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Experiences of Supporting Local and Remote Mobile Phone Interaction in Situated Public Display Deployments

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ABSTRACT

Public displays and mobile phones are ubiquitous technologies that are already weaving themselves into the everyday life of urban citizens. The combination of the two enables new and novel possibilities, such as interaction with displays that are not physically accessible, extending screen real estate for mobile phones or transferring user content to and from public displays. However, current usability evaluations of prototype systems have explored only a small part of this design space, as usage of such systems is deeply embedded in and dependent on social and everyday context. In order to investigate issues surrounding appropriation and real use in social context field studies are necessary. In this paper we present our experiences with field deployments in a continuum between exploratory prototypes and technology probes. We present benefits and drawbacks of different evaluation methods, and provide a number of validated lessons from our deployments. [Article copies are available for purchase from InfoSci-on-Demand.com]

Keywords: Action Research; Case Study; Ethnography; Human/Computer Interaction; Mobile Technologies; Public Sphere; Socio-Technical Systems

INTRODUCTION

The use of mobile phones provides a range of new and novel opportunities for supporting interaction with public displays. Furthermore, such interaction can help overcome some of the problems associated with interactions with public
displays. An example is the potential inability of users to interact with a touch screen display because of its physical placement (e.g. inappropriate height for a wheelchair user). Mobile phones can also support multi-user interaction and act as a means of transferring content to a public display or display content to the user’s device. While these issues have been investigated in lab studies it is not clear how they will be appropriated in everyday life. In this article we discuss our explorations of some of these issues and present a number of lessons as a result. The lessons are based on our experiences with supporting both local and remote mobile phone interaction with a number of situated display deployments. Our research approach involves a tight cycle where theoretical issues and understanding, developed through reflection on empirical observations, are used to design deployed systems that test and explore theories. These deployed systems then create a new context for observation of user behaviour and thus lead to fresh insights, discoveries and refinement of theoretical understanding.

RELATED WORK

There is surprisingly little published work relating to the combination of mobile phones and situated public displays, and the vast majority of these systems have only been evaluated in the lab, if at all. ContentCascade (Himanshu, Gossweiler, & Milojicic, 2004) for example enables a user to download content from a public display onto her mobile phone using Bluetooth. The system was tested in a small and informal user study using movie clips. More recent work by Mauser, Marsden and Harper (2007) has investigated the potential for supporting mobile phone interaction with public displays in order to enable users to select and download content without requiring the user to keep their phone in a discoverable state. Their approach required the user to take a picture of the content screen that he/she wishes to download and then send this picture back to the public display server as a Bluetooth transfer, thus providing the server with the user’s phone’s Bluetooth MAC address. The server then performs image recognition to determine the content required by the user, which is then transferred via Bluetooth to the user’s phone. The system has only been evaluated informally. Ballagas, Rohs, Sheridan and Borchers (2005) present a survey of interaction techniques with mobile phones, most of which are used to generate input to a public display. The majority of systems they present have been evaluated only in lab studies. Rukzio, Boll, Leichtenstern and Schmidt (2007) present a comparison of different interaction techniques with mobile phones, which have been evaluated in the lab. Some systems use Bluetooth as a means to detect the presence of people rather than as a means to enable explicit interaction. Two examples of these systems are the BluScreen system (Payne, David,
Jennings, & Sharifi, 2006), which links advertisement displays, agents bidding for advertisement space and the detection of presence via Bluetooth, and CityWare (Kindberg & Jones, 2007), where urban activities of users were tracked with Bluetooth scanners.

The majority of systems built have been evaluated only in lab settings and not in field deployments. Therefore, there is little knowledge to date regarding appropriation into everyday life of systems that combine public displays and mobile phones. This general bias has also been identified generally in mobile HCI research (Kjeldskov & Graham, 2003). The focusing on usability issues only and ignoring appropriation has come under increasing critique (Greenberg & Buxton, 2008). Although the added value of field studies for finding usability flaws can be doubted (Kieldekov, Skov, Als, & Høegh, 2004), its unique applicability to study appropriation has been shown (Rogers et al., 2007). For the related field of Ambient Displays, Skog (2006) has shown that many interesting aspects can only be observed from longitudinal field studies. For public displays, Huang, Mynatt and Trimble (2007) have shown that the challenges of the real world lead to unexpected usage patterns that probably cannot be predicted from lab experiments.

