

Context Sharing in a ‘Real World’ Ubicomp Deployment

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Abstract

While the application of ubicomp systems to explore context sharing has received a large amount of interest only a very small number of studies have been carried out which involve ‘real world’ use outside of the lab. This article presents an in-depth analysis of context sharing behaviours that built up around use of the Hermes and Hermes 2 interactive office door display systems received during deployment. The Hermes and Hermes 2 systems provided a groupware application supporting asynchronous messaging facilities, analogous to a digital form of Post-it notes, in order to explore the use of situated displays systems to support awareness and coordination in an office environment. From this analysis we distil a set of issues relating to context sharing ranging from privacy concerns to ease of use; each supported through qualitative user feedback and quantitative analysis of use.

1. Introduction

Context sharing is an established topic within ubiquitous computing research. However, context sharing is underexplored in real world longitudinal ubicomp deployments where behaviours have built up around new technologies integrated into everyday life. Many examples of ubicomp prototypes exist where the motivation has been to detect and automatically share new or previously unavailable types of context, such as a person’s current location [1] or even the state of their coffee cup [2]. However, Mark Weiser’s ideas for ubiquitous computing [3] were not simply a new direction for the application of contemporary and emerging technologies. Weiser first presented his vision of ubiquitous computing (ubicomp) in the early 1990’s when he outlined how this new computing paradigm raises new challenges for human computer interaction, as computers would now be “*interwoven in to the fabric of everyday life*”. Weiser’s vision included seamless integration of computing technology into an environment and more natural interactions with technology. Once the technology becomes a familiar part of everyday life it is then possible to empirically study its impact in detail. For ubicomp prototypes and their new functionalities to be interwoven

into the fabric of everyday life it is crucial for adoption and appropriation behaviours to take place. One way to enable this is through long-term deployments of prototypes. This article presents a qualitative analysis of the usage behaviours which emerged through the use of prototypical ubicomp systems (Hermes and Hermes 2 [4]) supporting context sharing deployed over extended periods.

Hermes and its successor Hermes 2 provide a groupware application to supporting context sharing through asynchronous messaging facilities. The aim of the work was to explore the use of situated displays systems to support awareness and coordination in an office environment. The system consisted of interactive digital door displays deployed outside office in the Computing Department at Lancaster University and available for use by the office occupant and any visitor to the office or passer-by. Occupants of offices equipped with Hermes displays (display owners) were able to manually share personal context in the form of short textual messages (e.g. “Gone for coffee” or “Running 15 minutes late”) or images. One particularly novel aspect of the work on Hermes was longitudinal deployment outside of the lab in order to allow integration of the system into existing daily routines. Evaluation of usage in Hermes, both quantitative and qualitative, enabled a range of issues relating to context sharing to be identified (detailed quantitative analysis of usage in Hermes can be found in [4]). While previous publications on the Hermes system have largely focussed on user-centred design or technical issues, here we focus on empirical analysis of themes around context sharing using qualitative data obtained from users of the system over a longitudinal period.

The remainder of this paper is structured as follows. Section 2 presents related work. Section 3 introduces and describes the Hermes and Hermes 2 systems, including a description of the design and deployment methodology, technical overview and evaluation techniques used. Section 4 provides an analysis of the usage of Hermes from two door display owners in detail. Section 5 distils a set of emerging issues from the usage of Hermes relating to context sharing. Section 6 provides a broader discussion of context sharing in the Hermes system. and the paper is concluded in Section 7.

2. Related Work

A range of display-based ubicomp prototypes exist with varying display size and functionality. However, for the majority of these systems the goal was exploration of technical feasibility and the system remained a ‘lab’ prototype with little or no documented use. This section discusses display-based prototypes of similar design or development approach to Hermes and Hermes 2.

The 'dynamic' door display project at Georgia Tech [5] appears similar to the Hermes system in terms of enabling awareness and providing messaging functions, additionally the hardware used and functionality provided is also similar to that used in Hermes. Unfortunately, it appears that work in this project ended before any significant deployment or reasonable evaluation of the system took place. The work on 'Smart Doorplates' [6] also appears similar to the Hermes system and utilising a similar door display hardware configuration. However, the main aims of the work on Smart Doorplates appear to be investigation of navigation and location awareness applications. This work seems to use a primarily technology driven development approach, focussing on 'proof of concept' demonstrators of the underlying architecture. The RoomWizard system [7] has been developed with a user-centred design approach, similar to this work. It appears that use was effectively mandated and the system became part of the daily routine of its users (evident from user interviews). The functionality of the RoomWizard system is simple, in common with the Hermes and Hermes 2 systems, and interestingly, O'Hara *et al* found that complex usage patterns built up around it. The TxtBoard system [8] was deployed for use outside of the lab for a relatively long period of time similar to this work. In order to analyse use, system logs and user feedback were used, this qualitative and quantitative investigation is also similar.

McCarthy *et al* investigated the use of deployed UniCast and OutCast displays [9] using both quantitative and qualitative analysis. Deployment of this system has included over fifteen UniCast displays and one each of the GroupCast and OutCast. Analysis of use of UniCast displays over several months has reported that the most used applications were the ability to view local web cams and retrieve the location of others. In [10] it appears that one aim of the Uni Board system was similar to that of this work, namely deploying a prototype and logging use for later analysis. However, they favour a technology led design approach and appear more interested in investigating interaction with displays from inside a web browser. Work at Carnegie Mellon University [11] makes some interesting points about the use of doors as 'interruption gateways' and a 'medium for communication'. However, while user-centred design techniques were used to develop prototypes, the focus appears to be the production of 'proof of concept' demonstrators rather than longer term deployment and evaluation. Research on the Family Message Board has demonstrated how the use of prototypes as technology probes can provide user-centred design in the 'field'. Browne *et al* [12] initially developed a simple prototype which they intended to deploy and use various methods (such as logging, interviews, comments, suggestions) to understand use, which is similar to this work.

