Digifieds: Insights into Deploying Digital Public Notice Areas in the Wild

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Figure 1. Deployment of Digifieds in Oulu: market square (left) and public library (right).

ABSTRACT

Traditional public notice areas (PNAs) are nowadays a popular means to publicly exchange information and reach people of a local community. The high usability led to a wide-spread use in stores, cafes, supermarkets, and public institutions. With public displays permeating public spaces and with display providers and owners being willing to share parts of their display space we envision traditional PNAs to be complemented or even replaced by their digital counterparts in the future, hence contributing to making public displays a novel communication medium. In this paper we report on the design and development of Digifieds (derived from digital classified), a digital public notice area. We deployed and evaluated Digifieds in an urban environment in the context of the UbiChallenge 2011 in Oulu, Finland over the course of 6 months. The deployment allowed the users' view to be studied with regard to the envisioned content, preferred interaction techniques, as well as privacy concerns, and to compare them against traditional PNAs.

Keywords

Digifieds, public displays, interaction, classifieds, urban computing

Categories and Subject Descriptors

H.4.3 [**Information System Applications**]. Communications Applications — Bulletin Boards

1. INTRODUCTION

In recent years, a significant decrease in prices for commercial display technologies can be observed, leading to ever more stores as well as public and semi-public spaces being equipped with public displays. Though first networks of public displays emerge, they are mainly operated by large outdoor advertisers (e.g., JC Decaux, Stroeer), or limited to a micro-environment, such as shopping malls or university campuses. However, with retailers owning and networking their displays, we envision these displays to be opened up

to running content from third parties being not only advertisers, but also customers, event organizers, or charities.

Traditional forms of shared public display spaces include public notice areas (PNAs) and can be found in various locations such as stores (containing mainly classified ads), restaurants and bars (events), university buildings (housing), or public institutions (announcements, events). With digital displays we envision public notice areas to be made more attractive to owners, content providers, as well as posters. (1) Digital content can be augmented with multimedia content and services, e.g., images, videos, or Google Maps. (2) Networking capabilities enable easy content distribution and remote collaboration. (3) Easy means can be provided for digitally taking away information (e.g., a phone number or address) by allowing classifieds to be sent to an email address or be transferred to the mobile phone. (4) Content management can be eased by removing stale content automatically. (5) Digital content can be searched and sorted in order to quickly find relevant or popular content.

In previous research, Alt. *et al.* [3] studied traditional PNAs with regard to values for stakeholders, content, and access control, and derived design implications for digital PNAs. Following these implications we designed and developed Digifieds (derived from digital classified), a digital public notice areas. In the context of the UbiChallenge 2011 [21] we deployed Digifieds in an urban environment in Finland. Observations, interviews, and a field trial allowed us to gain an in-depth understanding of the users' view. Our research focussed on the users' expectations with regard to content, suitable interaction techniques, and potential privacy concerns that arise when inputting (private) information in a public environment.

The contribution of this paper is twofold. Firstly, we report on the design, development, and deployment of Digifieds, providing a detailed description of the system architecture and components. Secondly, we report on the findings from our evaluation: (1) The preferred content is events, sales, and community-based information. (2) Both the mobile and the display client could be easily used - preferences depend on the user's situation and privacy concerns.

2. RELATED WORK

The development of digital public notice areas draws from research in different domians, most notably from networking public displays, content, privacy, and interaction techniques.

Many projects have explored technical requirements for networking digital displays across different locations such as offices [1][8] or in public spaces [19] [29]. Furthermore, several studies looked at current practices around public notice boards and displays. Churchill *et al.* studied the influence of introducing public displays into an office space [7] and published insights into the augmentation of the users' environments [9]. CoCollage is a community supporting social network application for public displays to promote the conversation and the community within a café [16]. Public display networks also support the development of communities [23] [24]. Taylor *et al.* [31] deployed a simple photo gallery in a central social point in a rural village to understand the community. He reported that the display can act as a meeting point for users with similar interests (see also [32]). Huang *et al.* [13] investigated various paper and digital displays and their actual placement, as well as how often people look at them. Based on their findings, they reported design recommendations for increasing the visibility of displays and how to better match people's behavior and the displays' content.

When using displays in a public setting, privacy might be compromised as users are required to provide personal information. On one hand, users are concerned about third parties abusing their data, on the other hand, users do not want people standing behind them to spy upon them. Whereas this seems to be only a minor issue in smaller communities [8], publicly available systems provide several solutions to minimize the impact on privacy. Alt *et al.* [2] use profiles that are not only calculated as a blend of the user's self-assessed interest and his interaction with the system, but tie them to a Bluetooth MAC address rather than to private user data. Furthermore, Shoemaker *et al.* [28] and Berger *et al.* [6] suggest to use an additional private display to show sensitive information.

Previous research has shown, that catering content to the user's interest is crucial for making public displays attractive. The main reason is that displays are being ignored if people do not expect to find anything interesting on them [18]. Many approaches tackle this issue by trying to automatically adopt content to the target audience. Groupcast [15] is an example of public displays that identify the audience via a wireless badge and tailors display content based on pre-stored profiles. Alt *et al.* [2] used Bluetooth to recognize the audiences in the vicinity of a public display and adopt the content based on dynamic profiles. ReflectiveSigns [17] is a digital signage system that automatically learns the audience's preferences for certain content in various contexts and presents them respectively. Furthermore, using a motion tracking system [33] or a camera-based approach [25] for detecting the audience has been explored.

When designing interactive public displays, suitable means for interaction are crucial. Researchers have focused on using mobile phones for interaction [27]. Several mobile phone interaction techniques have been proposed. While Ballagas *et al.* [4] used the mobile phone's camera to control a cursor on large displays, Sahami *et al.* [26] used the flashlight as a means for interaction. Transparent markers embedded on the display are used to allows any camera-enabled device to interact with the display [14]. Other means such as SMS, MMS, and speech have been investigated in [10] [11] [30]. NFC technology is also used to simulate button-based interaction behavior in the digital world [12]. Nawaz *et al.* explored eye gaze and head gestures as means for interaction with displays [20].

