Just-for-Us: A Context-Aware Mobile Information System Facilitating Sociality

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ABSTRACT
Mobile computer technologies are increasingly being appropriated and used to facilitate people's social life outside the work domain. Addressing this emerging domain of use, we present the design of a context-aware mobile information system prototype facilitating sociality in public places: Just-for-Us. The design of the prototype system was informed by two empirical studies: an architectural analysis of a recently built public space in Melbourne, Australia and a field study of small groups socialising there. We describe these two studies and illustrate how findings informed our prototype design. Finally, we outline an ongoing field study of the use of the Just-for-Us prototype.

Categories and Subject Descriptors
H5.2. [**Information interfaces and presentation (e.g., HCI)**]: User Interfaces - *User-centered design, Graphical user interfaces, Screen design*.

General Terms: Design, Human Factors.

Keywords: Context-awareness, Sociality, Indexicality, Mobile Information System, Built Environment, User Study, Field Study.

1. INTRODUCTION
Mobile computer technologies are increasingly being appropriated to facilitate people's social life outside the work domain. Mobile phones, and especially SMS texting, have changed the way people communicate, interact in the physical world, and coordinate their social activities [12] [25]. Smart Phones and Personal Digital Assistants (PDAs) connected to the Internet bring access to web-based communities to the mobile user and extend the potentials of SMS through Internet-chat capabilities and facilities for video-based communication. By embedding networked sensors into the built environment, adding advanced positioning technology and short range network capabilities (such as Bluetooth, RFID tags, etc.), mobile services are emerging that adapt their content to both the user's physical and social contexts. For example, mobile dating services exist which alert the user when they are in the proximity of a potential partner who matches their own pattern of attributes [4]. As another example, swiping electronic membership cards at the entrances and exits of cafés, discotheques, music clubs, etc. in some Danish cities makes it possible for members of a social group to identify the whereabouts of their friends and other people through the mobile Internet, and to see which places in the city are currently busy and which are not [13]. In the more experimental domain, context-aware mobile systems show the location of friends in vicinity [9], take into consideration the user's social context when presenting event and tourist information [16], and create couplings between physical and virtual spaces by enabling people to attach text and media content to physical locations for others to find [24].

The emergence of systems like these represents a new trend of huge interest to the mobile HCI community: facilitating sociality through context-aware mobile devices. However, adapting mobile information systems to people's social context is not trivial and further research is needed into a series of fundamental questions. What should such systems do and how is the user's social context taken into consideration in interaction design in a way that makes sense and is useful to a user currently engaged in a situated social activity? Addressing some of these questions, this paper presents a case study example of how sociality can be facilitated by a context-aware mobile information system adapting to the user's physical and social context. On the basis of a field study, it is shown how people's situated social interactions in public places are complex and how the physical and social affordances of a place influence the situated interactions that occur there. Informed by these studies, the presented prototype exemplifies how sociality can be facilitated on mobile devices by providing information that is "Just-for-Us".

The paper is structured in the following way. Section 2 briefly introduces the concepts of sociality, social indexicality and Just-for-Us Information. Section 3 describes two empirical studies of physical and social context and outline key findings informing our prototype design. In section 4, we describe the interaction design and technical implementation of a mobile prototype just-for-us system, which adapts to the user's physical and social context. Section 5 briefly describes how we are currently studying the use of the prototype system through a series of field visits. Section 6 concludes and indicates further work.

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2. SOCIALITY, SOCIAL INDEXICALITY AND JUST-FOR-US INFORMATION

Sociality is a term traditionally used by sociologists for describing the support for social interaction between people. In relation to interaction design, sociality is strongly associated with on-line interaction in virtual worlds but has also started to appear in relation to the use of mobile information and communication technologies in context. Gaver [10] relates sociality and the physical world by defining "affordances for sociality" as being "possibilities offered by the physical environment for social interaction". Crabtree and Hemmings [5] use the terms sociality and social interaction interchangeably while exploring the relationship between architecture, technology and social interaction in domestic space. In discussing the integration of technology and our interactions in urban spaces, Wittel [28] correlates the terms of face-to-face sociality with face-to-face interaction.

