

Human–Computer Interaction and Innovation in Handheld, Mobile and Wearable Technologies

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Chapter 6

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

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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.

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 Maunder, 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,

Table 1. Overview of deployments

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

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 focussing 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 (Kjeldskov, 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.

Figure 1. InfoLab visitor interacting with the Hermes Photo Display (March 2006) (left) and Hermes II Office Door Display (March 2007) (right)



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.

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. “PUBLICLOCATIONCFLOOR”. 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

Figure 2. The leader of the computer club 'playing' with the Bluetooth feature of the Wray photo display, and the screen for selecting a mobile phone to download to (March 2006)

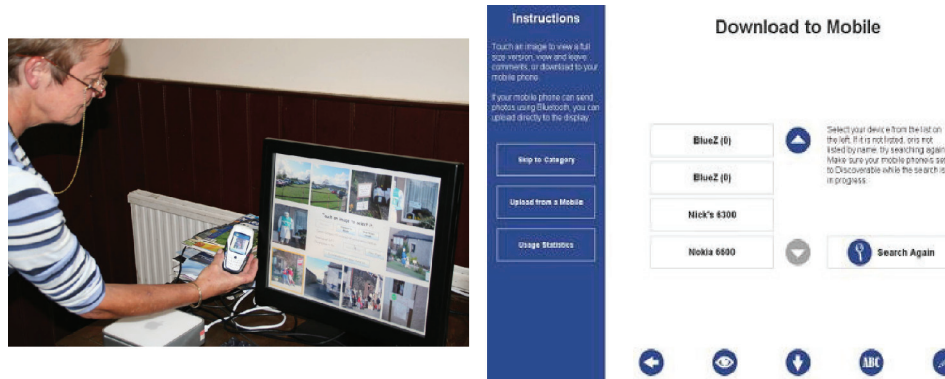
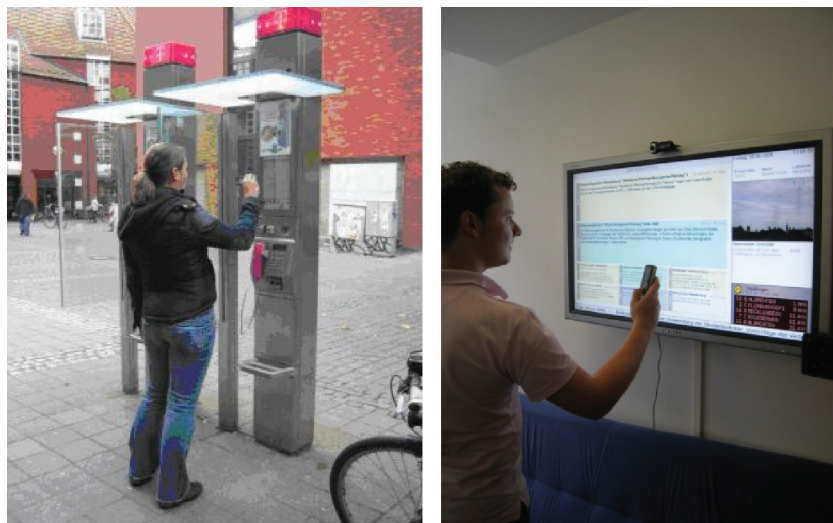


Figure 3. Taking a photo of the MobiDiC Coupon display, and user interacting with the iDisplays system



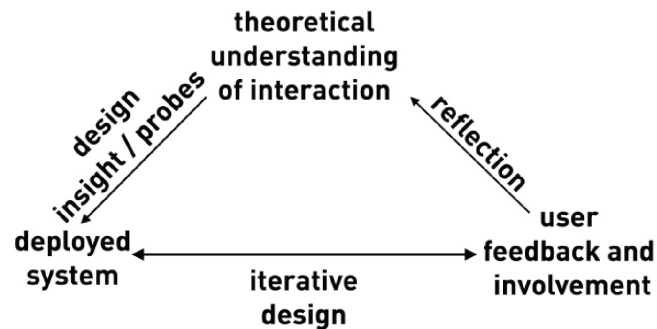
then present the photographs at a participating shop. Shopfinder is a small companion application supporting the coupon/advertising system. People can download it after having taken a photograph of a coupon in order to get guidance to the shop, which offers the coupon. They initiate the download by sending 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

Figure 4. Pattern of deployment based research



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 observation 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 ethnographic techniques (Bernard, 2005) on a continuum from the informal to formal and qualitative to quantitative. Inductive 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 traditional usability studies receives higher priority later in the design phase. This contrasts slightly with existing ambient 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 seconds 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 quantitative 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 behave unnaturally when first conscious of the fact that their actions are being recorded. To observe even longer periods 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 with 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 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.

