for viewing content, not posting/editing content.

Table 5-2 Numbers of access requests by different users

	All visitors	Participants			
		A	B	C	D&E (the couple)
The *Status Updates* page	129	28	5	19	23
The *Recent Changes* page	73	19	3	17	7

At First Night, the number of access requests for the Recent Changes page was significantly increased (73 times), compared to the 39 times of that page at the Arts Festival. The Status Updates page was accessed (129 times) even much more than the Recent Changes page. The right four columns of Table 5-2 suggest these two pages were also generally heavily used by the participants at First Night, considering the field trial lasted only a couple of hours and the participants spent much time on actual festival activities rather than the use of our devices and software. The exception was participant B, who accessed these two pages not that often but also not very few.

The Status Updates page listed all users' latest status, and the Recent Changes page listed all recent changes to the whole site, including blog posts and status posts. Since these two pages were important indicators for users to know other people's recent physical activities and online activities, from the above data it seems clear that the users did care about other event attendees, especially their physical status, and also the software features concerning status updates and recent changes on our system satisfied this requirement.

Posts Analysis

There were totally 17 status updates posted by the participants by using the status updates tool. They can be categorized into several types (see Table 5-3). Among them, 7 were posts about what building/room the participant was in and another 4 were about what place or which event the participant was going to go to or already on the way to. Two posts were about what the participant was doing and another 2 about what the participant was feeling. The remaining 2 did not describe the participant's status directly, but more like a talk or response to others. These free text status posts conveyed diverse and flexible content that helped us understand what kind of personal status information the participants would like to share.

Table 5-3 Types of status update posts and corresponding numbers

Type	**Number**	**Example(s)**
Where I am	7	"back in hall"
Where I am going	4	"Going to ice sculptors"
What I am doing	2	"eating"
What I am feeling	2	"I am having fun"
Other	2	"good night", "congratulations!"
Total	17	

It was notable that 11 of the 17 posts were about where the participant was or was about to be. Clearly the users commonly felt that sharing their location or their presence at an event to other people on the system was important and they would like to share such information. Location sensitive technologies should be able to make it easier to share such information by

detecting the users' geo-coordinates. However, it seems more work needs to be done to translate detected geo-coordinates into an event name or a location name meaningful to users.

Summary

Generally speaking, users were quite interested in other event attendees' physical status, not only their latest status but also their previous status. They thought knowing such information was fun. More user requirements included allowing users to check the status of a group of people they specified, to comment on other people's status, and to connect certain people directly.

Participants would like to share their status, especially about their location or their presence at an event.

The status updates feature on our system satisfied the basic requirement of sharing and knowing personal status, and the free text status posts conveyed diverse and flexible content. The user awareness function did bring about more desires to interact with other people.

Chapter 6

Discussions

Comparison between Two Field Trials

By prototyping and field testing, we have reaped some findings that would help us understand how people might find an event of interest and how they might share or interact with others around an event, as well as what improvements they suggested for the prototyping system.

Table **6-1** lists the main findings with a comparison between the two field trials. The findings are categorized around the three main functions/features: event search, event blogging, and user awareness. Each finding item is assigned a reference number (e.g. S1, S2, etc.) for easier reference. The circle marker is used to indicate at which field trial a finding item was gained. It can be seen from the table that there are some differences between the findings from the two field trials. These differences could be evoked by the following causes.

The improvement of the system After the Arts Festival, we added two important awareness features. First, the "Status Updates" feature has been found to bring about more desires to interact with other people. Some users even pointed out it would have been more fun if more people had used our application. Second, the always-shown line that highlighted who most recently modified which page could help users be aware of the recent posting and easily navigate to it. Both of them would probably contribute to an increase of sharing experience and reading and responding to others' posts. This can explain the difference on B9 between the two trials. Obviously, A1-A5 could only be found at First Night since they were all about what we did after the Arts Festival.