Indexicality is a concept drawn from semiotics, applied to the design of mobile device interfaces to streamline and reduce the amount of information delivered to the user [15] [22]. Indexicality is a property of a representation that gives it a context-specific meaning and thus only makes sense in a particular setting. In applying indexicality to mobile human-computer interaction, information in the interface is indexed to information present in the user's immediate surroundings, such as, for example, signposts, buildings and roads. Social indexicality takes the idea of indexicality a step further, and makes reference to, for example, the user's current social group and their history of shared experience, such as where people usually meet or what they usually do when they go out together. Combining physical and social indexicality, we create information that is "just-for-us". It is not a compilation of all available knowledge about a place, delivered in a hierarchical or location based format, but a selection of that information that is relevant to the time, place, and the people involved in a situated social interaction.

3. EMPIRICAL STUDIES: PHYSICAL AND SOCIAL CONTEXT

With the purpose of investigating the role of physical and social contexts of people's situated social interactions we conducted two empirical studies at the newly opened public space of Federation Square, Melbourne, Australia. The first study was an expert inspection of the architectural and informational elements constituting the physical context at Federation Square. The second study was a series of contextual interviews made with people socialising in this space, studying their social interactions to understand the social context of the space. Federation Square was chosen for this study because it is a multi-modal public space with a mixture of distinct architectural features and embedded digital elements that provide a variety of activities to visitors. Federation Square has cafes, restaurants, shops, cinemas, galleries, gathering places and open spaces and functions as a small-scale city district (figure 1).

In the first study, methods were adapted from Urban Planner Kevin Lynch [18] and Architect Christopher Alexander [1]. Lynch and Alexander both modelled built environments, specifically cities,

Figure 1. Federation Square, Melbourne, Australia

with regard to the people that inhabit them, incorporating social theories and user needs into analyses of physical environments. Lynch [18] developed a method for visual analysis of city precincts through descriptions of key aspects of physical space held by people as they navigate and orient themselves within cities, extracting an environmental image of a place. Alexander [1] empirically investigated the interplay between architectural space and its inhabitants and identified architectural design problems in context and their impact on inhabitants of that environment. Although situated within the field of architecture, the works of Lynch [18] and Alexander [1] have also been explored within the field of human-computer interaction. For example, Dieberger and Frank [7] use the work of Lynch to create a city metaphor for navigating complex information spaces. Crabtree et al. [6] use the concept of Alexandrian patterns to inform the design of new technologies for use in domestic settings. Informing the design of web based systems for supporting social interaction, Erickson and Kellogg [8] use Alexander and Lynch for exploring the relationship between physical spaces and social interaction. Within the field of mobile human-computer interaction, Lynch has inspired the design of several mobile guide systems such as [11] [17]. The works of Alexander and Lynch also inspired the study of "familiar strangers" in urban settings reported in [23] and the design of the "Jabberwocky" personal mobile device facilitating social interaction between familiar strangers in public places.

Inspired by Lynch and Alexander and the use of their works in HCI, the aim of our first empirical study at Federation Square was to inquire into how architectural and informational elements of the built environment contribute to the visitor's experience of a public place. This involved observational expert audits in the field by a trained architectural observer recording the relationship between elements of the environment. Identifying the main characteristics of the space, content analysis [20] and affinity diagramming [2] were used to derive, group and refine categories from the collected data. The findings from the first study are described in detail in [22].

The aim of the second study was to enquire into the "use" of Federation Square by regular visitors as a place for socialising. In this study, McCullough's typology of everyday situations [19] was used as a starting point for a classification of the social activities of people associated with being out on the town: eating, drinking, talking; gathering; cruising; belonging; shopping; sporting; attending; and commemorating.