Findings from previous work emphasize the need of embedding existing routines into a novel system to support both usability and acceptance. People usually stop by to read posts or leave messages while they are on the go. The actual interaction is not the main task of a passer-by. Typically, posting or reading is combined or triggered by the user's primary task, e.g., shopping or waiting. Furthermore, information on a PNA proposes locality. Information is related to people visiting the area and shops, increasing the attraction for certain tasks. As an example, a PNA in a music store is more attractable to search for a guitar than in a computer store. Additionally, the user's preferences with regard to privacy have to be taken into account in order to make inputting private information in a public space acceptable, e.g., by providing additional input modalities. Finally, interaction with a digital PNA must be simple and quick. Several technologies and modalities have been explored but, so far, hardly considered the users' current situation. At the focus of this work we look into which content is suitable, how the user's privacy can be preserved, and which interaction techniques are suitable, drawing on findings from previous work.

3. LESSONS FROM TRADITIONAL PNAS

Previous work has investigated the use of traditional public notice areas and identified potential benefits of digital PNAs for the display providers, the content providers, and the viewers [3]. In the following section we briefly outline these benefits, which are important requirements for the development of a digital PNA.

3.1 Display Providers

For display providers – in most cases the owner of the location where the display is deployed – the motivation for having a shared public notice area includes customer satisfaction as well as the need for information dissemination. At the same time, the display providers struggle with the, often cumbersome, maintenance of their PNAs. Whereas many people place content, almost nobody removes outdated items, leading to the traditional PNAs getting polluted. As a solution, digital versions could have an expiration date hence allowing outdated content to be removed automatically.

In a similar manner, a remote management of content could be enabled. Often display owners have an agenda and content that does not match this agenda is being removed (e.g., in public institutions, churches, and bars). With digital PNAs, new content could be simply brought to the attention of the owner and means be provided to ban content from the display if it is considered to be inappropriate. Hence the owner can be given full control over the display and his willingness to share it can be increased.

Sometimes, offensive or sexual content can be found on PNAs. Identifying and removing them by the display provider is cumbersome as frequently monitoring the PNA would be required. With a digital version, an abuse function could be incorporated that allows inappropriate content to be reported by other viewers.

Nowadays, advertisements from the display provider can be found next to the shared public notice area, e.g., in the form of brochures and flyers. Here, digital PNAs could add value by augmenting posts with context-sensitive ads. For example, popular content nowadays includes housing – subsequently, relocation companies or also students could offer their help for moving - following a similar approach as Gmail or Facebook where content is being scanned for keywords and appropriate ads are being shown.

3.2 Content Providers

In parallel, we see the following benefits for the people providing content on PNAs. With means to augment a classified with images, videos, or GoogleMaps content can be made much more attractive and visible. Already on traditional PNAs some people dedicate a lot of time to create eye-catching content.

As information is being entered and made available in a public space, privacy may be a major hindrance to not use digital PNAs. On traditional PNAs there is no way of protecting a person's privacy as she leaves her email or phone number to be contacted. With a digital version, means for sending a message through the system can be provided without revealing personal information to the sender. Only as the content provider considers the offer to be appropriate she may personally get in contact with the person being interested and provide her contact information.

Finally, one drawback of traditional PNAs is that in order to reach many potential customers, content has to be placed in many locations. This process can be eased if posting remotely (e.g., from home or from a mobile phone) is provided. Furthermore, once an item is sold, the offer can be easily removed without forgetting any published classified and further requests can be avoided. In case any questions about the offer occur, posts can be modified to clarify important points.

3.3 Viewers

Often viewers have a very clear idea of what they are looking for when approaching a PNA (e.g., a 1-room flat for a student). Whereas PNAs with a lot of content make it very difficult to find matching classifieds, a search or sorting functionality can help to find content more quickly. Furthermore, an indicator for the popularity of a classified can be provided, e.g., a view count that indicates how many people have been interested in this item.

Whereas traditionally contact information has to be written down or small tear-aways have to be provided, digital PNAs could offer easy means to transfer not only the contact information but even the entire classified to the phone or send it to an email address. Hence, reviewing or comparing different offers later is easily possible.

Finally, viewers can benefit in the same way as the content providers by images or videos which potentially better describe the advertised item. GoogleMaps could make it easy to identify the location of the article and be used for finding the pick-up address.

4. THE USERS' VIEW

At the core of our research we were interested in the users' view on digital public notice areas, most notably the content, suitable interaction techniques, and privacy. In the following we outline the research questions we aimed at answering in this work.

4.1 Content

Traditional public notice areas are highly popular, even in the times of platforms such as eBay[1] and Craigslist[2], that offer similar services. We found that content on traditional PNAs has usually a strong local character. For services, such as babysitting or cleaning, that cannot easily be offered supra-regionally, and for offering items that are difficult to ship (e.g., a bed or a bike), public notice areas provide a good opportunity to find a local audience. Consequently, buyers can, e.g., easily pick up things by car. Furthermore, content informing about local events is especially interesting to the local community and tourists.

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[1]eBay website: http://www.ebay.com
[2]Craigslist website: http://www.craigslist.org
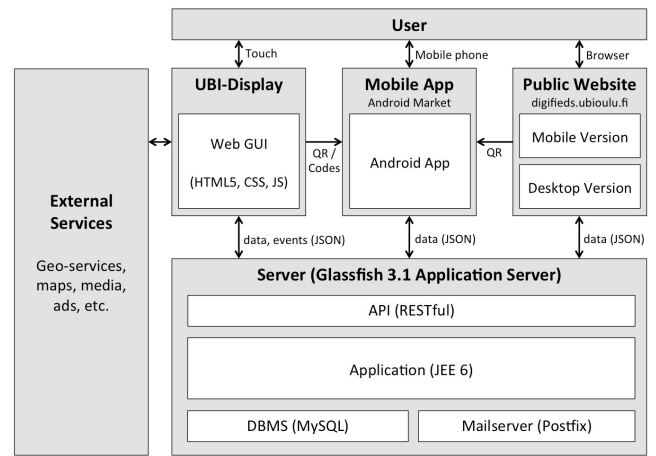
Figure 2. System Architecture: A Glassfish application server is used to store the data. The mobile client, the display client, and the website access the content via the RESTful API.

RQ 1: Which content do people post and take away with them from digital public notice areas?
To better understand which types of content should be supported by a digital PNA, we interviewed people and asked them to fill in a questionnaire on content they are interested in on traditional PNAs and on content they would expect on digital PNAs. Furthermore, we analyzed the content being posted during the evaluation period. Finally, we compared content on traditional PNAs from previous work with the content posted on Digifieds.