Table 6-1 Comparison between the main findings of the two field studies

	Main Findings		Arts Fest	First Night
Event search	S1	In the process of choosing an event to attend, the event start time and location were important factors people would consider.	○	
	S2	In the process of choosing an event to attend, the relationship between the time or location of an event and one's current context was an important factor people would consider.	○	
	S3	People seemed more interested in the events that were going to start very soon and/or close to their location.	○	
	S4	Exploration on simple location relationship can be done through a map showing events distribution as well as a search by specifying the location parameter explicitly.	○	
	S5	Sometimes event type was used to search an event for attendance.	○	
	S6	Event search by content was proposed as a user requirement.	○	
	S7	Users needed a convenient way to find/pinpoint the event they wanted to blog.		○
	S8	Customized event search was rarely used.	○	○
	S9	A list of less than or approximate 20 events was fine for just browse.	○	○
Event blog-ging	B1	Event blogging was generally thought as a useful function.	○	○
	B2	Textual blog posts were used to describe personal activities at events, comment on events, and share event information.	○	○
	B3	Textual blog posts were used to greet other users and ask questions about events.		○
	B4	Pictorial blog posts were used to capture event scenes.	○	○
	B5	Pictorial blog posts were used to convey user presence.	○	
	B6	The difficulty in typing on small handheld devices was an important barrier for blogging.	○	
	B7	There was a desire to talk about unlisted events (e.g. by creating new event pages or blogging unlisted events).	○	○
	B8	Some hierarchical structure might need to be considered for better organizing events on event support systems.	○	
	B9	There was no noticeable interaction between the participants based on event blogging.	○	
User aware-ness	A1	People were generally quite interested in other event attendees' physical status.		○
	A2	Some people were only interested in specific persons' (e.g. buddies') status.		○
	A3	Some people were interested in others' latest status as well as previous status.		○
	A4	It was suggested to increase interpersonal interaction based on awareness of other people's status.		○
	A5	Users would like to share their status, especially about their location or their presence at an event.		○

The contexts of the field trials Compared with First Night, the Arts Festival lasted much longer time, consisted of more events, and was spread over a larger area. This might be part of the reason why the participants at the Arts Festival generally reflected more concerns about the time and location of an event (S1, S2, S3, and S4), although S8 ("Customized event search was rarely used") was found in both of the two trials. In addition, during the four days of the Arts Festival, participants decided on their own time to attend it, whereas at First Night, there was a common start time of the system trial (6pm on Dec 31st). Consequently more participants used the system at the same period of time during First Night than during the Arts Festival. This might also contribute to the difference of the social interaction level (B9) between the two trials, since the posts would probably be more of interest to other participants if the relevant events were still going on or just finished and enrolling in the system trial starting at the same time should increase the possibility of such kind of posting. Another difference was that the Arts Festival was held in the daytime, whereas the system trial at First Night was in the evening. Since the camera on the UMPCs cannot take clear photos in the dark, only one picture was tried and uploaded. As a result, some functions the pictorial blog posts might have been used for were not observed at First Night (B5).

The number of participants and the form of study instruments We did not have large number of participants in each of the field trials and the interview questions were all exploratory and open-ended and only partially structured. Both of them might increase the chances that a happening or a response in a field trial was not found in the other one. Therefore, we should combine the findings of the two field trials to achieve a more comprehensive understanding.

Design Implications

Though our field studies were exploratory in nature, some design implications can be derived (part of them are actually suggestions from users). The following is a discussion about important design implications from the three aspects: event search, event blogging, and user awareness.

Event Search

Generally speaking, users need to find an event on the system in two situations. One is to search an event of interest to attend, and the other is to enter the information space of a specific event to check event information or blog this event. The former occurs before the attendance of an event. It is exploratory and the user usually does not have a clear idea about which event to attend when doing an event search, though he or she probably has some clear or vague preferences on the events he or she would like to choose. Accordingly the technical support should focus on helping the user better explore events and facilitate decision-making. The latter often occurs during or just after the attendance. In this case, the user already knows which event he or she wants to find. Thus the technical support should focus on pinpointing the event easily and quickly. In our initial design, we only paid attention to the former situation, but overlooked the latter.