3. Hermes and Hermes 2

Hermes and Hermes 2 were designed to support asynchronous messaging and have been used to investigate how such systems, allowing explicit sharing of information, can be used to help support awareness and coordination between staff, and between staff and students in the Computing Department at Lancaster University. Hermes was deployed for approximately 27 months and its successor Hermes 2 has been deployed and in use since late 2006. Ten Hermes displays were deployed and 40 Hermes 2 displays have been deployed. These systems were also used to explore the affordances of a digital approach over traditional paper-based messaging mechanisms used on office doors such as those shown in Figure 1 (these pictures were taken in the Computing Building at Lancaster).

The design of the Hermes 2 system was heavily based on the findings from the original Hermes system (at the time of writing evaluation of the Hermes 2 is ongoing). An office door is an interesting place to study interactions which typically fulfils many functions:

“Office doors are more than entrances to rooms, they are entrances to a person's time and attention. People can mediate access to themselves by choosing whether to leave their door open or closed when they are in their office. Doors also serve as a medium for communication, where people can broadcast individual messages to passersby, or accept messages from others who stopped by when the door was closed.” [13]

An office door can be categorized as a ‘semi-private’ place, containing both private elements (as it ‘belongs’ to the occupant of the office) and public elements (as it is part of the corridor and visible to all passers-by). This particular place has some interesting impacts on the sharing of awareness information by office occupants. For example, while an office occupant may find it necessary to display a message addressed to a specific person or group on his or her door, the author is unlikely to include personal or sensitive information (as any passer-by can read the message).

In order to explore this domain a technology driven approach has been combined with a user-centred design approach. In order to help support adoption, door display owners (the main group of users considered in this work) were involved in the design process to lower their barriers to use. The term ‘adoption’ is used to imply use of technology in ways intended by its designers and the term ‘appropriation’ implies “*unexpected or unanticipated uses of technology*” [14].

The Hermes and Hermes 2 door displays provided a groupware application enabling office occupants to display information using short textual messages and image files. The application also enabled a visitor to an office to leave messages for the occupant, authored in a manner similar to traditional paper Post-it notes. One aim of the Hermes system was to produce a prototype performing a small number of tasks well in order to provide an information appliance. In order to achieve this aim the design of functionality and user interfaces was intentionally simple and, for example, only allows a single message to be shown at any one time.

In order to analyse adoption issues, the Hermes systems have been deployed for 'real world' use. This allowed exploration of a number of pertinent ubiquitous computing issues, in the context of a situated display systems, from hardware to human factors. This paper is based on quantitative and qualitative findings primarily from the Hermes system. All usage of Hermes (and Hermes 2) was logged to enable quantitative analysis and to enable qualitative analysis several questionnaires and an in-depth post-deployment interview was carried out, in addition to continual informal discussion, feedback and suggestions for improvement being solicited from users of the system. All ten Hermes door display owners were involved in these studies and this included senior academics, lecturers, PhD students, and secretaries within the computing department at Lancaster.

3.1 Methodology

The development effort of the Hermes systems focussed primarily on owners of door displays. This was because supporting adoption and use by owners was central to exploring the aims of the work. A phased development approach was used where each phase started by 'rapidly' prototyping and deploying an entire instance of the system (starting from the previous code-base prior to the initial phase) including new features and required modifications. The user interface also incorporated subtle changes and improvements, in response to feedback from owners and with the addition of new features, during each of these phases. The Hermes systems effectively acted as functional prototypes and were developed in an evolutionary manner.

In order to combine a technology driven and user-centred design, with limited resources, an eclectic approach was taken. In more detail, continual informal feedback was sought from owners via discussion of potential features, demonstration of existing features, reports of problems, specific suggestions for improvement and general discussion about use of the system. This feedback helped to focus the design on the owners and include their ideas, comments and suggestions in the design process. Collection of feedback in

these ways was possible because of the proximity of the developers and door display owners, and allowed valuable feedback to be collected in a low cost manner. This informal qualitative feedback was used both to help evaluate existing features and generate new requirements. In addition to informal channels of qualitative feedback, formal methods such as a questionnaire and a semi-structured interview were also used to investigate specific issues such as owner's use and potential new features. These techniques were chosen to help understand adoption and use over the longer term with limited resources (rather than evaluate a specific user interface design where techniques such as 'think alouds' and observational methods would be more appropriate). Additionally, utilising informal feedback through discussion and techniques such as interview gave flexibility to explore interesting issues as they emerged.

An important part of generating feedback via the formal and informal methods described previously was the deployment of door display prototypes for use in the 'real world', allowing an owner to use a prototype as part of his or her daily routines. All use of the Hermes system was logged and, in conjunction with the simple unrestrictive functionality, allowed the door displays to act as a form of technology probe [15] to help inform the design. Not only did the deployment in this manner enable the collection of qualitative feedback but logging enabled use to be quantitatively analysed. This further enabled the understanding of use and exposed new requirements. The development approach helped allowing initial adoption and continued use by using feedback to inform the design of features to lower owners' barriers to use.