**CASE STUDIES**

We now present six different field deployments in and around the cities and universities of Münster and Lancaster, which have allowed us to investigate appropriation from a number of different angles (see Table 1).

The systems presented first have been installed close to the researchers’ offices, which enabled continuous observation and easy access to the user groups, but constrained users to a university population. The latter systems have been installed in sites remote from the researchers’ offices, which enabled investigation of different user populations but also hindered continuous observation of the displays.

**Hermes and Hermes II**

Hermes (Cheverst, Dix, Fitton, Friday, & Rouncefield, 2003) and Hermes II (Fitton, 2006; Cheverst, Dix, Fitton, Graham, & Rouncefield, 2008) are electronic office doorplate systems that allow the owner of the office to display notices to visitors as well as visitors to leave messages for the owner. Users can remotely send an SMS for public display, as well as receive hand-drawn visitor messages via MMS. In order to enable wheelchair visitors to leave messages without installing a second lower display we are adding a feature that enables a visitor to leave a message on a door display using his/her mobile phone.
Table 1. Overview of deployments

<table>
<thead>
<tr>
<th>System</th>
<th>Installed From</th>
<th>Installed Until</th>
<th>Number Displays</th>
<th>Location</th>
<th>Functionality</th>
<th>Local Interaction</th>
<th>Remote Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hermes</td>
<td>March 2002</td>
<td>July 2004</td>
<td>13 displays</td>
<td>Office Doors of Lancaster University</td>
<td>Asynchronous Messaging</td>
<td>Touchscreen</td>
<td>SMS, MMS, Web, E-mail</td>
</tr>
<tr>
<td>Hermes II</td>
<td>May 2006</td>
<td>present</td>
<td>40 displays</td>
<td>Office Doors of Lancaster University</td>
<td>Asynchronous Messaging</td>
<td>Touchscreen</td>
<td>SMS, MMS, Web, E-mail</td>
</tr>
<tr>
<td>Hermes Photo Display</td>
<td>June 2003</td>
<td>June 2004</td>
<td>1 display</td>
<td>Hallway of Lancaster University</td>
<td>Sharing of Media</td>
<td>Touchscreen</td>
<td>MMS, E-mail</td>
</tr>
<tr>
<td>iDisplays</td>
<td>October 2005</td>
<td>present</td>
<td>12 displays</td>
<td>Hallways of Münster University</td>
<td>Textual Information Sharing</td>
<td>Mobile Phone (Java Application)</td>
<td>Web, E-mail</td>
</tr>
<tr>
<td>Wray Photo Display</td>
<td>August 2006</td>
<td>present</td>
<td>1 display</td>
<td>Post office in Wray Village near Lancaster</td>
<td>Sharing of Media</td>
<td>Touchscreen, Mobile Phone (Bluetooth)</td>
<td>Web, E-mail</td>
</tr>
<tr>
<td>MobiDiC</td>
<td>September 2007</td>
<td>present</td>
<td>20 displays</td>
<td>Streets in city centre of Münster</td>
<td>Retail Advertising/Discount Coupons, Navigation</td>
<td>Mobile Phone (Camera, Bluetooth, Java Application)</td>
<td>Web</td>
</tr>
</tbody>
</table>

The Hermes Photo Display

The Hermes Photo Display (Cheverst et al., 2005) enabled Hermes users (and more specifically the owners of Hermes displays) to send pictures to the display in a similar manner to sending pictures to their office door display (see Figure 1). Users could use MMS or e-mail in order to ‘post’ a picture and the subject header of the message was used to stipulate the location of the destination display, e.g. “PUBLIC LOCATION C FLOOR”. The initial system did not allow users to cycle through all the pictures received but would instead automatically select a sub-set of pictures to display.

iDisplays

The iDisplays system (Müller, Paczkowski, & Krüger, 2007) is a collection of public displays installed in the hallways of the University of Münster. Faculty can submit information items via a Web application and these items are shown on the displays alongside information like bus departures or weather forecast. We developed a Java application that users can install on their mobile.
phones. Using the application users can connect via Bluetooth to the displays to request an email with extended information on a news item, send an SMS containing a selected item to a friend, or store the information on the mobile phone’s calendar (see Figure 3).