In the first field study, we found the event start time and the event location were important factors in the process of deciding which event to attend. Users tended to find an event of interest that was going to start very soon and nearby. This echoed our initial envisioning of the system use scenarios. An example of the kind of use scenarios we envisioned was that a person, just finishing dinner in a restaurant, would use a mobile event system to help figure out what to

do next. Obviously, in this scenario, this person would probably be more interested in the events which would start very soon (or maybe were going on) and which were not far away (in terms of the transportation methods he or she could take).

Our design of the default event list and the event map seemed to meet such requirement fairly well during the Arts Festival. On the one hand, the default event list helped users explore upcoming events; and on the other hand, the event map helped users explore the event location distribution. Even so, we can still improve them for easier event exploration based on time and location. First, the time related attributes and the location related attributes can be combined more closely. For instance, the event distribution map can be improved to visualize time related attributes, such as using different markers to differentiate which events have not started, which are going on and which already ended, or using different colors to roughly represent the start time of upcoming events – e.g. the darker the color, the sooner the event will start. Second, the default event list and map can be enhanced by location sensitive technology. For example, they can both be adapted to the user's location, and the user's current location should be also marked in the map so that the user can know an event location relative to his/her position.

Besides supporting exploration of events for attendance, the system should also easily support pinpointing a specific event that the user has a clear idea about. Content-based search, e.g. search by keywords, has been suggested by participants during the Arts Festival. It should be a way to address this issue. Location sensitive technology can be another way, which, combined with time-related information, is especially useful for determining what event the user is currently attending. For example, if the system provides a location sensitive link to the blog for the event the user is attending, he/she can find the blog to participate in more quickly without need of searching for the event. We can also consider allowing the user to mark the events they are interested in as "my events" during event exploration so that later he/she can access these events more easily through the hyperlink list of "my events".

Searching events by specifying parameters was not often used during the two field trials. This means after all it is not very convenient and therefore we should try to meet most of the needs concerning event exploring and pinpointing through more convenient solutions. On the other hand, searching events by specifying parameters would probably become more important if the system is used for more general situations (e.g. if there are many more events on the system and they as a whole cover a much longer term and a much larger area), rather than just the very limited set of events for a festival or a celebration.

Event Blogging

The field trials provided us an overview of how users might use the event blogging. Though these functions, such as commenting on an event, describing personal activities, and greeting others, were achieved by the event blogging at the field trials, this does not mean the event blogging feature we designed is the only way or best way to achieve them. Since we got to know what these functions were through the field trials, it is possible for us also to consider other solutions to facilitate expressions of these functions.

We have found the degree of difficulty in the mobile input methods was a factor influencing the desire for mobile expression that we cannot ignore. Input difficulty would increase the time of interaction with technology for finishing a task (e.g. creating a blog post). Since interaction with technology competes for the same temporal resources that the social activities need, clumsy and slow interaction with technology would lead to uncomfortable interruption or disruption in regard to engaging in the event itself (Jacucci et al. 2007b), which is usually the main purpose for attending an event. Such “temporal tension” (Tamminen et al. 2004) has received attention from some researchers of mobile applications (Sarvas et al. 2004; Brown 2004). We should also take it into serious consideration in investigating more convenient ways

for users to create expressions. For example, can we provide some commentary phrases or content templates for users to choose or customize? How can we make better use of mobile multimedia capturing tools? Can speech-to-text technology facilitate and foster online conversation?