3.2 Hardware

The design of the hardware to support Hermes and Hermes 2 had to fulfil several key requirements, including compliance with university safety regulations, compliance with disabilities legislation, ease of deployment, development and management, and appropriate security. The fact that the door displays were to be situated in a public location and were required to run constantly meant the system had to comply with the Lancaster University's Health and Safety regulations. For the Hermes 2 system this means that specialised Power-over-Ethernet technology was required. Current UK disability legislation states that public facilities need to be positioned at a height that does not unduly discriminate against people using a wheelchair [16]. For this reason the door displays had to be situated at a relatively low height from the floor (approximately 150 cm). In order to support ease of deployment and development the chosen hardware solutions for Hermes was a PDA running Microsoft PocketPC. However, requirements for the Hermes 2 displays included a larger

screen, webcam and more processing power over the older system. Therefore in order to satisfy these requirements the approach taken was to include a small embedded PC board under the floor with associated housing above the floor containing touch screen monitor, webcam, microphone and speaker with cabling routed through a space in the door frame. Each Hermes 2 screen requires its own individual under-floor embedded PC board that boots a Linux operating system over a private network from a central server (in order to simplify management). Although access to the Computing Department is restricted during evenings and weekends, it was unrestricted at all other times (the display system was automatically shut down during these periods to save energy). For this reason the Hermes and Hermes 2 door display devices needed to be mounted in such a way that opportunistic theft of the device would be difficult. Additionally, access to buttons on the screen device had to be removed in order to prevent malicious tampering with the devices and to help move the prototype in the direction of an information appliance. The completed prototypes adhering to these requirements is shown in figure 2 (Hermes left, Hermes 2 right).

3.3 Software

At an early stage it was decided to use a Java based implementation for both the Hermes and Hermes 2 systems. This decision was made primarily due to the cross-platform nature of Java which would potentially enable the Hermes applications to run on a wide range of devices (not limited to the current hardware or software implementations). The overall architecture for the Hermes system is shown in Figure 3 where different colours are used to indicate the different communication protocols used. For more technical detail on the software design of Hermes and Hermes 2 see [4].

The primary feature of the Hermes systems is the ability to set a public message visible to all passers-by (analogous to a Post-it note) in order to share personal context. This facility is only available to occupant of an office equipped with a Hermes display (i.e. the display's 'owner'). The Hermes (and Hermes 2) system supported two types of messages, a 'default' message which was used to personalise the display (e.g. a favourite picture or cartoon selected by the display owner) and a 'temporary' message to share pertinent information with a range of temporal granularities (e.g. ranging from 'back in 5 minutes' and 'gone for coffee' to 'Away Thursday and Friday back Monday' and 'Away at MobileHCI'). A temporary message obscures a default message and was designed to be set and removed frequently. A default message was designed to provide a 'background' when no temporary message is set. A message could be textual or an image (or even a video clip in Hermes 2), an owner was allowed to set an image in order to support a higher

degree of expressivity than with plain text. A wide variety of local and remote interaction methods were provided to allow door display owners to share messages using their door display. As can be seen from Figure 3, remote interaction methods included SMS messages, MSN Messenger, e-mail and via a web portal (these methods are included in Hermes 2). Local interaction methods included selecting a short textual message from a predefined list and drawing a freehand message using the touch screen (again supported in Hermes 2). The predefined message list consisted of up to ten short textual messages that could be personalised by the owner, this feature allowed an owner to set a temporary message very quickly with two taps on the touch screen (the first to reveal a hidden menu containing the predefined messages and the second to select the desired message). These interaction methods were added in response to user feedback or in order to help owners adopt and appropriate the system fit in with existing working practises and daily routines.

4. Context Sharing in Hermes

While previous publications have considered categorisation of types of awareness in a sample of messages shared using Hermes [17], here we explore how users' behaviour changed as they integrated Hermes into their daily routines and utilised it for sharing personal context. The definition of context used in this work is "... any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves" [18]. The culture at Lancaster is based around meeting at offices, both formal (pre-arranged by all meeting participants) and informal (opportunistically visiting an office in the hope of a meeting). Hermes was used primarily to support this culture, for example, by a display owner sharing messages to explain she/he was not in their office during periods when a colleague may call to see them. The owners of Hermes door displays included actively collaborating academics and researchers in close physical proximity [19] and secretaries with responsibilities including ordering equipment and other administrative duties concerned with research projects. Visitors to offices included students (undergraduate, masters and PhD), administrative staff, researchers, lecturers, senior academics and external visitors. All of the ten Hermes door display owners participated in a post-deployment interview and this section analyses responses from two owners in detail. These owners were chosen as they were the highest users of the system and have very different levels of technical knowledge and job roles. During the final phases of deployment in Hermes (a period of approximately 5 months) user *A* set on average 4 messages per day while user *B* set an average of 6 messages a day while the overall average across all users was 2 per day in this period.

4.1 User A

This section analyses responses to the Hermes interview from owner A, who had a door display since the early Hermes deployment. In addition to duties as a senior lecturer, this technically knowledgeable owner was involved with several research projects in addition to being an MSc course admissions tutor and supervising a range of undergraduate and postgraduate students. This led to regular scheduled and unscheduled meetings with both students and staff. The owner regularly updated his door display when leaving his office (for example when going for lunch), and remotely using SMS as appropriate:

“I’ve definitely used it when I’ve had people coming to meet me here and I’ve been stuck, I was definitely stuck at the post office queuing once, I’ve been stuck on the bus, all sorts of places, and I’ve texted in and said I’m going to run late, and I’ve used that three or four times I guess”

The owner commented that colleagues would update his door display if he forgot to do so, an interesting (and unintentional) example of appropriation enabled by trading-off of security for ease of use:

“I use it to say out to lunch, and it’s quite interesting that the guys, if I don’t, as I always set it to out to lunch as I walk out the door, if I forget, they set it to out to lunch for me, which I think it quite nice”

This door display owner worked in the Computing Department from approximately 9am to 5pm most days including out of term time, though did spend much time working away. The Hermes system appeared to have been adopted as part of his daily routines, for example when talking about working from home he said:

“I would update Hermes to say I’m working from home – it’s part of my working routine”

This owner’s primary method for organising meetings was via e-mail for all types of visitors, with MSN messenger being used to a lesser extent (preferred by PhD students and researchers). He mentioned that the most successful method of organising a meeting with him was often to go directly to his office, but apart from his door display he didn’t use any other methods to indicate availability (such as leaving his office door ajar). He found that all types of visitors, including those external to the Computing Department, would notice and leave messages on his door display:

“.. and I’ve had visitors who have left me a message saying, you know, had to run and get a taxi, or left me a message on Hermes to say they’ve gone.”

This owner felt that Hermes lent itself to sharing relatively unspecific messages, owing to the ease of setting a temporary message from the predefined list on his door display. However, he would have liked to include more information when setting messages using this method, and often used e-mail or MSN Messenger to set messages that included more detail:

“I only set it to thing that weren’t very specific, like in a meeting, out to lunch, and back shortly. What I would have liked to have done is had a hierarchy of frequently used things I could say: in a meeting, and then it would come up, in innovations lab, in X’s office. I would have liked to have been more specific, so I actually used to set my message by e-mail and then more latterly by messenger a lot, because I wanted to give people more information.”

The owner strongly disagreed with the idea of having his location sensed and shared on his door display, he wanted control over what information was displayed and disliked the idea of his exact location being continually available. He was unsure about having his activity inferred from his location and displayed, but said he would try it. However, he stated that he would like a system which made accurate contextual suggestions when he went to change his message, but would want overall control:

“... so maybe it would have said: I’ve inferred that you’ve been sitting in this thing and your calendar says that you’re in a meeting, do you want me to set your doorplate to ‘I’m in a meeting’, yes or no. I think I would have liked that.”

This owner set temporary messages at his door display daily when leaving and entering his office. This was his most heavily used interaction method as it was both convenient for him and he found it easy to associate the physical interaction method with the action of leaving and entering his office:

“... it’s at hand, it’s something about your setting it on Hermes as well, so the changes you are making are associated with the physical thing right there, the direct interaction metaphor.”

He also made much use of e-mail (between weekly and daily) to set messages from both at home and in the department. The door display owner began to use MSN Messenger as an alternative to e-mail, but he found that this method was less reliable than e-mail when initially introduced. He made use of the SMS integration feature approximately on a monthly basis.

The web portal was this owner’s least favourite (and least used) interaction method, only being used to delete messages left by visitors and configure his preferences as necessary. The owner described the

facility of remote interaction as his favourite feature of Hermes, it being something he did not have previously. When asked about his least favourite feature of Hermes, he described that because all messages were set via a server if there was a problem with the server or connectivity to it he could not set a message on his door display. He found this frustrating, as even though his door display was functioning correctly, he could not always set a message:

“...it doesn’t work in disconnected mode, so that when the network is down, which is frequently outside of your control, it would just hang basically, because it would be trying to set the status on the server, and really I didn’t care about the server I wanted to change the message then, and if that change took a long time to propagate back to the server then that’s fine, I didn’t care, I just want it to change the status on the doorplate there and then, and let the system worry about the reliability problems, and so I think that my least favourite feature has to be the dependence on the network.”

This owner said that he usually set a message on his door display between five and ten times a day (which was consistent with the usage logs), occasionally forgetting to set a message when leaving his office. He set messages in order to help make others aware of what he was doing and how to find him:

“I guess it’s public spirited, it’s trying to help people to be aware of what I’m doing and being able to find me more easily, or work out whether I’m available, or when I’ll be back or something.”

When asked if he checked to see if messages he had set appeared, he admitted to “often” checking on both messages set from his predefined list at the door display and set using e-mail. The owner went on to explain that there had been periods where the system had been working flawlessly and he came to trust it completely, however, it only took a few failures to begin undermining that trust:

“...there were definitely long periods where it was so reliable you wouldn’t have even questioned it. I had a couple of failures with the SMS gateway, where I set the message with my phone and it just never appeared, and that really undermined my confidence...”

He said he found the confirmation given when setting a message via MSN Messenger reassuring and, after experiencing very few failures using this method, rarely checked to see if messages set using this method appeared. When asked what it would take for the owner to completely trust the system he responded:

“If every time you set it it appeared then you’d just get to trust it wouldn’t you.”

He then went to talk about two changes that would help improve his trust, re-designing the client and server to be independently stateful with synchronisation (to solve the problem he described previously) and providing some sort of additional information about synchronisation (i.e. when a message set at the server had propagated to the server). As the owner was very technically savvy, it seemed very important for him to know not just if the system was not working but also why it was not working, having a mental model where he could identify where problems occurred seem to increase his trust:

“...I mean it’s helping you answer that question if something has gone wrong where it’s gone wrong as well, so if you know you’ve told the server then you know that the system knows and it’s just a matter of time...”

When asked about reliability, this owner described how occasionally there were problems with individual interaction methods, which would effectively prevent him from using Hermes:

“...the SMS stuff I couldn’t get to work, then the e-mail stuff failed, we had all the stuff about whether the message was in the subject line or in the body, and it stopped seeming to be able to parse my e-mails, those are my two primary ways of setting the door display. And both of them had gone, and I was like grrr! You know this is slowly becoming unusable...”