The Wray Photo Display

The Hermes Photo Display was later repurposed and deployed in Wray (Figure 2), a small village near Lancaster, with the intention of investigating how a public display could support a rural community (Taylor et al., 2007). In early design sessions with our user group in the community (members of the village ‘Computer Club’ with varying levels of computing skills) we discussed deploying a photo display system, and also discussed the idea of supporting the uploading and downloading of pictures to and from the display using mobile phones, which was met with some enthusiasm. We initially intended that this would be the main method for handling display content.

MobiDiC

MobiDiC (Müller, Jentsch, Kray, & Krüger, 2008) is a public display advertising system. The displays show coupons (see Figure 3) that can be photographed by passersby using their mobile phone. To claim a discount at a shop, people can then present the photographs at a participating shop. Shopfinder is a small companion application supporting the coupon/advertising system. People can download it after having taken a photograph of a coupon in order to get guidance to the shop, which offers the coupon. They initiate the download by sending the coupon to the display via Bluetooth Object Push. The display system then generates a customized Java application and sends it back to the mobile phone. When users launch
the Shopfinder application, it shows a series of landmark pictures that help users finding their way to the shop.

**EVALUATION/DEVELOPMENT METHODOLOGY**

Our research approach involves a tight cycle where theoretical issues and understanding, developed through our reflection on empirical observations, are used to design deployed systems that test and explore the theories (see Figure 4). These deployed systems then create a new context for observation of user behaviour and thus lead to fresh insights, discoveries and refinement of theoretical understanding. The deployed systems take a role on a continuum between technology probes (Hutchinson et al., 2003; Graham et al., 2006) and traditional field prototypes (i.e. working prototypes evaluated in the field or in-situ) and support a single main functionality and use logging as a main method to generate data. Their goal is to identify long-term user needs as well as to study appropriation of the technology. We adopt an iterative and user centered design based approach to each deployment where the obser-
vation and involvement of users serve the dual purpose of traditional user centred design and source for further theoretical analysis. The challenges of carrying out such user centred design as part of a rapid prototyping development context is discussed in (Fitton et al., 2005). In order to achieve real use, the systems must meet real or emerging needs, and avoid interfering with the activities usually carried out at the location of their deployment, perhaps even taking advantage of these activities. In order to elicit the empirical data...
used as part of the reflective process we employ a variety of mostly ethno-
graphic techniques (Bernard, 2005) on a continuum from the informal to formal
and qualitative to quantitative. Induc-
tive analysis techniques like grounded
theory (Glaser & Strauss, 1967) are then
used to code the data, build categories,
sort them and build theory. A key aspect
of our approach is applying the tenets of
existing techniques (technology probes
and ethnographic methods) in order to
carry out evaluation during a ‘real world’
deployment at low cost and where tradi-
tional usability studies receives higher
priority later in the design phase. This
contrasts slightly with existing ambi-
etent display evaluation research where
often heuristic evaluation is carried out
with lab-based prototypes (for example
(Mankoff et al., 2003)).

BENEFITS AND DRAWBACKS
OF EVALUATION TECHNIQUES

To obtain data for analysis, we use a
variety of ethnographic methods. In this
section we compare our experiences
for different techniques for the specific
case of public display interaction with
mobile phones.