Figure 2. Contextual interview at Federation Square

On the basis of McCullough's typology, field observations were carried out using contextual interviews [2] and observational ethnographic techniques [3] with established social groups on location at Federation Square (figure 2). The participants in the second study were three different established social groups. Each group consisted of three young urban people, mixed gender, between the ages of 20 and 35, who had a shared history of socializing at Federation Square together. Prior to the field visits each group received a 10 minute introduction to the study followed by a 20 minute interview about their socializing experiences and preferences. The participants were then taken to the nearby Federation Square, where they were asked to involve themselves in the kinds of interactions and activities they would usually do together when socialising out on the town. The participants were not given specific tasks but were asked to verbalize their actions and interactions and to respond to the interviewer's questions for clarification about things being said, and implicit decisions and interactions being made. An observer recorded the field visits on digital video. Three field visits were carried out, lasting approximately three hours for each group. The video recordings of the participants' situated social interactions were subsequently used at the foundation for a thorough grounded theory analysis [26] of transcripts and affinity diagramming of themes to draw successively higher levels of abstraction. The findings from the second study are described in detail in [21].

4. THE DESIGN AND IMPLEMENTATION OF JUST-FOR-US

On the basis of the findings from the two empirical studies, we designed and implemented a high-fidelity context-aware mobile prototype system, Just-for-Us, facilitating sociality when out on the town. Just-for-Us keeps track of the user's location, current activity, friends within close proximity, the location and activities of other people, and the current environmental conditions. It also keeps a history of the user's visits to places around the city.

4.1 Technical Implementation

Just-for-Us was implemented as a web application running in Microsoft Pocket Internet Explorer on HP iPAQ h5550 connected either directly to the Internet through WLAN or via GPRS on a Bluetooth enabled mobile phone. This approach facilitated delivering all content by means of simple HTML pages and graphics files over a standard HTTP connection. Since, however, HTTP does not support pushing information to the user this was implemented by maintaining an open HTTP connection using pushlets [27]. The content of Just-for-Us is powered by a relational mySQL database divided into three parts. Firstly, it contains information about the physical layout of Federation Square, the location and accessibility of places, descriptions and photographs of landmarks and transition points, and simple way finding descriptions for getting around the space. As the physical layout of the space is continuously modified, the information in the database is designed to be easily updateable. Secondly, the database contains information about the different establishments at Federation Square and about the space itself. This includes descriptions and photographs of places, descriptions of special events, menus, lists of special offers, programmes, logos, etc. For maintenance of information, vendors can modify their own data through a simple web interface. Thirdly, the database contains dynamic information about a user's current context (location, activity, social group, etc.) and their history of visits.

The web interface of Just-for-Us was implemented using PHP for server-side generation of HTML pages on an Apache web server on the basis of the content and context information in the mySQL

Figure 3. Just-for-Us prototype system architecture

database. Dynamic client-side interaction and handling of pushed information was implemented using JavaScript. In this sense, Just-for-Us works very much like any other dynamic website, and is very easy to extend and modify. Making the application primarily server-side has the benefit of requiring only the exchange of small pieces of HTML code, images and URL requests over the network rather than the exchange of heavy program code. Furthermore, it makes use of the server's processing power for quick program execution rather than relying on slow mobile device processors.

Supporting the functioning of the web application, a number of server-side programs were implemented to perform specific sub-tasks. One such application monitors the contextual information in the database and pushes information to the user when appropriate. Another server-side application uses the database to dynamically generate PNG maps and annotated photographs. The overall prototype architecture is outlined in figure 3.

Just-for-Us allows several ways of resolving the physical location of the user: through GPS, WLAN or by Bluetooth beacons embedded in the built environment. Using Bluetooth beacons for positioning, the system does not know the exact coordinates of the user but only has a rough idea of his position (for example, if he is in a specific café or in the main square). The presence of friends in the vicinity of the user is resolved by scanning for other Bluetooth devices with network ID's matching the user's list of friends. Positioning and friends in vicinity is resolved locally on the user's device and relayed to the mySQL database through a small client application running in the background.