4.2 Interaction Techniques

The success of traditional PNAs lies in their high usability. Pen and paper allow content to be posted by everyone, also ad-hoc, and tear-aways as well as flyers available in multiple copies allows information to be taken with one simply and quickly. As a consequence, suitable interaction techniques that realize a similar functionality and are highly intuitive as well as easy to use need to be provided.

**RQ2: What are suitable interaction techniques?**
For the evaluation we implemented a display client and a mobile client. In a field trial we aimed at evaluating both clients with regard to usability and conducted semi-structured interviews in order to identify potential shortcomings and issues.

4.3 Privacy

Making private information available in public space (e.g., a phone number or email address) might prevent many potential content providers from using the PNA. Though there is some evidence from traditional PNAs that in anticipation of the envisioned benefit (e.g., selling the advertised item) it is ok for people to provide this information, taking into account users' privacy concerns might add to a further and quicker uptake of the system.

RQ 3: Which privacy issues arise while interacting with displays in public space?
In order to investigate privacy issues, we conducted the field trial in a public space, hence creating a realistic atmosphere. Afterwards, the users had to fill in a questionnaire in which we assessed privacy concerns with regard to traditional and digital PNAs and we conducted semi-structured interviews.
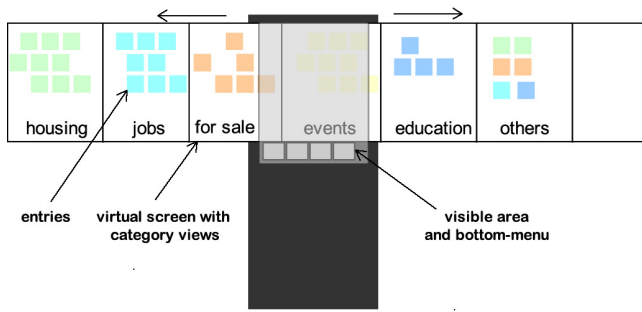
Figure 3. Conceptual layout of the display client: The display client provides different views that can be scrolled horizontally.

5. DIGIFIEDS

In order to tackle our research questions we developed a prototype of a digital public notice area, called *Digifieds*[3] – derived from digital classifieds. The Digifieds platform consists of four components (Figure 2): (1) a central server back-end for the data management, (2) a web-based display client for visualizing information and direct interaction, (3) a mobile phone client as an alternative interface for interaction with the display, and (4) a public web client. Additionally, a web-based administration interface for content and configuration management is being provided.

The prototype consists of a client-server infrastructure that allows arbitrary display clients to be connected. We also provide a mobile phone application that allows content to be created on-the-go and to be transferred it to the display. Similarly, content can also be transferred from the display to the mobile phone.

5.1 Digifieds Server

The Digifieds server is the central component of the system. It is responsible for the data management and storage and provides access for arbitrary clients (display, mobile phone, web) through a RESTful API. In order to provide a robust server application for the real-world deployment we opted for the Java Enterprise Edition 6 Framework (JEE6). The Glassfish 3.1 application server is used to ensure scalability (easy thread management and clustering) and trouble free updating of the running server application without compromising active sessions. A MySQL database is used for permanent data storage and can be accessed through a Java Persistency API (JPA) layer. Furthermore, caching is used to optimize database access and hence reduces CPU usage and overall access times.

Besides storing the content and layout information of each digified, we use the central database to manage information, configuration as well as available categories for each connected display client. For evaluation purposes, all API interactions can be logged. The lightweight JSON data format is used for transferring data between server and the connected display clients. An XML format, e.g., for use by external applications, can also be used by simply changing the corresponding HTTP request headers.

5.2 Digifieds Display Client

Our main goal when designing the GUI of the display client was to preserve the advantages of traditional paper-based PNAs while at the same time enhancing it with digital features, such as multimedia content (pictures, videos), interactive content (maps), popularity-

[3]Note, that in the remainder of this paper we use the term *Digifieds* to describe our platform, whereas *digified* describes a classified ad being posted on the platform.

Figure 4. Digifieds Display Client: The display client shows an overview of the different views on the left, the active view, containing the actual digifieds, on the right.

by-click count, sorting posts by various criteria (date, popularity), automated removal of outdated messages, search functionality, and novel take-away techniques (e.g., post to email or phone). For the display client's graphical layout we had to tackle three challenges. Firstly, it had to be recognizable as a PNA, not just as a digital display; secondly, content had to be presented in a well-arranged manner (even if containing a lot of content); thirdly, interaction had to be enabled in a very easy and intuitive way.

We adapted the layout of traditional PNAs, making content look like paper classifieds attached to a wall. In order to cope with scarce space, we decided not to display all content on one single screen but split the PNA into several views. The concept is depicted in Figure 3. Each view holds posts related to a certain category, e.g., "Housing", "Sales", etc. Using buttons on the left and right side of the display enables switching between these views horizontally. In case a single view is overloaded with entries, it can also be scrolled vertically. The dimension of the active view adjusts automatically to the screen resolution. The background layout of a PNA can also be customized for each category. Using different views for scaffolding does not only help solving the space issue but we envision easing the use of the board and making browsing more convenient.

Finally, if displays are touch-enabled the client provides an on-screen keyboard that allows users to create and send posts without using additional devices. Users can choose color and category of the digified from predefined values. Using the system does not require any registration or login process. Digifieds can also be taken away in three ways: (1) by sending them to an email address, (2) by scanning a QR-code with the phone, and (3) by storing a 5-character alphanumeric code which can be used on the public website or in the mobile phone app. A cart function allows multiple digifieds to be taken away easily at the same time.

The display client uses AJAX to create an interactive UI capable of attracting and enticing people through immediate feedback. HTML5 and CSS are used to layout the content. Using asynchronous HTTP requests, the display client periodically polls for data changes. If there is any new content, the corresponding GUI elements are being updated. Currently, a default update rate of 30 seconds is being used. However, since each display's configuration can be modified on the server, adjustment to arbitrary update rates as well as dynamic rates based on the data load can be easily realized. To minimize the data traffic, the internal browser cache is used for media documents (images, videos, HTML, CSS) and the browser's local storage API is used to save the digified's data in JSON format.

Figure 5. Digifieds Mobile Client: The mobile client allows to create and take away digifieds. Furthermore, it stores all digifieds that have been previously created or taken with one.

Figure 6. Taking away content: Users can send digifieds to their email address or transfer them to their mobile phone using either the QR code or the alphanumerical code.