Observing Users

_Casual Observations_ proved a major
source of information especially for
the displays where we are often in the
vicinity. For example, in the iDisplays
deployment, it could easily be observed
that most people only have very short
glimpses between a half and two sec-
onds while they pass the display, without
stopping. However, the only available
data are field notes, and it can be hard to
investigate short interactions in detail.
To remedy this, we used _Video Analysis_
with cameras installed on top of three
displays in the iDisplays deployment.
Video capture was triggered by motion
detection to record user behaviour. On
one day, 378 situations where users
passed a display were analyzed. The
benefits of this technique were that
interactions for an entire day could be
observed in detail, allowing quantita-
tive comparison of different displays.
However, the cameras capture only a
very narrow field in front of the display,
and it is necessary to capture multiple
days of usage because many users be-
have unnaturally when first conscious
of the fact that their actions are being
recorded. To observe even longer peri-
ods of time, we used _Automated Face
Detection_ and logged the times faces
were found in front of displays. The
main benefit of this automatic technique
is that user behaviour can be compared
over longer periods of time. However,
only the view times are captured, and
interesting behaviour may go unnoticed.
An in-depth discussion of the challenges
associated with the use of video (and
other techniques such as usage logs) to
produce digital records of interaction in
ubiquitous computing environments is
presented in (Crabtree et al., 2006).
Asking Users

*Unstructured Interviews* gave the opportunity to gain further information from the user in-situ after interaction with the display had taken place. To find more detailed answers to specific questions, *Semi-structured Interviews* proved useful. For example it became obvious that most users only used very specific information from the iDisplays. The kind of information used, however, varied greatly for different users. For example, while one user only wished to view the clock another user was not aware of the clock and only viewed the bus departure times. However, because these interviews take place after the user has finished interacting, users are often not able to recall their own behaviour precisely. *Repertory Grid Interviews* proved useful to elicit the dimensions users use to think about a given topic in their own words. In one case, we asked users to compare different displays regarding whether they had used them with a navigation system that combines mobile phones and public displays (Müller et al., 2008). This resulted in an ordered list of dimensions that influence whether people look at the displays, for example whether the user can already see his goal, or whether he currently looks at the phone or the environment. This then helps in determining which research questions may be worth pursuing and which not. However, the interviews tend to be very focused on the categories and lack richness. We employed *Contextual Inquiry* to investigate users’ normal procedures when dealing with noticeboards (Müller et al., 2007). From this analysis, it was possible to identify different kinds of posters and displays people are interested in, as well as to identify opportunities for mobile devices to fit into their workflow. However, this kind of analysis is usually constrained to a few typical situations that users believe are important, and does not include in-situ observation. *Probe Packs* proved useful in the Wray deployment for identifying social spaces. A *Comments Book* in the Wray deployment generated over 60 feature requests, experience statements and suggestions.

Logging

*Interaction logging* was implemented in all our deployments and proved very useful in determining variations in long-term use of the systems. For the MobiDiC Shopfinder for example, the interaction logging showed that in seven weeks the Shopfinder was downloaded 130 times, with peak download times in the afternoon, and some downloads as late as 2am or early as 7am. The main benefit of interaction logging is that a lot of data is generated automatically. When the logs show some interesting patterns however, it is usually not possible to gather more information about the event.
CHALLENGES FOR FIELD STUDIES INVOLVING PUBLIC DISPLAYS AND MOBILE DEVICES

Moving field studies out of the lab and into the ‘real world’ bring rich and varied findings. However, unexpected challenges are often raised. The following section considers the user-centric challenges which resulted in some of our prototypes receiving relatively small levels of use. Next, the technical challenges that had to be addressed during our field studies are presented. Finally, the remaining pragmatic challenges which emerged from our field studies are discussed.

User-Centric Challenges

The initial challenge concerns the visibility of the system and whether it is high enough for users to notice it. While for example we installed the iDisplays in such a way that users had to walk towards them in hallways, for many MobiDiC Displays users had to turn their head. We tried to advertise the MobiDiC system by posting A4 posters on top of them and distributing 5000 flyers, but this had almost no effect in mitigating the lower visibility of these displays.