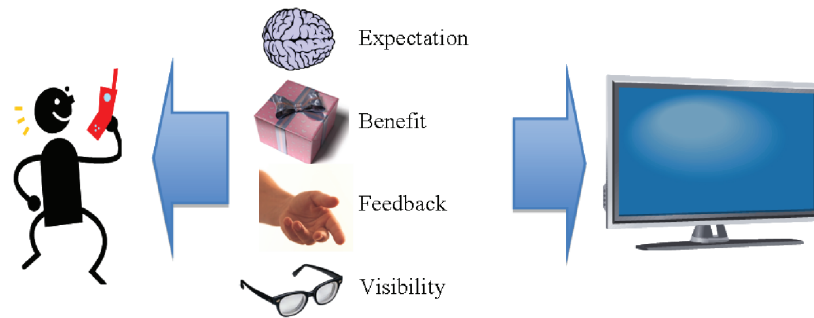
Lessons

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

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



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 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

- Ballagas, R., Rohs, M., Sheridan, J. G., & Borchers, J. (2006). The smart phone: A ubiquitous input device. *IEEE Pervasive Computing / IEEE Computer Society [and] IEEE Communications Society*, 5(1), 70–77. doi:10.1109/MPRV.2006.18
- Bernard, H. R. (2005). *Research Methods in Anthropology: Qualitative and Quantitative Approaches*. Walnut Creek: Rowman Altamira.
- Brignull, H., & Rogers, Y. (2003). Enticing people to interact with large public displays in public spaces. In [IOS Press.]. *Proceedings of INTERACT, 2003*, 17–24.
- Carter, S., Mankoff, J., Klemmer, S. R., & Matthews, T. (2008). Exiting the cleanroom: On ecological validity and ubiquitous computing. *Human-Computer Interaction*, 23(1), 47–99. doi:10.1080/07370020701851086
- Cheverst, K., & Dix, A. D. Fitton C. Graham, & M. Rouncefield (2008). Situatedness of awareness information: Impact on the design and usage of awareness systems. In P. Markopoulos & B. de Ruyter (Eds.), *Awareness Systems: Advances in theory, methodology and design*. Chapter 17, Springer.
- Cheverst, K., Dix, A., Fitton, D., Friday, A., & Rouncefield, M. (2003). Exploring the utility of remote messaging and situated office door displays. In [Springer.]. *Proceedings of MobileHCI, 2003*, 336–341.
- Cheverst, K., Dix, A., Fitton, D., Kray, C., Rouncefield, M., & Sas, C. (2005). Exploring Bluetooth based mobile phone interaction with the Hermes Photo Display. In [Springer.]. *Proceedings of MobileHCI, 2005*, 47–54. doi:10.1145/1085777.1085786
- Crabtree, A., French, A., Greenhalgh, C., Benford, S., Cheverst, K., & Fitton, D. (2006). Developing Digital Records: Early Experiences of Record and Replay. *Computer Supported Cooperative Work*, 15(4), 281–319. doi:10.1007/s10606-006-9026-z
- Fitton, D. (2006). *Exploring the design, deployment and use of Hermes: A system of situated digital interactive office door displays* (Doctoral dissertation, Lancaster University, 2006).