5.3 Digifieds Mobile Phone Client

In order to allow content to be created on-the-go, we developed an Android application. The application is compatible with all Android phones running OS 1.5 and higher. With this client the user can create new digifieds, containing a title and content (text, images and/or videos), and define additional information such as the expiration date, address, or contact data. The digifieds are permanently stored for future use on the phone and in the central database.

To enable exchanging content between phone and display in a transparent and understandable way we implemented two techniques: (1) Alphanumeric code: once the user creates a new post on the phone, it is stored on the server and assigned an ID. Then, on the server, a 5-character alphanumeric code (e.g., 4XB6A) is generated from this ID and being displayed on the phone. This code can then be entered on the display (see Figure 6). Alike, entries on the screen can be transferred to the phone just by entering the alphanumeric code displayed next to each digified in the provided field on the display client (Figure 6). (2) QR code: for transferring digifieds from the display to the mobile phone we provide a QR code next to each classified. The QR code can either be used to open the classified in the mobile browser, or, if it is scanned with the mobile phone client, be kept on the phone.

The alphanumeric code and the QR code are used for two reasons. Firstly, they are needed to identify the display or display group (see section "Deployment") on which they are to be displayed. Secondly, to preserve the locality of the display, we wanted people to personally come to the display. Note, that technically remote posting on a display could easily be implemented.

Finally, the mobile client provides an interactive map with the locations of all digifieds-enabled public displays.

5.4 Digifieds Web Client

For people who do not own a smartphone or who prefer composing their digified on a PC at home or at work, we provide a public website[4]. This website serves two purposes. Firstly, it provides further information about the Digifieds platform, e.g., a tutorial about how to use it, information on where to find displays running Digifieds (interactive map), and a download link to the mobile app in the Android Market. Secondly, the website can be used, similar to the display and mobile client, for creating new digifieds or retrieving digifieds that have been found on one of the public displays. When creating a digified on the website, images and videos from the local PC can be embedded, and the PC keyboard as well as the computer monitor may be used to create sophisticated designs in a more flexible way. However, as with the mobile app, a created digified still has to be activated using the display client before becoming publicly visible. In order to retrieve one or many digifieds that have been found on a public display, a user only needs to enter the alphanumeric code. Subsequently, the original digified, including all images, videos, maps, and a form for contacting the owner, will be displayed on the website. If the user used the display client's cart function, multiple digifieds can be shown at once.

6. DEPLOYMENT

Our research has been conducted in Oulu, Finland. Oulu provides a city-wide network of 6 indoor and 6 outdoor displays [22], operated by the University of Oulu. The displays are deployed in public spaces, such as the library, the market square, the swimming hall, and the university. The display network was deployed in 2009, providing nowadays a unique environment that allows public displays to be studied without the novelty effect usually occurring when deploying new systems. As the displays have been around for more than 2 years, many citizens are familiar with the displays and frequently use them. This is reflected also by the fact that 73.3% of our participants stated to have used the displays before.

> "I used this application [Digifieds] for the first time, but I have been using the UBI displays a few times before". (Interviewee I13, technician)

Digifieds has been deployed as a finalist of UbiChallenge 2011 [21]. The Open Ubiquitous City Challenge (UbiChallenge) provides international researchers an opportunity to transfer their ideas from the lab into an urban environment. For the deployment, a team of 3 researchers integrated the system with the existing infrastructure and thoroughly tested it before the public release on 6th of July 2011. The application was available to the public until 31st of December 2011. To allow content to be posted on multiple displays but at the same time preserve the local character, we designed a concept called *display groups*. Each group consists of a number of displays with certain properties. Figure 7 depicts the concept. In this example displays are grouped based on location, e.g., all displays at the market square (Area A), all displays in the pedestrian area (Area B), and all displays at the sports center (Area C). However, the concept is not limited to location but displays can be grouped based on arbitrary criteria (e.g., in-/outdoor, size, orientation, etc.).

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[4] http://digifieds.ubioulu.fi/

Figure 7. Display Groups: To preserve the locality of content we created a concept called *display groups*. This concept allows displays to be group according to arbitrary criteria. In this example, displays are grouped based on location, e.g., market place (blue), pedestrian area (red), and sports center (yellow).

Figure 8. Observations at the Public Library: Two researchers observed people looking at or interacting with the display from a hidden location and took field notes.
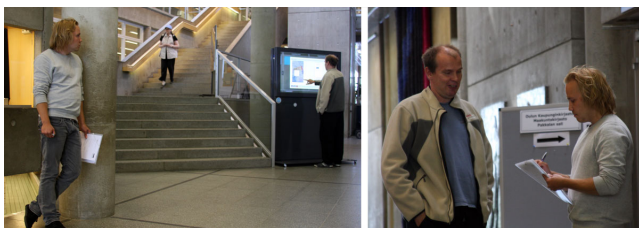

Figure 9. Interviews in the Public Library: The interviewer first observed people as they approached the display. Once they turned away he approached and asked them for an interview.

For the initial content, we collected content from traditional PNAs in the surroundings of the displays. We contacted the content providers and asked their permission to feed their content to the Digifieds platform. Furthermore, we asked the organizers of local events if they would be interested in advertising these events through our system. In this way we received a considerable number of initial items in the week prior to the official release. For the initial deployment all displays were assigned to the same group.

7. EVALUATION

While the Digifieds service was available to the public (July until December 2011) we performed a variety of evaluations, including
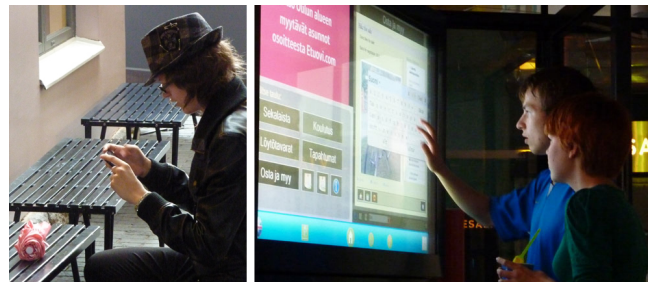
Figure 10. Field Trial: We asked people to create digifieds about different topics (e.g., *You found an umbrella and want to place it on the display.*, left) as well as to look for and take away digifieds by sending them via email or to the phone (right).

observations, interviews, and a field trial. The observation and interviews were conducted on 11th and 14th of July 2011. The field trial ran over two weeks from 1st until 12th of August 2011.

7.1 Observations and Interviews

We observed people for two reasons: firstly, we wanted to reveal usability issues; secondly we aimed at obtaining valuable feedback on situations in which people approached the display, on content they were interested in, and on how they used the system.