Another key challenge for field studies emerges when use of the prototype is not mandated (as was the case with all systems described here). In this case, use of the system relies entirely on the user’s own motivation and, unfortunately, some of our prototypes received low levels of use with respect to mobile phone interaction.

When considering initial use, the first challenge to overcome is the difficulty users have in perceiving the affordance(s) (Norman, 1999) of interaction associated with a public display (especially concerning supported interaction with a mobile phone). Currently, mobile phone interaction is an uncommon concept which the general public does not expect. We have attempted to overcome this problem by displaying instructions for interaction on the display (MobiDiC) or on a poster close to the display (Hermes Photo Display and Wray). Once users are aware that they can interact with a display using their mobile phone the second challenge is to mitigate any social issues which may discourage use (such as potential embarrassment (Brignull & Rogers, 2003)).

One finding from a questionnaire based study involving the Hermes Photo Display (Cheverst et al., 2005) was that a significant number of users made positive comments about being able to send pictures from their mobile phone from a distance that would effectively make their interaction socially invisible.

One potential ‘shortcut’ we hoped would overcome these first two issues was that of non-users observing existing users. Unfortunately we found that this was not successful, possibly because the number of existing users did not reach a ‘critical mass’ or interactions were too seldom and short to be readily observed. However, an enthusiastic user
‘champion’ existed in the Wray Photo Display deployment who proved effective in encouraging use from others.

The next challenge concerns the motivation of users to expend effort to interact with a display. Typically, in order for a user to interact they must perceive that they will receive some form of benefit (Grudin, 1988) immediately.

The fourth challenge concerns the user’s willingness and ability to engage with technology. Communicating instructions to a user with an unknown level of technical experience and unknown make and model of mobile device clearly presents a problem. This problem is compounded when the user may be unwilling or unable to follow seemingly simple instructions such as ‘turn on Bluetooth’. In a field study with MobiDiC, for example, five out of twelve users needed more than 10 seconds to activate Bluetooth on their mobile phone. Additionally many passersby wouldn’t take part in the study due to security and privacy reasons they were assuming.

Technical Challenges

In order to support remote interaction via mobile phones all of the systems described here utilized Bluetooth. This led to a variety of technical challenges. With multiple devices in range Bluetooth discovery is often an unreliable process and when numerous devices are found (sometimes without the textual ‘friendly’ name) users find it challenging to identify the desired device. We have found that multiple Bluetooth dongles can be used to increase the probability of discovering mobile phones (but discovery carried out on mobile phones remains problematic). Often multiple public displays are installed next to each other. In the MobiDiC deployment, we gave them descriptive Bluetooth names (e.g. MobiDiC-Domplatz-left), while for the Shopfinder it did not matter which display the coupon is sent to. Another key problem is that of installing applications on user’s mobile phones via Bluetooth (mitigated by supplying users which pre-configured phones). Once the problematic processes of Bluetooth discovery and device pairing being completed successfully, the application is sent to the user’s phone (typically a Java application packaged in a .jar file) and the user is left with the task of installing and running it (which is often very challenging unless the user is familiar with the process). Another key technical challenge is that of providing high levels of reliability. Often we found it difficult to detect whether a remote display had crashed and that failure may be localized, for example only preventing one aspect of the system (such as an interaction method) from working. For larger deployments (Hermes, iDisplays, MobiDiC) especially we addressed this problem by developing automated detection and notification of failures. One method that proved robust against failures was to take regular screenshots and compare them automatically, so e.g.
Windows error messages in front of the display content can be detected.

Pragmatic Challenges

A range of additional pragmatic challenges emerged from experience of our field trials, these included:

Difficulty of observing users – With many users, each interacting only for a small number of seconds, we found it difficult to explore why a user interacted with the system (e.g. for idle investigation or in order to carry out a task).

Difficulty to obtain users for evaluation – Results of user studies are often skewed by certain user groups (e.g. younger people typically being far more prepared to interact and more au fait with technology). It is often difficult to find non-users in an open community to explore their motives.

Difficulties for data logging – Collecting, storing and interpreting usage can be challenging in itself but it is also difficult to investigate the ‘trace’ of genuine users with the background noise of other users idly playing with the system.