User Awareness

Before this study, it seemed only Jacucci et al. purposefully introduced some user awareness cues into their mobile event support system to augment mobile interaction between event attendees (Jacucci et al. 2007a). Our field trial results also suggested user awareness features have a positive impact on social interaction, though our design of user awareness features was different from theirs (see Table **1-1**). Hence we suggested such kind of features should be taken into consideration when developing mobile event support systems, and even any other systems emphasizing mobile interaction.

According to participants' concerns at First Night, the awareness features can be improved from two aspects. First, more affordances for interpersonal awareness or interpersonal interactions based on awareness should be provided since users had such a requirement. For example, users should be allowed to comment on status posts or directly contact a specific person in some way after reading his or her status. Also, they should be allowed to check other users' status history, not just their latest status. Second, the existing social relationships should be considered for refining the interpersonal awareness and means of interaction. For example, users should be allowed to create their buddy list, only check their friends' status, and share the event photos with people they specify.

We have found that users commonly felt that sharing their location or their presence at an event with other people on the system was important and they would like to share such kinds of

information. Location sensitive technologies should be able to make it easier to share such kinds of information by detecting users' geo-coordinates. For example, the system can provide a location sensitive button for the user to post what event they are at as a status update, if he/she chooses to do so. However, it seems some work needs to be done to translate the detected geo-coordinates to an event name or a location name meaningful to users.

Future Work

We believe it is important to open up the work on mobile support for community event attendees. We have investigated it from three aspects – event information acquisition, in situ experience sharing, and user awareness – and proposed our design. Through field trials, we have witnessed users' need for event information searching and their desire for social interaction and interpersonal awareness at events. We have elicited some design implications about how to support such needs and desires. Unfortunately, in our two field trials we were unable to try collaborative generation of event information in a grassroots way.

Our goal is to develop an exemplified community-oriented mobile application, and to document it by empirical studies of people using it in daily life. We hope that by adopting our system, community members will more actively participate in community activities, therefore increasing the sense of belonging or even taking actions to serve or change their community, and that they will build more relationship with other community members through more opportunities to share with each other. The prototyping work and field trials reported in this thesis are just the first step towards this goal. Future work can be considered from two aspects.

First, we can consider putting more effort into investigating people's existing practices related to event attending. Our current prototyping work was mainly inspired by previous event support systems documented in the literature, the capacities of a pervasive wireless infrastructure,

and developers' personal knowledge, experience, and informal observation on issues concerning event attending. We actually did not have a systematic understanding of the existing practices. This can lead to an insufficient analysis of the potential intervention points where the existing practices can be augmented by wireless/mobile technology.

Second, we need to consider further evaluating the system (after improvement) in the real settings for which it was designed, since such an ecologically valid evaluation (Carter et al. 2008) is the most reliable way of vetting new designs and seeing the effect of an application on real life. Ecologically valid evaluation requires us to expose the system to community daily life and avoid intrusive intervention or control on users' natural use of the system. Our two field trials, where we sacrificed the realism of system use to some extent in order to get useful data for analysis within a day or a couple of days, were just an expedient way to this end. If we want to go further in conducting an ecologically valid evaluation on our system, we will have to handle the following challenges.

Issues of Development First, as the system will be used uncontrolledly in real life, a high-level robustness is a must. This means the system should be able to handle a variety of possible situations even though some of the situations might occur rarely. Second, the system will be used for events much more heterogeneous than the small set of events for our previous field trials, thus more design and development work is needed to deal with the heterogeneity. Third, there are various types of handheld devices people are using in their daily life and none of them is absolutely dominant. In order to make many people become potential users since the user scale might affect the evaluation results concerning social interaction and the community sense, multiple types of devices would probably need to be supported for running our applications. All the above three points will significantly increase development difficulty and labor.