Observations were conducted around the displays in the public library and in the market place over the course of two days. Overall, 60 people were observed. For the observations, a researcher would hide in a location close to the display and take notes of the behavior of the user (see Figure 8). Additionally, gender and age was noted.

In parallel we conducted semi-structured interviews. The interviewer would first observe any person approaching the display, regardless of whether he interacted or not (see Figure 9). As soon as the person turned away from the display we asked whether the person would agree to an interview. For the interview we used two different interview guidelines – one for people who interacted and one for people who did not. Besides following the guidelines, the interviewer would respond on interesting statements of the interviewees. In total, 29 of out 60 people agreed to an interview (21 knew the display before). The interviews were audio recorded.

7.2 Field Trial

We conducted a field trial where people had to solve different tasks with the display and the mobile client. The trial was run in a public space (a university building) which helped us to create a realistic environment where people would be exposed to passers-by watching as they performed the field trial. Hence we were able to gather valuable feedback, especially with regard to privacy.

People were recruited from the street in front of a large department store and then sent to the university building. As they arrived they got a brief introduction to the study and were asked to sign a consent form. Then, we provided them the first part of a questionnaire where we asked them about their mobile phone usage (e.g., how often they used it, if it had a touch screen, if they used it to surf the web, and if they had installed third party apps) and whether they had used the UbiDisplays before. Then we asked about their use of traditional PNAs (how many they knew, how often they used them, which type of information they were usually looking for as well as taking away, and which information they are posting).

Afterwards, we asked them to test our display application. For posting content we gave them the task to place a digified about a mobile phone they had (virtually) found into the "Lost & Found" category (see Figure 10 right). After that we wanted them to look for a bike and send an according classified to their email address.
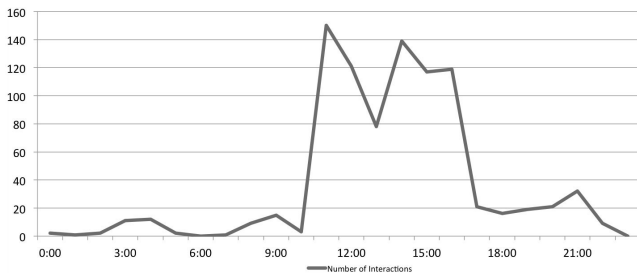
Figure 11. Distribution of Digifieds usage over the day: people mainly used Digifieds in the lunch break and in the after hours.

After finishing both tasks, they were asked to complete a standard SUS questionnaire (System Usability Scale) [5].

Next, we asked them to test the mobile application which we had preinstalled for them on a Samsung Galaxy mobile phone. Therefore they first had to create a digified about selling an umbrella we provided them (see Figure 10 left) and place it in the category "Sales". After that we wanted them to search for and take away two digifieds, every time using one of the two supported interaction techniques supported by Digifieds. First, they should take away the digified on the 'Beach Tennis Cup 2011' event using the QR code. Second, we asked them to transfer the 'Sky Diving Oulu' ad to the mobile phone by using the provided code. Then they again had to fill in a standard SUS questionnaire.

After finishing the tasks we asked them to fill in the last part of the questionnaire. Here we were first interested about which kind of information they would like to find or take away from Digifieds and which information they would post on Digifieds. Then we wanted to know what the users' opinion was on entering (private) data in public space, on the display client, and on the mobile phone. Finally, they were asked to rate the different features of Digifieds and provide qualitative feedback.

7.3 Log Files

Between 7th of July and 31st of August 2011, user interactions with the Digifieds platform were logged. We collected data about how often, when, and where Digifieds was launched. Furthermore, we logged which content users were interested in (based on for which content the detail view was opened). Finally, we analyzed the posted items with regard to content and layout.

8. FINDINGS

During the 2-month evaluation period we had a total of 1126 launches of the Digifieds application on the displays (avg. 125 per week). Figure 11 shows the distribution over the day. People used the application mainly during lunch break and in the afternoon, probably as they were shopping or on the way home from work. The analysis of the log file shows that 900 users looked at the content in more detail. In the following we provide in-depth findings with regard to content, privacy, and interaction techniques.
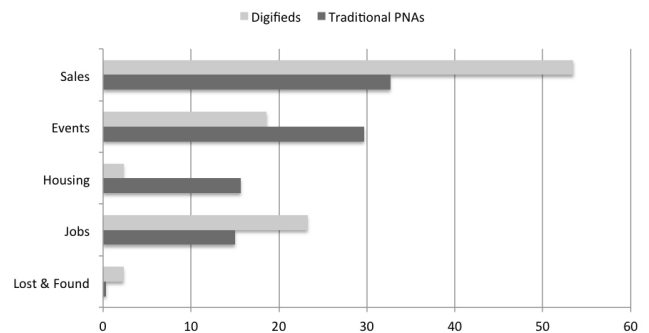
8.1 Content

Knowledge about the preferred content on PNAs provides useful hints with regard to which content should be presented where, when, and to whom (given that it is possible to detect the audience).

Firstly, we were interested in *comparing content on traditional and digital PNAs*. During the field trial we asked users in a questionnaire which type of information they were usually looking for and taking away from traditional PNAs. Figure 12 (dark bars) shows
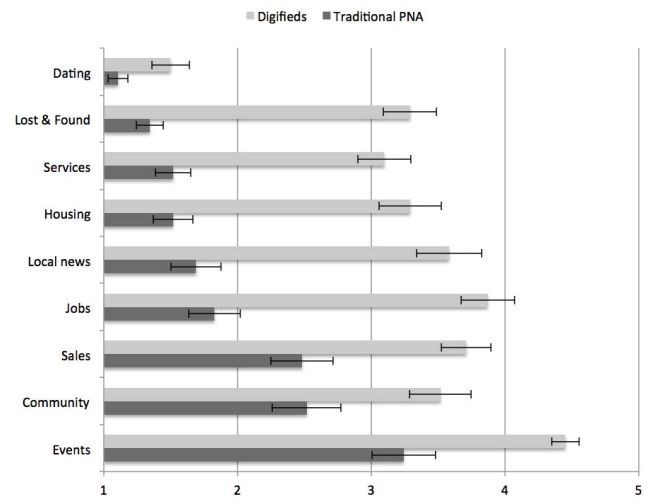
Figure 12. Preferred content on: Which information are you interested in on traditional / digital PNAs? (5-Point Likert scale, 1=not interested at all, 5=very interested)

Figure 13. Comparison of content between traditional PNAs (based on data from previous work) and Digifieds: Sales and Events were the most popular content. (in percent)

that most users are interested in events, community-related information and sales, or, in other words, content that is mostly locally relevant. When comparing these findings to digital PNAs we found that people seem to also expect mainly event-related information but also other locally relevant content, such as community-based information, sales, and local news. Also "Jobs", "Services" and the "Lost & Found" categories are promising (see Figure 12, light bars). Statements of the interviewees support these findings:

> "I was expecting to find information on events and news from neighboring areas (I10, speech therapist)".