4.2 Interaction Design

The Just-for-Us prototype was designed for Microsoft Pocket Internet Explorer running in full screen mode. The interaction design of the system to a large extent resembles a normal web page being accessed from a handheld device. The user can use the stylus to select links on the touch screen and use the on-screen keyboard or digitizer for entering text. To avoid scrolling, long pages were cut into a sequence of sub-pages. The design of the Just-for-Us prototype is based on four ideas emerging from the empirical studies:

1. Making the Invisible Visible: Augmenting the User's Physical Surroundings
2. Supporting Ad-Hoc Communication about Places, Activities and Time
3. Indexing Recommendations and Content to History and Context
4. Representing Activities within Proximity and Indexing to Familiar Places

4.2.1 Making the Invisible Visible: Augmenting the User's Physical Surroundings

The empirical studies of Federation Square revealed that the space is divided into four overall districts each with its own distinct characteristics and landmarks. This division into four districts was used as a starting point for our prototype design.

When logging on to the Just-for-Us system while physically located at Federation Square (or when entering Federation Square while logged on to the system) a "home screen" is pushed to the device displaying information corresponding to the district where the user is presently located (figure 4).

Figure 4. Home screen: augmentation of the user's built surroundings

The home screen consists of four elements; 1) the name of the district, 2) textual descriptions of places in that district, 3) an activity meter showing the current patronage and primary activity at a selected place, and 4) a 360º annotated panoramic view divided into a series of sequential photographs. The activity-meter indicates how many people are currently present at a place, and shows what they are doing there. The annotations on the panoramic photograph show what is located behind the physical structures surrounding the user, thus making the invisible visible through a form of indirect augmented reality. Clicking on an annotation, a short description of that place and a list of what's currently happening there, such as specials or upcoming events, movies etc., are displayed. Furthermore, the activity meter below the panoramic photograph is updated to reflect the patronage and primary activity of the selected place. Using the arrow icons below the photograph, the user can pan left and right, exploring the district and accessing more information about places in it. By default, the panoramic photograph is focused on the landmark with a corresponding textual description of the district. When entering a new district, the corresponding home screen is automatically pushed to the device.

4.2.2 Supporting Ad-Hoc Communication about Places, Activities and Time

Another significant finding from the field studies was that people typically coordinate meeting up with their friends in a highly ad-hoc manner. Typically, this involves a lot of communication back and forth, negotiating who, why, where and when to meet. The preferences for these factors are highly dependent on context and final decisions are seldom made until the very last minute. Activities depend on who you are meeting and what the others want to do. Places to go to depend on what activity you want to do and your shared history of going out. Places to meet depend on people's physical familiarity with a place, how long you have to wait, and the presence and activity of others. When to meet depends on people's physical distance from potential meeting places, who you are

meeting up with, and why you are meeting up. These findings informed the design of the "contact" screen of Just-for-Us, providing a text-based communication channel to one's friends with a set of shared representations for negotiating a rendezvous (such as mutual location information).

When the user selects the "Contact" option on the top menu bar of the screen, the system displays a list of friends similar to the contacts list in e.g. MSN Messenger. The list is divided into three parts: 1) friends who are online and within proximity of the user; 2) friends who are online but further away; and 3) friends who are offline. If two or more friends are currently together (within close proximity of each other) they are displayed as a group. When the user selects a friend or a group of friends, an Internet chat session is established (figure 5).