Issues of Deployment The difficulties in deployment are often caused by the forward-looking nature of research on novel systems and applications for which the conditions of use in

real life might still be immature. As for deployment of our system for evaluation, a nearly pervasive wireless infrastructure is needed, at least within a not-too-small region where many community members will often be, and people should not be asked to pay more for using this infrastructure just because they want to use our application. In our previous field trials, poor wireless connectivity made the participants often frustrated. In the natural use of a system in daily life, such frustration might lead to users' abandoning application use, resulting in the failure of the evaluation. Hence an appropriate wireless infrastructure should be ready for ecological evaluation. In addition, some novel (e.g. location-sensing related) functions often rely on the support of the mobile devices themselves, whereas the mobile devices most people are using might not have such support. Thus the capacities of mobile devices used by people of the community being studied should be considered. Researchers need to find an appropriate community for study or lend participants some devices capable of novel functions.

Another deployment issue is concerned with working together with mobile service providers to market the application. In order to evaluate our system, the level of use necessary for evaluation has to be triggered and maintained. Since our system was supposed to support information generation in a grassroots way and social interaction, many users, clearly, are required for it to be useful and attractive. Usually researchers do not have enough power to incubate and stimulate adoption and thus have to partner with some organizations or businesses which are more powerful in this aspect. Typically these are the leading mobile service providers. However, if the partners have ultimate control of the deployed software, they might modify the software or the relevant business plan during the evaluation and take things out of the researchers' control. Such kind of problem was encountered in our own experience and was also documented by other researchers, such as Carter et al. (Carter et al. 2008). Thus the collaboration process should be carefully considered and planned to try to avoid such kind of problem.

These issues will become intractable challenges to an ecologically valid evaluation of the system design and investigation of whether and how the system use benefits the local community. Other projects that also attempt to design community wireless applications, especially those emphasizing interaction between community members, would probably also have to confront (all or most of) these issues on the way to achieving ecologically valid designs, so it would be better to consider them early on.

References

Abowd, G., Atkeson, C., Hong, J., Long, S., Kooper R., Pinkerton, M. (1997) Cyberguide: A mobile context-aware tour guide. *Wireless Networks*, 3:421-423.

Ananny, M., Biddick, K., C., Strohecker, C. (2003). Constructing public discourse with ethnographic/SMS "texts." In *Proceedings of Mobile HCI 2003*, 368-373.

Bamford, W., Coulton, P., Edwards, R. (2007) Space-time travel blogging using a mobile phone. *Proceedings of the international conference on Advances in computer entertainment technology*. 1-8.

Barkhuus, L., Jørgensen, T. (2008) Engaging the crowd: studies of audience-performer interaction. *CHI '08 extended abstracts on Human factors in computing systems*, 2925-2930.

Beale, R. (2005) Supporting social interaction with the smartphone – designing pervasive systems. *IEEE Pervasive Computing*, 4(2): 35-41.

Beamish, A. (1995) Communities On-Line: Community-Based Computer Networks. *Masters Thesis*, Department of Urban Studies and Planning, MIT.

Benford, S., Rowland, D., Flintham, M., Drozd, A., Hull, R., Reid, J., Morrison, J., Facer, K. (2005) Life on the edge: supporting collaboration in location-based experiences. *Proceedings of the SIGCHI conference on Human factors in computing systems*. 721-730.

Berkowitz, B. (1996) Personal and Community Sustainability. *American Journal of Community Psychology*, 24: 441-59.

Björk, S., Falk, J., Hansson, R., Ljungstrand. P. (2001) Pirates! Using the physical world as a game board. *Proceedings of Interact 2001 Conference on Human-Computer Interaction*.

Blanchard, A. (2004) Blogs as Virtual Communities: Identifying a Sense of Community in the Julie/Julia Project. In *Into the Blogosphere: Rhetoric, Community, and Culture of Weblogs*, Antonijevic, S., Gurak, L., Johnson, L., Ratliff, C., and Reyman, J. Editor. (Available at: http://blog.lib.umn.edu/blogosphere/blogs_as_virtual.html)

Brown, T. (2004) The future of designing experiences. *Closing Plenary at CHI 2004*, Austria Vienna, April 29th, 2004.