Typically, this owner noticed that Hermes was not functioning correctly when he attempted to set a message at his door display and the user interface would hang or the message set would not appear. The fact that he was often able to deduce why the failure was occurring enabled him to come up with such technical suggestions for improvements to improve trust, as described previously. When asked if he was aware of the factors that affected reliability, this owner correctly identified all the causes of failure. He also recognised the difficulty in providing a prototypical system such as this to run continually.

When talking about his overall impression of reliability, this owner’s comments seemed to conflict slightly with earlier statements, saying:

“..and on the whole it was very very resilient.”

He also strongly disagreed that failure affected his future use:

“...I carried on using if through all the problems, I strongly disagree with that. That’s mainly because it worked really really well at the start, if it had never worked well at the start, maybe I wouldn’t have become such a strong advocate of the system.”

This response highlighted the crucial importance of the initial trust formation phase [20] in the staged development and maintenance of trust process [21].

This owner's technical knowledge of the system affected the way he coped with failure, for example, if he thought there was a problem with the wireless network connection or a temporary software fault, he would regularly 'test' the system to see if the problem had been solved, a last resort being to e-mail the system administrator. If he perceived the problem to be major, such as hardware failure, he would e-mail the system administrator immediately.

In addition to previous comments on usability, when asked if the introduction of the ability to set a message at a door display from a predefined list had increased his use the owner strongly agreed, but reiterated that he would have liked to include more information. However, he did agree that the trade-off of level of detail for ease of use was acceptable, and disagreed that the security and ease of use trade-off was unacceptable.

This owner was clearly an advocate of the Hermes system and was not only keen to use Hermes, but found it useful as part of his working routines. His technical knowledge enabled him to deduce the likely causes of failure and develop appropriate coping strategies. This also enabled him to make very specific suggestions for improvement and to use this knowledge to evaluate proposed new features.

4.2 Owner B

This section analyses responses to the Hermes interview from owner *B*, who has had a door display for a slightly shorter period than *A*. She is classified as a semi-technical owner, having limited experience in some areas of computing.

This Hermes door display owner was a research secretary, responsible for finance, ordering of equipment and invoicing for approximately 50 research projects. She had all types of members of staff (from PhD students to the HoD) visiting her office on a regular basis, often these visits are important and involve making arrangements including a time constraint, for example arranging travel at the 'last minute'. This owner used Hermes almost every time she left her office and when she would be away for longer periods, primarily to let visitors know when she would be back.

This owner works part-time, with set hours, but regularly starts earlier and finishes earlier than the usual 9am-5pm, she mentioned that others were not usually aware of her hours of work. People called at her

office to see if she was free to discuss something immediately, when asked about how others arranged meeting with her, she replied:

“I’m not the type of person you make an appointment to see - my door is open all the time and everyone just turns up...”

Aside from arranging travel, ordering equipment was another of this person’s main duties, typically a person would e-mail her with a list of items to be ordered, and receive and e-mail back when the order had arrived, they would then call at her office to collect it.

She propped her office door open when in her office (unless she was taking a lunch break) and prior to using the Hermes system, she used to set a paper message ‘whirler’ to indicate why she was not in her office from a list of predefined messages. When asked if she found it more acceptable to display information about an activity than location, this owner strongly agreed, and expressed concerns about people coming to see her when at lunch outside of the department, stating:

“...people only need to know that I am not available in my office, not necessarily where I am.”

This owner regularly set messages from her predefined list of temporary messages at her door display when leaving her office, this was her favourite method of interaction which she found very quick and easy:

“As I’m pulling my door closed I’m tapping my screen to say....”

She occasionally used the web interface or MSN Messenger to set messages when away from her office or when needing to set a message not catered for by her predefined list, stating that she used the web portal less when MSN Messenger was introduced, and that it provided a backup if the MSN Messenger integration was not working.

This owner stated that she set a message on her door display more than ten times a day (which from quantitative analysis proves accurate), aiming to use it every time she left her office. She explained that this was because people didn’t make appointments and simply went to her office, so it was important that people knew where she was. When asked about how often she checked to see if messages set had appeared she said she always checked to see if messages set using the door display and web portal appeared, but rarely checked when using MSN Messenger: however, she did wait for the confirmation message sent back through MSN Messenger.

When asked how often Hermes was not working, she said approximately monthly, but that there were “*months on end*” where the system did work, punctuated by weeks with lots of problems. This owner had a coping strategy for dealing with failure, realising that if the Hermes server was not ‘signed in’ on MSN Messenger there might be a problem, but the whole system might not necessarily have failed. She would then attempt to set a message using her door display, if this failed she would then attempt to reset her door display. If this did not fix the problem she would contact the system administrator.

This owner strongly agreed that the ability to set a message at a door display from a predefined list had increased her use as it was simpler and faster compared to the previous methods. When asked if she found she did not include enough detail in messages set from her predefined method, this owner strongly disagreed, because her messages were “*well chosen*”:

“...for example, if someone knew I was at the photocopier they would know where I was and be able to estimate how long I might be.”

This is an interesting example of appropriation as for this owner the Hermes system was effectively acting as an electronic ‘message whirler’.

When asked if the door displays provided enough expressivity, she said she was not sure, stating that she sometimes had difficulty fitting all important points in a small space, but reasoning that it was “*only a note*”. This owner strongly agreed when asked if she found malicious or accidental changing of her messages a problem, describing how she thought that her own temporary message was sometimes accidentally removed when visitors left a note, and that this was a problem when she set messages valid for long periods (e.g. “On holiday till X”).