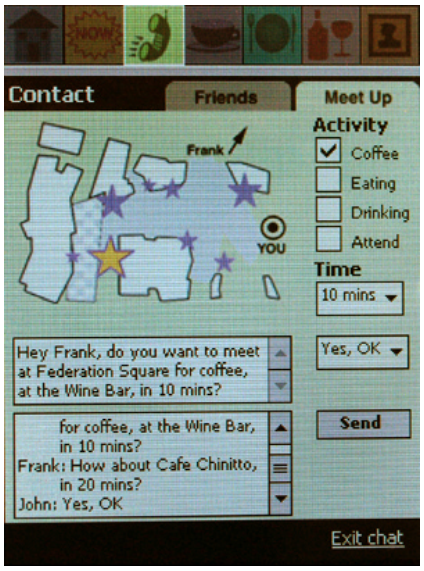

Figure 5. Contact screen: shared objects (map, activity, time) and chat window

At the receiving end this causes a brief ringing tone and a flashing telephone icon on the top of the screen. Apart from supporting free text input, the chat screen, more importantly, also supports automatic generation of small pieces of text with the purpose of supporting communication about people, places, activities and time. At the top of the screen, a small map shows the user's immediate surroundings and the location of the participants in the chat (absolute if within the map area and relative if not). Next to the map, the user can choose between the activities supported by the places on the map. When selecting an activity, recommended places generated on the basis of the user's history and current context are shown on the map by means of different sized coloured stars. Interacting with the map, activity checkboxes and a time drop-down menu generate auto text in the outgoing message window such as, for example, "Hey Frank, do you want to meet at Federation Square for coffee at The Wine Bar in 10 minutes?". When an automatically generated text message is sent, it causes the selected place, activity and time to be synchronized among the participants in the chat, who can now modify the original suggestion, causing a counter suggestion such as "No, but what about a drink at Transport Hotel in 25 minutes?". As in a traditional Internet chat, people can leave the conversation and new people can be invited. The conversation continues until everyone leaves.

4.2.3 Indexing Recommendations and Content to History and Context

Another finding from the empirical studies, which had impact on the design of Just-for-Us, was that places and spaces are dynamic and that setting matters immensely for the quality of socializing – especially in relation to its physicality, the presence and activities of other people and its convenience in terms of closeness. It was notable that people like to go back to places they know well, have been to before with friends in their current social group, or that have been recommended by a friend. People seldom go to completely new places if a familiar place exists within convenient distance. On the basis of these findings, Just-for-Us attempts to support the ongoing negotiation of where to go by indexing to the social group's shared knowledge of familiar places and providing information for the group to be able to size-up the situation before committing to entering a place. When the user clicks on one of the four activity-icons at the top of the screen (coffee, food, drinks or cultural events), the system presents a list of recommendations of providing this activity (figure 6).

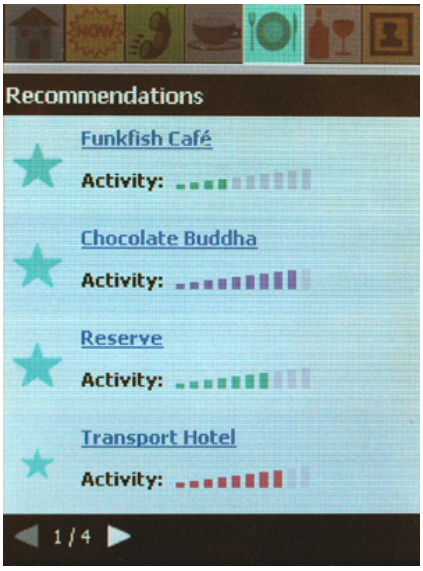

Figure 6. Recommendations screen: ranked list of places to go for food

Rather than simply sorting this list, for example, alphabetically, it is sorted on the basis of the systems knowledge about user's familiar places (history of prior visits), current physical and social setting (where the user is and who he is with) and the current weather conditions. Firstly, the list contains places where the user has been to before with the people that he is currently socializing with. This is followed by places that all people in the social group have been to before, but have not been to together. Thirdly, the list contains places where the user has been before, that none of the other people in the social group have visited (the user's own past experience). This is followed by places that the user has not been to, but that other members of the current social group have (implicit recommendations from friends). Finally, the remaining places in the vicinity of the social group, not familiar to anyone, are displayed. Within these listings, places are ranked in consideration to the frequency of past visits, the proximity of places, the current activity in places, and how well the weather situation of past visits to a place fits the current conditions. The highest scoring places are

highlighted with a star next to the place name in the list. Furthermore, each place has an associated "activity-meter" displaying the current patronage and primary activity (like the one used on the "home" screen). From the list of recommendations, the user can access more information about a place such as menus or programmes. If the user is physically present at a place supporting the selected activity, Just-for-Us will assume that he is primarily interested in information about that specific place and thus takes him directly to the menu or programme. If he is interested in places other than his current situation, he can access the list of recommendations through a "Show other places" link on the bottom of the screen.