- Fitton, D., Cheverst, K., Kray, C., Dix, A., Rouncefield, M., & Saslis-Lagoudakis, G. (2005). Rapid prototyping and user-centered design of interactive display-based systems. *IEEE Pervasive Computing / IEEE Computer Society [and] IEEE Communications Society*, 4(4), 58–66. doi:10.1109/MPRV.2005.85
- Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. New Brunswick: Aldine Transaction.
- Goffman, E. (1959). *The presentation of self in everyday life*. New York: Anchor Books.
- Graham, C., Rouncefield, M., Cheverst, K., Gibbs, M., and Vetere, F. (2007) How Probes Work. In *Proceedings of OzCHI 2007* (pp. 29-37). ACM Press.
- Greenberg, S., & Buxton, B. (2008). Usability evaluation considered harmful (some of the time). In *Proceedings of CHI 2008* (pp. 111-120). ACM Press.
- Grudin, J. (1988). Why CSCW applications fail: problems in the design and evaluation of organization of organizational interfaces. In [Portland, Oregon, USA: ACM Press.]. *Proceedings of CSCW, 1988*, 85–93.
- Himanshu, R., Gossweiler, R., & Milojicic, D. (2004). ContentCascade incremental content exchange between public displays and personal devices. In [IEEE Computer Society.]. *Proceedings of MobiQuitous, 2004*, 374–381.
- Huang, E., Mynatt, E., & Trimble, J. (2007). When design just isn't enough: the unanticipated challenges of the real world for large collaborative displays. *Personal and Ubiquitous Computing*, 11(7), 537–547. doi:10.1007/s00779-006-0114-3
- Huang, E. M., Koster, A., & Borchers, J. (2008). Overcoming assumptions and uncovering practices: When does the public look at public displays? In [Springer.]. *Proceedings of Pervasive, 2008*, 228–243. doi:10.1007/978-3-540-79576-6_14
- Hutchinson, H., Mackay, W., Westerlund, B., Bederson, B. B., Druin, A., Plaisant, C., et al. (2003). Technology probes: Inspiring design for and with families. In *Proceedings of CHI 2003*, (pp. 17-24). ACM Press.
- Kindberg, T., & Jones, T. (2007). “Merolyn the Phone”: A study of Bluetooth naming practices. In [Springer.]. *Proceedings of Ubicomp, 2007*, 318–335.
- Kjeldskov, J., & Graham, C. (2003). A review of mobile HCI research methods. In [Springer.]. *Proceedings of Mobile HCI, 2003*, 317–335.
- Kjeldskov, J., Skov, M. B., Als, B. S., & Høegh, R. T. (2004). Is it worth the hassle? Exploring the added value of evaluating the usability of context-aware mobile systems in the field. [Springer.]. *Proceedings of MobileHCI, 2004*, 61–73.
- Mankoff, J., Dey, A. K., Hsieh, G., Kientz, J., Lederer, S., & Ames, M. (2003). Heuristic evaluation of ambient displays. In *Proceedings of CHI 2003*, (pp. 169-176), ACM Press.
- Maunder, A., Marsden, G., & Harper, R. (2007). Creating and sharing multi-media packages using large situated public displays and mobile phones. In [ACM Press.]. *Proceedings of Mobile HCI, 2007*, 222–225.
- Müller, J., Jentsch, M., Kray, C., & Krüger, A. (2008). Exploring factors that influence the combined use of mobile devices and public displays for pedestrian navigation. In *Proceedings of NordiCHI 2008*. ACM Press. doi:10.1145/1463160.1463194
- Müller, J., Paczkowski, O., & Krüger, A. (2007). Situated public news & reminder displays. In *Proceedings of AmI 2007*, (pp. 248-265), Springer.
- Norman, D. (1999). Affordances, convention, and design. *Interaction*, 6(3), 38–43.
- Payne, T., David, E., Jennings, N. R., & Sharifi, M. (2006). Auction mechanisms for efficient advertisement selection on public displays. In [IOS Press.]. *Proceedings of ECAI, 2006*, 285–298.

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Rogers, Y., Connelly, K., Tedesco, L., Hazlewood, W., Kurtz, A., & Hall, R. (2007). Why it's worth the hassle: The value of in-situ studies when designing ubicomp. In [Springer.]. *Proceedings of Ubicomp, 2007*, 336–353.

Rukzio, E., Boll, G., Leichtenstern, K., & Schmidt, A. (2007). Mobile interaction with the real world: An evaluation and comparison of physical mobile interaction techniques. In [Springer.]. *Proceedings of AmI, 2007*, 1–18.

Skog, T. (2006) *Ambient Information Visualization* (Licenciate Thesis, IT-university of Göteborg, 2006).

Taylor, N., Cheverst, K., Fitton, D., Race, N., Rouncefield, M., & Graham, C. (2007). Probing communities: Study of a village photo display. In [ACM Press.]. *Proceedings of OzCHI, 2007*, 17–24. doi:10.1145/1324892.1324896

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