> "I wanted to know what was going on in the city at the moment." (I13, technician)

Several tourists were looking both for events as well as for directions to the city's major sites (even though this functionality was not provided). Students often stated to be interested in housing, especially at the beginning of a new term.

Secondly, we were interested in the *content posted on Digifieds*. When we analyzed our log files we found that between 7th of July and 31st of August, 49 classifieds had been posted in 8 categories. "Sales" was the most popular category (23), followed by "Jobs" (10) and "Events" (8). Two posts with sexual content were removed. To
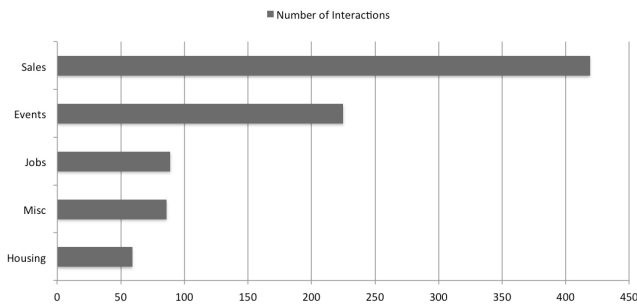
Figure 14. Viewer Interest: Viewers were interested in detailed information on sales and in events.

compare this to traditional PNAs, we analyzed photo logs from an ethnographic study [3] that included 22 traditional PNAs and 300 pieces of content. Figure 13 shows a comparison of the content. We found that in both cases, the PNAs contained mainly posts on sales as well as events and jobs. Housing was not as popular on Digifieds, which might be a result of the fact that the evaluation was conducted in the main holiday period. As Oulu is a student city, interest for housing may grow as soon as the new term starts.

Thirdly, we analyzed the log files for assessing the *viewers' interest*. To do so, we calculated for how many posts of the respective category, viewers opened the detailed view of the content, which we believe to be a good indicator for interest (see Figure 14). We found that "Sales" and "Events" were most popular.

Summarizing the findings, it can be seen that the envisioned content as well as the actually posted content correlates both for traditional as well as for digital PNAs. When looking at the absolute numbers, more content was posted in the category "Sales" than in the category "Events", which we think is due to the fact that there are simply less events taking place than items being offered. Nevertheless, events and local information is highly relevant.

Overall it seems, that the preferred content depends on two factors: the location of the display and the viewer. Both often have a relationship (e.g., a tourist is more likely to be found in the vicinity of a display in the city center than in the swimming hall, whereas displays on the university campus are likely to attract mainly students). In many cases, content providers as well as viewers share the same place (e.g., one student offering his apartment and another student being interested in it). Yet, in cases where this is different (e.g., if an event organizer wants to advertise a rock festival on the market square to students), means have to be provided to allow content to be distributed to the intended places. With our area concept we provide a mechanism which allows doing so based on location. Future versions could allow to distribute content not only based on location but also other types of context, such as income or population density. Also the time of day could be taken into account.

8.2 Privacy

In our interviews, several people expressed concerns that their privacy might be affected either if leaving personal information such as an email address on a publicly available display so that it could be found by everybody, or if people standing behind them watched as they entered this information.

> "I don't want that people notice me to get interacting with erotic show classifieds on the public display." (I14, IT worker)

> "A phone can be used in private, without outside disturbance." (I18, student)
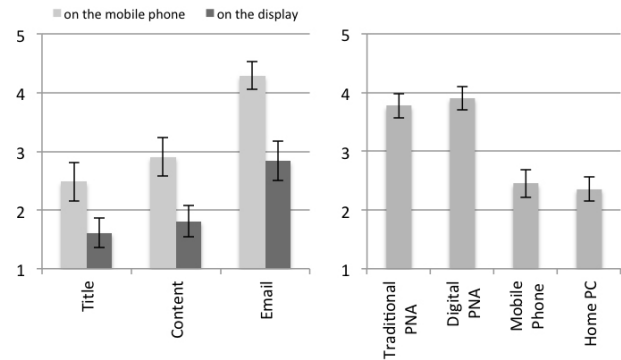
Figure 15. Privacy Concerns: (1) Privacy is being perceived as being strongly affected if inputting sensitive information on the display. Mobile phones can potentially overcome this issue (left). (2) Privacy concerns are similar for traditional and digital PNAs; phones and PCs are more privacy preserving.

Subsequently we aimed at further investigating this issue in the field study. In our questionnaire (31 participants) we tried to find out which information is subject to privacy concerns and how this relates to inputting information on traditional PNAs. Additionally we were interested in whether the mobile client is able to cope with these concerns.

Firstly, from analyzing the answers in the questionnaire we found that inputting personal information (e.g., an email address) is perceived as being more privacy affecting than inputting more general information such as the title or the content of a digified. This is true both for inputting information on the display (= in public space) and on the mobile phone (= privately) (see Figure 15). However, when we compared the perceived impact on privacy for email this was found to be significantly stronger on the public display than on the mobile phone (t=-5.82, df=30, p<.001).

Secondly, we were interested in whether there is a difference in the perceived impact on privacy when comparing traditional to digital PNAs. Here we found that there is no significant difference (t=1.2, df=30, n.s.). The impact on privacy compared to digital PNAs was perceived to be significantly smaller compared to the mobile phone (t=-6.69, df=30, p<.001) as well as to the PC (t=-6.83, df=30, p<.001).

Concluding, the findings indicate that the users' privacy concerns – with regard to both other people lurking as well as private information being publicly available – have to be taken into account as this is indeed being perceived as a major issue. Surprisingly, many people still use traditional PNAs where neither of these issues is being tackled. This contradiction might be explained by the fact that reports in the media about the abuse and the loss of lots of personal information (e.g., credit card data) lead to a change in mind. In the Digifieds platform we address both issues. Firstly, the mobile client provides an alternative to enter sensible data in private. Secondly, the email address is not shown on the display in plain text. We provide a form that allows viewers to get in contact with the content providers without revealing the email address. Only as the content provider answers, his email address is revealed to the viewer.