4.2.4 Representing Activities within Proximity and Indexing to Familiar Places

A final finding from the field studies of socialising at Federation Square, which had impact on the design of Just-for-Us, was that people make sense of a place through the social affordances provided by other people; where they are going and what they are doing there. People often use this information as important cues for where to go and what to do themselves. It also accommodates people's desire for interaction by proximity between their own social group and others. This finding informed the design of the "now" screen.

When the user clicks on the "now" icon on the main menu bar, the system displays a small map of the user's immediate surroundings with superimposed, dynamically updated, coloured circles indicating the clustering and activities of people within proximity (figure 7).

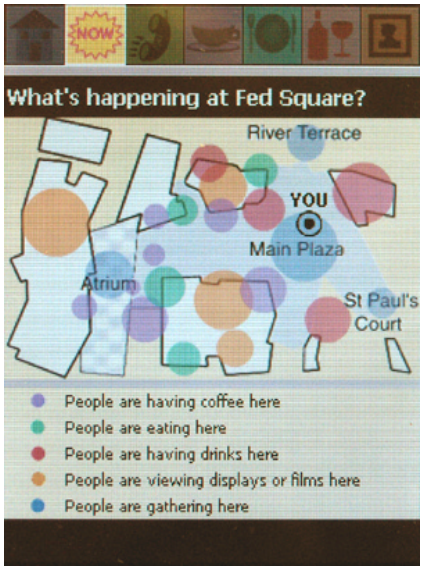

Figure 7. Now screen: showing clustering and activities of close-by people

The radius of the circles indicates the number of people at a place while the colour represents their prevalent activity (e.g. "having coffee", "having a drink", "eating" or "attending a cultural event") using the system's general colour coding of these activities. The map also shows the user's (approximate) location. Clicking on the coloured circles on the map, the user can access more information about a place: detailed descriptions, photographs, menus, programmes, and directions on how to get there from their present location (figure 8). The maps are generated continuously on the server on the basis of the context information in the mySQL database.

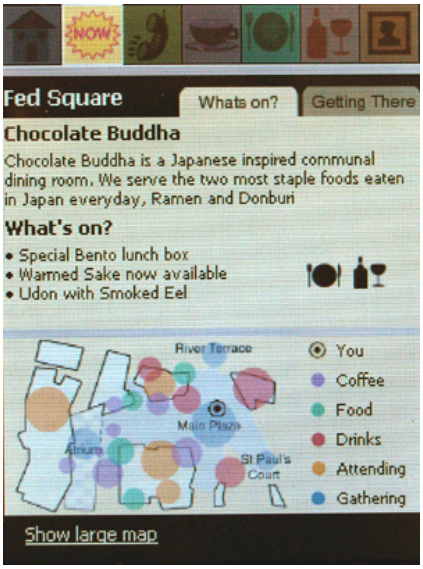

Figure 8. Now screen: details about selected place and small activity map

The field studies also revealed that people seldom navigate by means of detailed maps and route descriptions when making their way around a built environment such as Federation Square as a part of a social group out on the town. Neither do they need or want to. Instead they make use of indexes to familiar places and landmarks in their surroundings. This finding was used to inform the design of the "Getting There" tab in Just-for-Us (figure 9).