Burak, A., Sharon, T. (2004). Usage patterns of FriendZone: mobile location-based community services. *Proceedings of the 3rd international Conference on Mobile and Ubiquitous Multimedia MUM '04*, 83:93-100.

Burge, J.L., Carroll, J.M., Ganoe, C.H., (2008) Involving the Community in the Design of Municipal Wireless. *Technical Report*, Center for Human-Computer Interaction, the Pennsylvania State University.

Burrell, J., Gay, G. K. (2002) E-graffiti: Evaluating Real-World Use of a Context-Aware System. *Interacting with Computers*, 14:301-312.

Carroll, J.M. (2005) The Blacksburg Electronic Village: A study in community computing. In P. van den Besselaar & S. Kiozumi (Eds.), *Digital Cities 3: Information Technologies for Social Capital*. Lecture Notes in Computer Science, Volume 3081. Berlin: Springer-Verlag, pp. 43-65.

Carroll, J.M., Ganoe, C. (2008) Supporting community with location sensitive mobile applications. In *M. Foth, ed. Handbook of Research on Urban Informatics: The Practice and Promise of the Real-Time City*.

Carroll, J. M., Rosson, M. B. (1996) Developing the Blacksburg Electronic Village. *Communications of the ACM*, 39(12): 69-74.

Carroll, J. M., Rosson, M. B. (2001) Better home shopping or new democracy?: evaluating community network outcomes. *Proceedings of the SIGCHI conference on Human factors in computing systems*, 372-379, March, 2001, Seattle, Washington, USA.

Carroll, J.M., Rosson, M.B. (2008) Theorizing mobility in community networks. *International Journal of Human-Computer Studies*, 66(12): 944-962.

Carter, S., Mankoff, J., Klemmer, S., Matthews, T. (2008) Exiting the cleanroom: On ecological validity and ubiquitous computing. *Human-Computer Interaction*, 23(1):47-99.

Cheng, Y-M., Chou, T-C., Yu, W., Chen, L-C., Yeh, C-L., Chen, M-C. (2007) Life is sharable: mechanisms to support and sustain blogging life experience. *Proceedings of the 16th international conference on World Wide Web*, 1277-1278.

Cheverst, K., Davies, N., Mitchell, K., Friday, A., Efstratiou, C. (2000) Developing a context - aware electronic tourist guide: some issues and experiences. *Proceedings of CHI 2000*, 17-24.

Christensen, C.M., Kjeldskov, J., Rasmussen, K.K., (2007) GeoHealth: a location-based service for nomadic home healthcare workers. *Proceedings of the 19th Australasian conference on Computer-Human Interaction: Entertaining User Interfaces*, 273-281.

Chwe, M. S. Y. (1998) Culture, circles and commercials: Publicity, common knowledge and social coordination. *Rationality and Society*, 10, 47-75.

Cosley, D., Frankowski, D., Terveen, L. (2006) Using intelligent task routing and contribution review to help communities build artifacts of lasting value. In *Proc. CHI*, 1037-1046.

Doctor, R., Ankem, K. (1995) A Directory of Computerized Community Information Systems. Unpublished report. Tuscaloosa, AL: School of Library and Information Studies, University of Alabama.

Engström, A., Esbjörnsson, M., Juhlin, O., Norlin, C. (2007) More TV! - Support for local and collaborative production and consumption of mobile TV. *Adjunct Proceedings of EuroITV 2007*, 173-177.

Esbjörnsson, M., Brown, B., Juhlin, O., Normark, D., Östergren, M., Laurier, E. (2006) Watching the cars go round and round: designing for active spectating. In *Proc. CHI 2006*, 1221-1224.