8.3 Interaction Techniques

In the field trial we had users compare both the display client and the mobile client with regard to usability. Some users reported that they considered the display client to sometimes be unresponsive (we believe that this was due to the capacitive display) whereas the phone client worked smoothly.
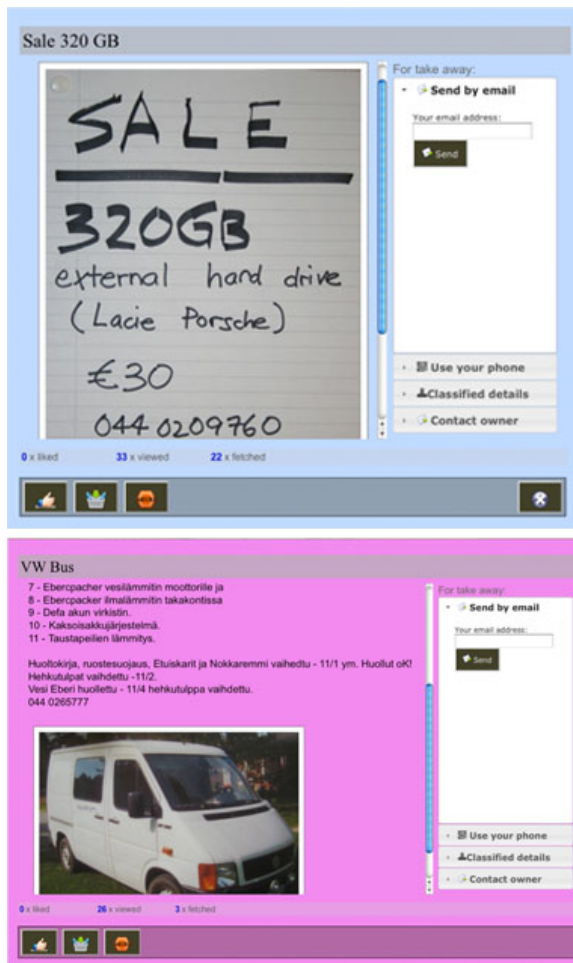
Figure 16. Content posted with Digifieds: (1) Scanned traditional classifieds (left) (2) Digified with images (right)

Users saw the strength of the mobile application in that it allowed to take pictures (this was not possible with the display client as there was no camera integrated), and in that it was possible to generate content on-the-go. Many of our trial participants were not familiar with QR codes. However, most were able to quickly figure out how this functionality worked and later stated that they quite liked the concept (e.g., P5, P16, P20, P22). Furthermore, they liked the opportunity to take multiple digifieds with them at the same time by means of the "Digifieds basket" feature.

In order to quantitatively assess the usability, the users had to fill in an SUS both for the mobile client as well as for the display client during the field trial. A Person correlation analysis revealed that people who rated the usability of the mobile client high, also rated the usability of the display client to be high (r=.375, df=29, p<.05), which is an indicator for that if people are familiar with either of the used technology they can easily adopt the other one. This is also supported by interviews where older people that did not use smart phones felt that the display was more suitable for younger people.

> "I think this is for young people – I should bring my grand children" (I25, pensioner)

With regard to practices we found that different approaches are being used to input information to the system. Whereas most people used the display client to type in text, others took a photo of

their handwritten page using the mobile application (Figure 16). This mostly happened if people had prepared a post with a sophisticated design (e.g., semi-professionally layout at the PC) or if they were in a hurry, having not enough time to type the text manually.

Similar to smart phones, public displays are being perceived as a "new technology". Interestingly, people who were familiar with smart phones had no problems at all to use the public display. In contrast, though many older people showed interest in the beginning, they stated in the interviews that they see the benefit more for the young generation. Consequently, one major challenge can be seen in finding ways to also entice the older generation and motivate them to adapt the new technology. Furthermore, we saw that providing multiple ways of publishing content (typing, taking a picture, etc.) is crucial to support both ad-hoc posters as well as semi-professional or even professional content providers.

9. DISCUSSION AND CONCLUSION

In this paper we presented Digifieds, a digital public notice area. We provided a detailed description of the design, implementation, and deployment in the context of the UbiChallenge 2011. Furthermore, we reported on observations, interviews, and a field study we conducted with the aim to better understand the users' view.

Our results show that, similar to traditional PNAs, both content providers and viewers envision locally relevant content, such as sales and events, but also community-related information to be found on the displays. The major issue were privacy concerns when providing personal information in public space – yet, incorporating mobile phones as personal devices can potentially overcome this. Finally, both provided interaction technologies – the display and the mobile phone – could be equally well used by our participants.

Though we investigated a rather specific application domain (public notice areas), our findings clearly show that people are indeed interested in public displays as communication medium. Once they discovered their interactivity as well as interesting content or functionality, they are coming back. With deployments such as Digified in Oulu, where people actively engage in providing content hence creating value on the display, we see a chance to overcome the display blindness in the future and make public displays an important part of urban spaces. Our findings show that the young generation is willing and able to use this "new" technology. For older people, we found that they show interest – many of our interviewees were pensioners that had a lot of time to explore the displays – but often refrain from using it because, on one hand they did not expect it to be interactive, on the other hand they probably were afraid of doing something wrong. Hence, good user interfaces that make using public displays easy and intuitive to use are essential to also attract this age group.

10. ACKNOWLEDGEMENTS

11. REFERENCES

[1] Agamanolis, S. Designing displays for human connectedness. In *Public and Situated Displays*, K. O'Hara, M. Perry, and S. Lewis, Eds. Kluwer, 2003.

[2] Alt, F., Balz, M., Kristes, S., Shirazi, A., Mennenoeh, J., Schmidt, A., Schroeder, H., and Goedicke, M. Adaptive user profiles in pervasive advertising environments. *Proc. of AmI '09* (2009), 276–286.

[3] Alt, F., Memarovic, N., Elhart, I., Bial, D., Schmidt, A., Langheinrich, M., Harboe, G., Huang, E., and Scipioni, M. P. Designing shared public display networks – implications from today's paper-based notice areas. In *Proc. of Pervasive 2011* (2011).

[4] Ballagas, R., Rohs, M., and Sheridan, J. G. Sweep and point and shoot: phonecam-based interactions for large public displays. In *CHI '05 EA*, ACM (2005).