Study setup problems – The investigators are faced with decisions such as whether participants should be provided with phones or use their own.

Difficulty in providing content – Our prototype systems require content of interest to potential users, without which adoption is only a remote possibility, and we found providing this content challenging.

COMBINING EVALUATION METHODS

The application of one single evaluation method alone often may highlight an interesting phenomenon, but usually does not provide enough information to understand different facets of the phenomenon. The application of multiple evaluation methods in multiple deployments enables us to observe phenomena from different angles, thereby providing a much richer and more validated image. In the following we discuss three exemplary observations and show how a range of deployments and methods helped uncover the different facets of these observations.

Reasons for Disuse

One finding consistent for all deployments is that mobile phone based interaction with the displays was much less than we expected. In the MobiDiC deployment for example, in the first 7 weeks of deployment the software was downloaded 130 times, and during the first four months 34 coupons were redeemed. The iDisplays interaction has been installed on the mobile phones of 10 users, but in six months was used only 20 times. The Wray Photo Display has logged between 300 and 500 image views a month, but only 4 successful Bluetooth downloads in total and no uploads. While all systems had been lab tested for usability flaws, the inherent social deployment environment and the constraints of everyday life meant
that the displays were used in very different ways than in the lab. This meant that other aspects became much more important than pure usability.

Users simply don’t see or ignore the displays – While about half of the people passing the iDisplays looked at them, almost nobody noticed the MobiDiC displays. Even when people made a telephone call in close proximity to the displays, their views seemed to systematically avoid the display straight in front of their face. When we asked people who had walked past a display, they mostly stated that they ignored public phones because they owned a mobile. When we interviewed people after making a call, they said that they had not seen the display because they were “not interested in technology”. For the Wray Photo Display, when interviewed many Wray residents claimed to have not seen the display, despite its location in the middle of the village’s only shop. Especially in the public where many things fight for the users’ attention, it seems to be difficult to make displays seen.

Users don’t like to stop at the displays – The video observation of the iDisplays allowed quantifying observations that people rarely stop: One display in the entrance was passed by 141 people, 29 looked at it, but only one stopped to look for 5 seconds. Another display in a sofa corner was passed by 114 persons, 47 looked at it, and six people stopped in front of the display. All persons who stopped did so for some other reason than to look at the displays, for instance to wait for someone (looking 45 seconds) or for making a phone call (looking 20 seconds). When asked, users said they have something important to do, and no time just to look at the display.

Users don’t expect interaction at the displays, especially because there is often no appropriate affordance that such interaction is possible – When we showed users the interaction, they were usually very surprised and didn’t expect that. For example, a user who was shown the MobiDiC display was exited: “Oh, I thought it was just advertising, but instead it is something useful for me!”

Users don’t prepare – If users have to prepare interaction is often impossible when needed. The Hermes SMS feature was only useful when users were not at the display, so it was necessary to plan the interaction in advance by storing the phone number of Hermes. With the Wray display, users simply didn’t carry their photos (that would be appropriate to upload) on their mobile phone, rendering Bluetooth interaction functionality useless.

Interaction does not fit into everyday life, and the benefit is too small – We found that only a very small number of users continued to use systems after the initial novelty of a new deployment waned. When users were questioned about this they often had simply forgotten that features existed or how to use them (a very common example was users forgetting the phone number required to ‘text’ a message to their display).
Additionally, many users felt that they didn’t have time to interact with systems (especially in the workplace scenarios of Hermes, Hermes II and iDisplays) and, perhaps most importantly, that they felt it was too much effort to interact with a system. In these cases, making relatively trivial changes to reduce the effort required to achieve a task, e.g. setting a message on a door display, resulted in significant increases in usage. It transpired that often users disabled Bluetooth on their mobile phones for power and security reasons. The process of taking out a phone, enabling Bluetooth and starting interaction takes at least one minute, and users commented that it was too much effort for the benefit. Even for the MobiDiC coupons, in interviews many people stated that they took the photo to try it, but then did not go to the shop because the benefit was too small. We would argue that the key reasons for lack of continued use are related to the cost/effort required for interaction being too high and the perceived benefit of interaction being too low. However, through the use of iteration and user-centred design techniques (such as those applied in Hermes) we did find it possible to lower the cost of use sufficiently to encourage adoption. In the Hermes system we also found it crucial for users to build up trust in the reliability of a system in order to encourage adoption, when users experienced failure when attempting to interact this proved especially damaging.