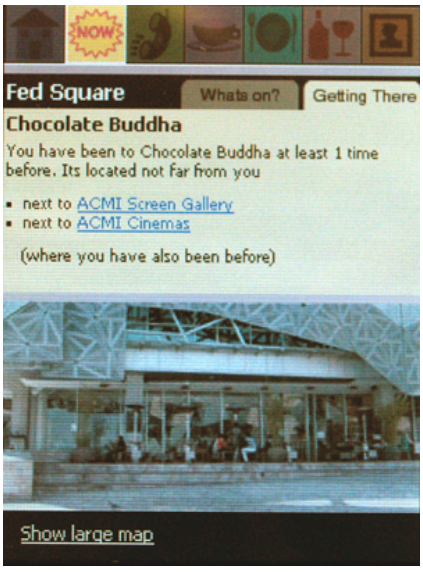

Figure 9. Now screen: way-finding instructions based on history of visits

Selecting this tab, presents a photograph of the selected place and a small set of cues about where it is located based on the user's current location and indexes to places where the user has been to before. If the place is in another district than the user, directions are divided into a series of sub steps on separate pages guiding the user

to that district through references to familiar places, landmarks and transition points. In this way, Just-for-Us takes into consideration what people already know about the environment they are situated in and makes use of people's ability to make sense of an unfamiliar place on the basis of a few simple cues. The "Getting There" tab is only available where it makes sense to provide this information. This excludes the home screen, where the user can see the location of places on the panoramic photograph, and recommendations to familiar places.

5. EVALUATION

The presented prototype has been evaluated through a series of heuristic inspections by the authors throughout its creation but has not yet been subjected to real users. At the time of writing, we are preparing a large-scale study of use and usability in the field at Federation Square to be conducted in March-April 2005. The study will include 16 social groups consisting of two or more people. The groups will be asked to use the system for approximately 1.5 hours while socializing at Federation Square. As previous research has stressed the value of researcher control in field evaluations [14], the users will be given a number of overall tasks to prompt use of the different parts of the system. Supporting this approach, the users will also be asked to validate the relevance and realism of these tasks in relation to the activity of socialising in public. Inspired by the constructive interaction approach to thinking-aloud studies with more than one user, the social groups will be asked to talk among themselves about their perception of, and interaction with, the system with the researcher only asking questions for clarification.

The use of the system will be documented on digital video by means of a newly developed, state-of-the-art mobile data collection facility developed as part of this project. This facility allows miniature wireless cameras to be attached to the mobile devices, capturing high-quality images of the screens and the users. Video signals are transmitted to a small bag carried by the test monitor, where they are mixed on the fly with a third-person view capturing the user's context. Ensuring high-quality sound, all users are wearing directional wireless microphones transmitting to an audio mixer in the test monitor's bag. Video and audio is recorded digitally on a 100GB mobile AV recorder.

At present time, we have conducted one full pilot study, causing minor modifications to the tasks and validating the reliability of the data collection equipment and the robustness of the prototype system. Findings from the planned study will be forthcoming.

6. CONCLUSIONS AND FURTHER WORK

This paper has addressed the challenge of facilitating sociality through mobile system design. On the basis of field studies of physical space and people socializing there, we have presented a mobile prototype system, Just-for-Us, which facilitates sociality by adapting not only to location but to the ensemble of physical and social context. The system exemplifies how "just-for-us" information and functionality can be tailored to the user's physical and social setting by indexing to information implicitly present in the user's surroundings, the user's existing knowledge and the user's current social setting.

Further work should investigate the use of the current prototype by identifying strengths and opportunities for improvements. Of special interest, we are exploring opportunities for allowing the users to contribute with their own content creating a rich layer of digital media overlaying the city. It would, for example, be interesting to create virtual entities of social groups and to blur the boundary between physical and virtual spaces by allowing for socializing by virtual proximity. On the technical side, we are developing a more flexible platform for extending the system to cover a much wider physical area, making the interface adaptable to even smaller mobile devices such as mobile phones, and extending the mobile, context-aware interface with omnipresent, traditional web-based access.

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