The Hermes system appeared ideal for this door display owner, providing a digital equivalent to the paper message ‘whirler’ she used previously. She used her door display on a very regular basis, the functionality allowing messages to be set quickly and easily from a predefined list fitting very easily into her existing daily routines.

5. Emerging Issues

This section presents a set of pertinent issues related to context sharing distilled from qualitative analysis of feedback (questionnaires and interview) from all Hermes door display owners. Where users *A* and *B* are discussed this is mentioned explicitly.

5.1 Privacy

The majority of owners (60%) stated that they found it more acceptable to share information about their activities rather than, for example, their location. One owner specifically described how this was to protect his privacy but was also interested in sharing different granularities of information under different circumstances:

“...you don’t want them tracking you down while you’re down at X or gone for lunch. Whereas if it was someone who had some urgent problem that they wanted sorted out then you might be a little less upset if they turned up at X saying ‘I’ve got this immediate emergency, can you help?’.”

However, for Hermes users it appears their primary privacy concern is to ‘protect’ certain periods of time from work-related interruptions (lunch breaks etc).

5.2 Access

Although owners were prepared to share personal context they invariably wish to have some control over who has access to the context, and when and where the context can be accessed. One owner clearly identified how control over access to their Hermes display afforded by its physical placement had important privacy implications:

“There is a difference between a ‘local’ person looking at my Hermes display and a ‘remote’ person. Issue is – how is information being used? Why is it being accessed?”

All display owners stated that they would allow others within the Computing Department to be able to view the message on their door displays remotely (evident in both the questionnaire and interview), but disliked or were unsure about the idea of their message being accessible by anyone with internet access. A formative study carried out into location disclosure by Consolvo *et al* [22] revealed that the most important factors in this context were *“who was requesting, why the requester wanted the participant’s location, and what level of detail would be most useful to the requester”*. This area clearly requires further instigation, as when sharing a message via the Internet a door display owner has little or no control over these three factors. Half the display owners disagreed that making their messages available to a wider audience would affect their decision to leave a message, while another said that theoretically this would reduce his likelihood of leaving messages but was unsure whether this would affect his usage in practice.

The owners had differing opinions when asked how this would affect the content of their messages, 60% of owners stating that this would greatly reduce the level of detail they included in messages. While one owner was concerned that criminals would potentially be able monitor his door display to see when he would be away from his home. Owner *B* felt that she would be more formal and precise about her messages, as people may be travelling modest distances across campus dependent on her message.

5.3 Temporal Granularity of Messages Set

Almost half of owners (40%) used the door displays to say what they were doing on a particular day e.g. “Am in today” or “Away Tues at Viva in Bristol” on a regular basis (with an average of two or more messages set per day). One such owner commented that the information which he shared via messages set on his door display could effectively act as a fairly accurate journal of his activities. Interestingly, this owner did not use paper notes to share messages relating to fine-grained activities before the deployment of Hermes. For the remaining 60% of display owners use was primarily for occasional critical messages e.g. “stuck in traffic - 10 mins late”.

One owner consistently used ‘temporary’ messages in order to display messages that were valid for longer periods of time than the usual ‘Gone for lunch’. Due to this owner working in two different locations, Hermes essentially acted as an indicator of whether the person was in the Computing Department or not.

5.4 Saliency

While the door displays were located in an ideal place for use by visitors, there was an inherent trade-off between the saliency of the each display and the social acceptance required for deployment in a public space. For example, the door displays could have employed bright colours and sound in order to attract the attention of visitors but this kind of design would have been distracting for members of staff working in the Computing Department and would most likely met strong opposition. Conversely, in the case of very low saliency, a new visitor may not realise that the digital door display should be consulted and hence miss a message. One of the early door display owners used to have a yellow Post-It note on the actual door saying “*look at display!*”. Strongly associated with the notion of Saliency is the notion of calmness. Weiser suggests that a calm technology [23] is one which “*...engages both the centre and the periphery of our attention, and in fact moves back and forth between the two.*”

Three door display owners (30%) commented that they had been able to infer from a visitor's subsequent behaviour that the visitor had seen the message on their door display. However, when probed further, owners seemed unable to remember specific instances and none of the owners interviewed recalled discussing their door displays with visitors. An email questionnaire was sent to all members of the Computing Department at Lancaster to explore visitor usage of the Hermes system but from the very small response no useful insights into this issue were gained.

5.5 Expressiveness

Early in the deployment of Hermes door display owners were able to set messages which were either textual or image files. While image files could be set as messages, potentially allowing for a relatively high degree of expressivity, to author an image file obviously requires the use of a computer, is often more time consuming than a paper note and can provide less expressivity than a paper note. Late in the deployment one owner specifically requested a feature to help provide the high level expressivity available with the paper notes he used previously (hand drawing of cartoons in this case). Expressivity in this sense is the freedom an owner has to express thoughts or feelings through a message: for example a hand drawing allows the use of text and pictures.

While the issue of expressiveness when setting a message proved extremely important for one owner, the other owners found the ease and speed of interaction more important. The four owners with the highest usage were all heavy users of a predefined list of temporary messages which could be set easily and quickly using the door display. When using this method owners were restricted to the list of messages they themselves had configured, effectively trading-off expressiveness for ease of use. The majority of owners (80%) found that they could include the level of detail they desired by customising the list of messages, while others occasionally used alternative interaction methods to include additional detail. Owner A clearly identified that the different interaction methods could be used for different levels of expressivity i.e. from textual messages (low), to free hand draw (medium), to images files (high). When asked if she found she did not include enough detail in messages set from her predefined list this owner strongly disagreed because her messages were "*well chosen*" and she assumed her visitors had tacit knowledge of her working activities:

"...for example, if someone knew I was at the photocopier they would know where I was and be able to estimate how long I might be."