Mobile phone based interaction may be eschewed if the same function is available via simpler means. For example, for the Wray display, web upload was much more popular than Bluetooth, as was the iDisplays RSS feed than the mobile application.

Additionally, enjoyment seemed to be perceived as a higher benefit than monetary incentives. The value of accessing historical photographs on the Wray Photo Display was cited as valuable numerous times in user feedback. The MobiDiC Coupons were however often not perceived as a big benefit.

The number of uses does not translate directly to usefulness: The Hermes SMS feature was used very seldom, but interviews have shown that in the cases where it has been used it was perceived as very useful and unique.

The Importance of Appropriate and Timely Feedback

Users of the Hermes SMS feature who encountered reliability problems asked for greater feedback. With the Hermes Photo Display, photos uploaded via Bluetooth were queued for display and consequently users whose photos were not shown immediately became frustrated (Cheverst, et al., 2005). Similarly, users who posted content to the iDisplays often walked directly to the displays to check, although a screenshot was presented at the web interface.
The Importance of Social Context and Representation of Self

Interviews revealed that people were only concerned about items that contained photos of people, which they did not want to appear distorted. The theory of social encounters provides a possible explanation (Goffman, 1959): When people submit information, especially photos, to a public display, they put a representation of themselves (or someone else) on the public stage. In order to see how this representation will be interpreted within a social frame, people want to see the full context how this representation appears (e.g. if it is on a public display on a toilet).

Appropriation

We have also observed a continuum of interference from users which affected the displays’ primary function, ranging from adding their own features, through to sabotage and vandalism. Some users would switch off the iDisplays every evening, but not switch them on again in the morning. Interviews have shown that the users were concerned for power consumption. For a display near a table, users would switch off the display while taking lunch, because it emitted so much light and heat, but regularly switch it on again after lunch. When we installed cameras on top of the iDisplays, they would be regularly turned away to point at the ceiling or the wall by anonymous users. In the iDisplays deployment users were allowed to modify content and structure of the displays: Next to the table football, a ‘football league’ module was installed spontaneously where the current high score was kept. In the sofa corner, during the European football championship 2008, another user spontaneously converted the display to a TV that would show the games. In the MobiDiC deployment, some users would post their own stickers on top of the displays. In one case, the text of one coupon shown was scratched into the display glass with a key, thereby making it permanent. The Comments Book revealed that many users viewed the Wray display as a noticeboard, although it was not designed with this functionality in mind.

LESSONS

Our experiences show that mobile phone interaction with public displays enables simultaneous and synchronous interaction for one or more users, supports interaction by users who, given the positioning of the display, are physically unable to interact directly, and can serve as a useful tool for transferring user content, e.g. pictures, to a display and to transfer display content, e.g. text items, coupons, or guide programs, to the user’s mobile phone.

Our research method for deployment-based research proved useful in a number of different deployments. Some of our experiences with methods and challenges reflect experiences of
researchers in other subfields of ubiquitous computing (Carter, Mankoff, Klemmer, & Matthews, 2008). For example, the problems of sparse data and reaching a critical mass have been reported for other applications, too. However, our specific experiences with public displays and mobile phones show that for this field slightly different techniques should be used (e.g. automated face detection) and different challenges become more important (e.g. the visibility of the displays or Bluetooth on/off). Some of the exemplary observations we could make combining multiple evaluation methods and multiple deployments could also be made using a single method in multiple deployments (Huang, Koster, & Borchers, 2008). Combining multiple techniques, it is possible to gather more detailed results (e.g. exact display viewing statistics by camera observation) and more depth (e.g. people stating not to look at displays because they expect only advertising). Researchers pursuing such deployments should consider a number of lessons we provide (Figure 5).