Espinoza, F., Persson, P., Sandin, A., Nyström, H., Cacciatore. E., Bylund, M. (2001) GeoNotes: Social and Navigational Aspects of Location-Based Information Systems. In *Ubicomp 2001: Ubiquitous Computing International Conference*, 2-17.

Farrington, C., Pine, E. (1997) Community Memory: A Case Study in Community Communication. In P. Agre and D. Schüler (eds.), *Reinventing Technology, Rediscovering Community*, Ablex Publishing, Norwood, NJ.

Getz, D. (1993) Festivals and special events. In M. A. Khan, M. D. Olsen, & T. Var (Eds.), *Encyclopedia of hospitality and tourism*, 789 – 810. New York, NY: Van Nostrand Reinhold.

Gursoy, D., Jurowski, C., Uysal, M. (2002) Residents attitudes: A structural modeling approach. *Annals of Tourism Research*, 29(1): 79 – 105.

Hall, A., Bosevski, D., Larkin, R. (2006) Blogging by the dead. *Proceedings of the 4th Nordic conference on Human-computer interaction: changing roles*, 425-428.

Hansen, F.A., Grønbæk, K. (2008) Social web applications in the city: a lightweight infrastructure for urban computing. *Proceedings of the nineteenth ACM conference on Hypertext and hypermedia*, 175-180.

Hirsch, T., Liu, J. (2004) Speakeasy: overcoming barriers and promoting community development in an immigrant neighborhood. *Proceedings of the 2004 conference on*

Designing interactive systems: processes, practices, methods, and techniques, 345-348, August 01-04, 2004, Cambridge, MA, USA.

Holmquist, L.E., Falk, J., Wigström, J. (1999) Supporting group awareness with interpersonal awareness devices. *Personal Technologies* 3(1-2):13-21.

Hourihan, M. (2002) What We're Doing When We Blog. O'Reilly. (Available on line at: http://www.oreillynet.com/pub/a/javascript/2002/06/13/megnut.html)

ITAA newsletter (2006) http://www.itaa.org/isec/pubs/e20063-05.pdf

Jacucci, G., Oulasvirta, A., Ilmonen, T., Evans, J., Salovaara, A. (2007a) CoMedia: mobile group media for active spectatorship. *Proc. of SIGCHI Conference on Human Factors in Computing Systems (CHI 2007)*, 1273-1282.

Jacucci, G., Oulasvirta, A., Salovaara, A. (2007b) Active construction of experience through multimedia: a field study with implications for recording and sharing. *Personal and Ubiquitous Computing*, 11(4):215-234.

Klante, P., Krosche, J., Ratt, D., Boll, S. (2004) First-year students' paper chase: a mobile location-aware multimedia game. *Proceedings of the 12th annual ACM international conference on Multimedia*, 934 – 935.

Kwak, N., Shah, D. V., Holbert, R. L. (2004) Connecting, Trusting, and Participating: The Direct and Interactive Effects of Social Associations. *Political Research Quarterly*, 57(4): 643-652.

Lane, G., Thelwall, S. (2005) Urban Tapestries: public authoring, place and mobility. (Available at: http://socialtapestries.net/outcomes/reports/UT_Report_2006.pdf)

Louridas, P. (2006) Using wikis in software development. *IEEE Software*, 23:88-91

Mandviwalla, M., Jain, A., Fesenmaier, J., Smith, J., Weinberg, P., Meyers, G. (2008) Municipal broadband wireless networks. *Communications*. 51(2):72-80.

Matyas, S., Matyas, C., Schlieder, C., Kiefer, H., Mitarai, H., Kamata, M. (2008) Designing location-based mobile games with a purpose: collecting geospatial data with CityExplorer. *Proceedings of the 2008 International Conference on Advances in Computer Entertainment Technology*, 244-247.

Maynes-Aminzade, D., Pausch, R., Seitz, S. (2002) Techniques for interactive audience participation. In *ACM SIGGRAPH 2002*. ACM Press, 257-257.