[5] Bangor, A., Kortum, P., and Miller, J. An empirical evaluation of the system usability scale. *International Journal of Human-Computer Interaction 24*, 6 (2008), 574–594.

[6] Berger, S., Kjeldsen, R., Narayanaswami, C., Pinhanez, C., Podlaseck, M., and Raghunath, M. Using symbiotic displays to view sensitive information in public. In *Proc. of PerCom '05*, IEEE Computer Society (Washington, DC, USA, 2005), 139–148.

[7] Churchill, E. F., Nelson, L., and Denoue, L. Multimedia fliers: Information sharing with digital community bulletin boards. In *Communities and Technologies*, Kluwer (2003), 97–117.

[8] Churchill, E. F., Nelson, L., Denoue, L., and Girgensohn, A. *The Plasma Poster Network: Posting Multimedia Content in Public Places*. IOS Press, 2003, 599–606.

[9] Churchill, E. F., Nelson, L., Denoue, L., Helfman, J., and Murphy, P. Sharing multimedia content with interactive public displays: a case study. In *Proc. of DIS '04*, ACM (New York, NY, USA, 2004), 7–16.

[10] Davies, N., Friday, A., Newman, P., Rutlidge, S., and Storz, O. Using bluetooth device names to support interaction in smart environments. In *Proc. of MobiSys '09*, ACM (New York, NY, USA, 2009), 151–164.

[11] Erbad, A., Blackstock, M., Friday, A., Lea, R., and Al-Muhtadi, J. Magic broker: A middleware toolkit for interactive public displays. In *Proc. of PERCOM '08* (Washington, DC, USA, 2008), 509–514.

[12] Hardy, R., Rukzio, E., Wagner, M., and Paolucci, M. Exploring expressive nfc-based mobile phone interaction with large dynamic displays. In *Proc. of NFC '09*, IEEE (Washington, DC, US, 2009), 36–41.

[13] Huang, E., Koster, A., and Borchers, J. Overcoming assumptions and uncovering practices: When does the public really look at public displays? In *Proc. of Pervasive '08*. Springer Heidelberg, 2008, 228–243.

[14] Hyakutake, A., and Ozaki. 3-d interaction with a large wall display using transparent markers. In *Proc. of AVI '10* (2010), 97–100.

[15] McCarthy, J. F., Costa, T. J., and Liongosari, E. S. Unicast, outcast & groupcast: Three steps toward ubiquitous, peripheral displays. In *Proc. of UbiComp '01*, Springer (London, UK, 2001), 332–345.

[16] McCarthy, J. F., Farnham, S. D., Patel, Y., Ahuja, S., Norman, D., Hazlewood, W. R., and Lind, J. Supporting community in third places with situated social software. In *Proc. of C&T '09*, ACM (New York, NY, USA, 2009), 225–234.

[17] Mueller, J., Exeler, J., Buzeck, M., and Krueger, A. Reflectivesigns: Digital signs that adapt to audience attention. Springer (Heidelberg, 2009), 17–24.

[18] Mueller, J., Wilmsmann, D., Exeler, J., Buzeck, M., Schmidt, A., Jay, T., and Krueger, A. Display blindness: The effect of expectations on attention towards digital signage. In *Proc. of Pervasive '09*, Springer (Heidelberg, 2009), 1–8.

[19] Nakamura, M. A. Creating a new channel for campus communication. In *Proc. of SIGUCCS '04*, ACM (New York, NY, USA, 2004), 56–59.

[20] Nawaz, T., Mian, M., and Habib, H. Infotainment devices control by eye gaze and gesture recognition fusion. *Consumer Electronics, IEEE Transactions on 54*, 2 (2008), 277 –282.

[21] Ojala, T. Ubi challenge: Research coopetition on real-world urban computing. In *Proc. of MUM '11*, ACM (2011).

[22] Ojala, T., Kukka, H., Lindén, T., Heikkinen, T., Jurmu, M., Hosio, S., and Kruger, F. Ubi-hotspot 1.0: Large-scale long-term deployment of interactive public displays in a city center. In *ICIW 2010*, IEEE (2010), 285–294.

[23] Redhead, F., and Brereton, M. A qualitative analysis of local community communications. In *Proc. of OZCHI '06*, ACM (New York, NY, USA, 2006), 361–364.

[24] Redhead, F., and Brereton, M. Designing interaction for local communications: An urban screen study. In *Proc. of INTERACT '09*, Springer (Heidelberg, 2009), 457–460.

[25] Rehg, J., Loughlin, M., and Waters, K. Vision for a smart kiosk. In *cvpr*, Published by the IEEE Computer Society (1997), 690.

[26] Sahami, A., Winkler, C., and Schmidt, A. Flashlight interaction: A study on mobile phone interaction techniques with large displays. In *Adj. Proc. of MobileHCI 2009* (2009).

[27] Schmidt, D., Chehimi, F., Rukzio, E., and Gellersen, H. Phonetouch: a technique for direct phone interaction on surfaces. In *Proc. of UIST '10* (2010), 13–16.

[28] Shoemaker, G. B. D., and Inkpen, K. M. Single display privacyware: augmenting public displays with private information. In *Proceedings of CHI '01*, ACM (New York, NY, USA, 2001), 522–529.

[29] Storz, O., Friday, A., Davies, N., Finney, J., Sas, C., and Sheridan, J. Public ubiquitous computing systems: Lessons from the e-campus display deployments. *IEEE Pervasive Computing 05*, 3 (2006), 40–47.

[30] Tang, A., Finke, M., Blackstock, M., Leung, R., Deutscher, M., and Lea, R. Designing for bystanders: reflections on building a public digital forum. In *Proc. of CHI '08*, ACM (NY, USA, 2008), 879–882.

[31] Taylor, N., Cheverst, K., Fitton, D., Race, N. J. P., Rouncefield, M., and Graham, C. Probing communities: study of a village photo display. In *Proc. of OZCHI '07*, ACM (NY, USA, 2007), 17–24.

[32] Taylor, N., Cheverst, K., Satchell, C., Foth, M., and MacColl, I. *Proceedings of Public and Situated Displays to Support Communities (Workshop @OzChi 07)*. Cairns, Australia.

[33] Vogel, D., and Balakrishnan, R. Interactive public ambient displays: transitioning from implicit to explicit, public to personal, interaction with multiple users. In *Proc. of UIST '04*, ACM (2004), 137–146.