One owner found that he typically set messages valid for several hours at a time, for example whether he was working in the Computing Department or not. He also set messages for shorter periods of time (e.g. “In Meeting”) but only when in the Computing Department. He described how he would need a proportionately easier method of interaction when setting messages valid for very short periods of time:

“...it’s almost like you need a proportionately easier way of setting the message, but if you think ‘if I’m going away for five minutes and it’s a fuff to set the message I won’t bother... The more effort it is, it seems it’s less likely used for the smaller shorter messages: that’s my way of thinking about it.”

This owner was unsure whether or not how busy he was affected his likelihood of leaving a message on his door display (tending towards agreeing that it did), explaining how he was more likely to set longer term messages when busy:

“It comes back to that sort of fine granularity of messages, so the longer lived messages, I think, you’re more likely to set even in a busy environment. Whereas if it’s a short term message, I personally would probably not set that proportionately to how busy I was...”

5.6 Control vs. Effort

This issue concerns an owner’s need to perceive that they have a strong level of control over what context is displayed on his or her door display. The Hermes system required owners to actively select or express context for display. In contrast, other awareness systems, such as the Active Badge system [1] allowed the owners to maintain a passive role by automatically capturing their context, e.g. location. There are a number of tradeoffs to be considered here, but the most obvious is that between effort (on behalf of the door display owner wishing to share their context) and control.

When owners were asked if they would like to have their location sensed automatically (for example using Active Badges) and displayed on their door displays responses were mixed, with two major concerns being privacy and the control over information displayed on door displays. When asked if they would like their activity automatically inferred and displayed on their door display, two less technical owners agreed, with one stating:

“...you often forget if you’re in a bit of a rush... it would be useful to just have it done automatically.”

However, the more technical owners were unsure about this idea, largely because they recognised the difficulty in implementing it accurately, one stating:

“I wouldn’t have a problem with trying to infer it, but I’d have a concern that the inference is correct.”

During the deployment of Hermes a feature was added allowed the setting of temporary messages by simply touching the screen (rather than completing an authentication process required previously). This feature was added in response to owner feedback that the screens were ideally placed to configure a message when leaving ones office but that a very low-effort method of interaction was needed to enable use. One implication of this was that the owner was effectively giving up some element of control in favour of reducing the effort required to set a message sharing his or her context. Owners were prepared to accept the fact that a mischievous passer by could select a temporary message on the door display. It is important to note, however, that the mischievous passer-by could only select a message from the prescribed set of messages available and that the owner has ultimate control over this prescribed set. Initial discussions with owners and the results of the questionnaire revealed that allowing the possibility for unauthenticated visitors to leave ‘inappropriate’ free-hand messages on door displays was not acceptable to owners.

At the same time a similar feature was added in order to reduce the effort of removing temporary messages, allowing them to be removed by simply touching the display. Prior consultation with owners suggested that this trade-off between effort and control was acceptable. However, a questionnaire revealed that a minority of owners (20%) were concerned that temporary messages could be removed by a mischievous passer-by. The system was modified in order to give owners control over whether a temporary message required authentication before being removed via a door.

The interaction method allowing messages to be set from a predefined list without any authentication clearly traded off control (or security) for ease of use (i.e. effort). In order to investigate this trade-off, owners were asked whether they found malicious or accidental changing of their temporary message to be a problem. The majority of door display owners (60%) reported that they had found their temporary message had been changed by others (no owners suspected that this had been done maliciously), but that it had not caused them much concern, a typical comment being:

“I did have it changed a couple of times, but it wasn’t a problem.”

This specific issue is also related to dependability, as the system's dependability is adversely affected if others can (accidentally or otherwise) remove a message the door display owner intends to be displayed. However, A found that this feature enabled his colleagues to appropriate his displays and change his temporary message if he had forgotten to configure one.

6. Discussion

In Hermes personal context (e.g. an owner's current location) was shared by manually setting a message, which contrasts with the popularity of investigating the technical feasibility automatically capturing and sharing personal context (e.g. via an active badge [1] or sensor-rich coffee mug [2]). Hermes gave an owner complete control over context shared, but the trade-off was the need to consciously set a message every time this was necessary (either at the door display or remotely), which essentially relied on an owner adopting the system as part of his or her daily routines.

Owners did not request features to automate sharing of context in Hermes, for example owner A was very clear that he wanted the "*final say*" over what was shown on his door display. However, to investigate this issue further several questions included in the Hermes owner interview and questionnaire were intended to investigate whether door display owners were prepared to forego control in order for their location (or an activity inferred from a location) to be displayed automatically. Only a single owner was prepared to have his location sensed and displayed on his door display but stated that he had concerns over how the information might be used and said that he would like to restrict access to specific groups of visitors. When owners were asked if they would be happy for their current activity to be inferred from their location and automatically displayed 50% agreed while 20% were unsure and 30% disagreed.

From investigation of categorisation of context sharing messages [17] the highest percentage of messages shared some information about activity (47%). It appeared that Hermes lent itself to the sharing of unspecific and expressionless messages indicating an activity, very popular messages being "Gone for lunch" and "Gone for coffee". These messages generally give an acceptable explanation of why a person is not in his or her office in the smallest number of words. Allowing owners to configure a list of predefined messages which could be selected quickly encouraged this behaviour (and increased use) as this interaction method required the smallest amount of effort. In the case of many door display owners, for the majority of use,

Hermes was acting as a digital message ‘whirler’ an owner selecting from the predefined list of temporary messages when leaving his or her office.