Nilsson, A. (2004) Using IT to make place in space: evaluating mobile technology support for sport spectators. In *Proc. ECIS 2004*.

Nurminen, A. (2006) m-LOMA - a mobile 3D city map. *Proceedings of the eleventh international conference on 3D web technology*, 7-18.

Olsson, D., Nilsson, A. (2002) MEP: A Media Event Platform. *Mobile Networks and Applications*, 7(3):244.

Open Geospatial Consortium (OGC), 2005. Open Location Services 1.1.

Paulos, E., Goodman, E. (2004) The familiar stranger: anxiety, comfort, and play in public places. *Proceedings of the SIGCHI conference on Human factors in computing systems*, 223-230.

Priedhorsky, R., Terveen, L. (2008) The computational geowiki: what, why, and how. *Proceedings of the ACM 2008 conference on Computer supported cooperative work*, 267-276.

Rao, B., Minakakis, L. (2003) Evolution of mobile location-based services. *Communications of the ACM*, 46(12).

Reitmayr, G., Schmalstieg, D. (2003) Location based applications for mobile augmented reality. *Proceedings of the Fourth Australasian user interface conference on User interfaces 2003*, 65-73.

Reeves, S., Benford, S., O'Malley, C., Fraser, M., (2005) Designing the spectator experience. In *Proceedings of the SIGCHI*, 741-750.

Rogers, E. M., Collins-Jarvis, L., Schmitz, J. (1994) The PEN Project in Santa Monica: Interactive communication, equality, and political action. *Journal of the American Society for Information Science*, 45(6), 401-410.

Rogers, Y., Price, S., Fitzpatrick, G., Fleck, R., Harris, E., Smith, H., Randell, C., Muller, H., O'Malley, C., Stanton, D., Thompson, M., Weal, M. (2004) Ambient wood: designing new forms of digital augmentation for learning outdoors. *Proceeding of the 2004 conference on Interaction design and children: building a community*, 3-10.

Sarvas, R., Herrarte, E., Wilhelm, A., Davis, M. (2004) Metadata creation system for mobile images. In *Proceedings of the 2nd International conference on mobile systems, applications and services (MobiSys'04)*. ACM Press, New York, 36–48.

Schmitz, J., Rogers, E. M., Phillips, K., Paschal, D. (1995) The public electronic network (PEN) and the homeless in Santa Monica. *Journal of Applied Communication Research*, 23:26-43.

Schuler, R.P., Laws, N., Bajaj, S., Grandhi, S.A., Jones, Q. (2007) Finding your way with CampusWiki: a location-aware wiki. *CHI '07 extended abstracts on Human factors in computing systems*, 2639-2644.

Tamminen, S., Oulasvirta, A., Toiskallio, K., Kankainen, A. (2004) Understanding mobile contexts. *Pers Ubiq Comp* 8:135–143.

Townsend, A.M. (2001) The Science of Location: Why the Wireless Development Community Needs Geography, Urban Planning, and Architecture. *Position Paper for CHI01 Wireless Workshop*. (Available at: http://www.acturban.org/biennial/case_studies/doc_teleworking/science_location.pdf)

Wang, C-M., Turner, D. (2004) Extending the wiki paradigm for use in the classroom. In *International Conference on Information Technology: Coding and Computing*, 255-259.

Want, R., Hopper, A., Falcao, V., Gibbons, J. (1992) The active badge location system. *ACM Transactions on Information Systems*, 10(1):91-102.

Want, R., Schilit, B., Adams, N., Gold, R., Petersen, K., Ellis, J., Goldberg, D., Weiser, M. (1995) The PARCTab ubiquitous computing experiment. Tec. report CSL-95-1, Xerox PARC.

Wikipedia “Municipal wireless network”, http://en.wikipedia.org/wiki/Muni_Wi-Fi

Wikipedia “Municipal broadband”, http://en.wikipedia.org/wiki/Municipal_broadband