1. **Manage User Expectations**

As the interviews indicate, user expectations seem to have played a strong role in the low uptake of interaction. Many users stated that they did not expect anything useful from the displays and therefore ignored them. **Suggestion:** It seems insufficient to provide high benefit and advertise the system. In order to make people look at the displays at all, a paradigm shift for users seems to be necessary so they expect something useful. A coherent system that is installed at multiple locations could help people learn what to expect from the displays.

2. **Provide a high benefit and unique functionality**

Because of technical problems, mobile phone interaction currently requires

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**Figure 5. Key areas influencing the relation between users and public displays**

![Figure 5](image-url)
quite some effort for the user. But even in the future, the necessity of taking the mobile phone out of one’s pocket maybe sufficient to prohibit spontaneous interaction with a public display. To warrant spontaneous use, the interaction should provide a high benefit. If the same functionality is provided via an additional channel, like the web, there is a danger that the mobile phone interaction will be eschewed in favour of the channel which requires less effort. **Suggestion:** Monetary benefit may not be best, as even a 10€ coupon was redeemed only by a few users. Until the technical hurdles of interaction become lower, rare interaction with high value, like a SMS notice of being late, may be the only option.

3. **Provide feedback that shows the whole context**

Consistently we observed that users became frustrated if content they submitted to the displays did not appear immediately. If they put a representation of themselves or others on a display, they are eager how it looks in context. **Suggestion:** It may be best for remote interaction to send a photo of the display including surroundings or at least a full screenshot as feedback.

4. **Install displays visibly, so users can stand comfortably in front of them**

Displays in areas where people merely pass by seem to attract much less interaction than in places where people wait. Care should be taken so that people can stand comfortably in front of the displays without disturbing others or blocking the way. However, even in waiting areas displays often seem to be overlooked entirely. **Suggestion:** Displays should be installed at locations where many people will look even without a display, preferably at eye height.

5. **Combine Observations, Interviews and Logging**

_Casual, video and automated observations_ proved useful to detect patterns in behaviour, and interviews to ask for the ‘why’. Logging revealed long-term trends and technology uptake. To obtain a full picture of appropriation and integration into everyday life, a combination of these methods is necessary. For example, logs for the MobiDiC coupons revealed that only very few coupons were redeemed. Further observations of users showed that people seem to actively ignore the displays, and interviews that they do so because they ‘are not interested in technology’ or ‘expect only advertisements’. **Suggestion:** To obtain a full picture of appropriation and integration into everyday life, a combination of these methods is highly useful.

6. **If possible, use multiple deployments**

Using just a single deployment runs the risk of mistaking problems with that
specific deployment for generalisable results and vice versa. **Suggestion:** Wherever possible, the combination of observations from multiple deployments can significantly strengthen observations. For example, the comparison of attention towards iDisplays and MobiDiC displays allowed us to find that in one case people know what is shown on the displays, while in the other case they ignore them because they ‘expect only advertisements’.

Applying these lessons, deployment based research promises the uncovering of further insights into the appropriation of public displays and mobile devices. Interesting directions for future research are the relationship and relative importance of social embarrassment and interference with co-present people, further investigations of the specific reasons why people do and don’t see and use public displays, and how appropriate feedback can be provided to reassure users of how their personal representation appears in public.

**REFERENCES**


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Jörg Müller is a PhD student at the University of Münster. His research interests include the design, adoption and evaluation of context adaptive digital signage, digital public displays that adapt to time, location, audience, etc. During his thesis research he deployed two digital signage systems, the MobiDiC system and, together with Paczkowski, the iDisplays system. He obtained a masters degree in computer science in 2005 from Saarland University with a thesis on car driver workload estimation (together with Daimler) and a bachelors degree from the same university in 2004 with a thesis on music visualization (together with Sony). Müller also founded the open source Mind Mapping program FreeMind.

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