7. Concluding Remarks

From quantitative and qualitative analysis of use it is clear that during the deployment of Hermes the door displays played a part in their owners’ daily routines. It is important to note that Weiser's view of ubicomp is that it "disappears" or "weaves itself in" and this is what was experienced with Hermes. The Hermes door display owners successfully adopted the displays as part of their working routines (with usage increasing steadily until the system was decommissioned) and even developed coping strategies to deal with failure. People, as you might expect, expressed their nature, personality etc. through their displays. Consequently, people who were concerned that others would have awareness of their presence and future presence within the dept would use their door display as a technology to mediate this communication, just as they may have used post-it notes or a message ‘whirler’ previously. Conversely, those who were not inclined to share their personal context would not and quite correctly were not forced too - this, of course, being a problem associated with earlier systems such as Active Badge. Within this however, is the question of whether Hermes facilitated those people who did wish to share personal context, and there is evidence that it did. This was achieved partly by providing properties such as the remote setting of messages and partly by utilising user-centred design to reduce the effort required to interact, e.g. setting a temporary message by touching the screen.

References

- [1] Harper, R.: Looking at ourselves: an examination of the social organization of two research laboratories. Proceedings of the ACM Conference on Computer Supported Cooperative Work (CSCW '02). Toronto, Ontario, Canada (1992) 330-337
- [2] Gellersen, H., Beigl, M., Krull, H.: The MediaCup: Awareness Technology Embedded in a Everyday Object. Proceedings of International Symposium on Handheld and Ubiquitous Computing (HUC '99). Karlsruhe, Germany (1999) 308-310
- [3] Weiser, M.: The Computer for the 21st Century. Scientific American, Vol. 265 (1991) 94-104
- [4] D. Fitton, Exploring The Design, Deployment and Use of Hermes: A System of Digital Interactive Office Door Displays. PhD thesis, Lancaster University, Nov. 2006.

- [5] Nguyen, D., Tullio, J., Drewes, T., Mynatt, E.D.: Dynamic Door Displays, GVU Technical Report GIT-GVU-00-30, Georgia Tech (2000)
- [6] Trumler, W., Bagci, F., Petzold, J., Ungerer, T.: Smart Doorplate. *Personal and Ubiquitous Computing* 7 (2003a) 221-226
- [7] O'Hara, K., Perry, M., Lewis, S.: Social coordination around a situated display appliance. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '03)*. Ft. Lauderdale, Florida, USA (2003) 65-72
- [8] O'Hara, K., Harper, R., Unger, A., Wilkes, J., Sharpe, B., Jansen, M.: TxtBoard: from text-to-person to text-to-home. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '05)*, Extended Abstracts, Oregon, USA (2005) 1705-1708
- [9] McCarthy, J.F., Costa, T.J., Liongosari, E.S.: UniCast, OutCast & GroupCast: Three Steps Toward Ubiquitous, Peripheral Displays. *Proceedings of International Conference on Ubiquitous Computing (UbiComp '01)*, Atlanta, Georgia, USA (2001b) 332-345
- [10] Segawa, N., Murayama, Y., Nakamoto, Y., Gondo, H., Miyazaki, M.: A Message Board on WWW for On-Door Communication. *Proceedings of International Conference on Multimedia*. Orlando, Florida, USA (1999) 187-190
- [11] Jeffrey, N., Jacob, O.W., Darren, G., Jodi, F.: Mediator and medium: doors as interruption gateways and aesthetic displays. *Proceedings of Designing Interactive Systems (DIS 2002)*, London, UK (2002) 379-386
- [12] Browne, H., Bederson, B., Plaisant, C., Druin, A.: Designing an Interactive Message Board as a Technology Probe for Family Communication. *University of Maryland Technical Report HCIL-2001-20* (2001)
- [13] Jeffrey, N., Jacob, O.W., Darren, G., Jodi, F.: Mediator and medium: doors as interruption gateways and aesthetic displays. *Proceedings of Designing Interactive Systems (DIS 2002)*, London, UK (2002) 379-386
- [14] Dourish, P.: Evolution in the Adoption and Use of Collaborative Technologies. *Proceedings of Workshop on Evolving Use of Groupware at ECSCW '99*, Copenhagen, Denmark (1999)
- [15] Hutchinson, H., Mackay, W., Westerlund, B., Bederson, B.B., Druin, A., Plaisant, C., Beaudouin-Lafon, M., Conversy, S., Evans, H., Hansen, H., Roussel, N., Eiderback, B.: Technology probes: inspiring design

for and with families. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '03), Ft. Lauderdale, Florida, USA (2003) 17-24

[16] Disability Rights Commission: Code of Practice - Rights of Access: Goods, Facilities, Services and Premises, Vol. III (2002)

[17] Cheverst, K., Dix, A., Graham, C., Fitton D. and Rouncefield, M. Exploring Awareness Related Messaging through Two Situated Display based Systems, in Special Issue of Human-Computer Interaction, Volume 22, Number 1-2. pp.173-220. June 2007.

[18] Abowd, G. D., Dey, A. K., Brown, P. J., Davies, N., Smith, M., and Steggles, P. 1999. Towards a Better Understanding of Context and Context-Awareness. In *Proceedings of the 1st international Symposium on Handheld and Ubiquitous Computing* (Karlsruhe, Germany, September 27 - 29, 1999). H. Gellersen, Ed. Lecture Notes In Computer Science, vol. 1707. Springer-Verlag, London, 304-307.

[19] Kraut, R., Egidio, C., and Galegher, J. 1988. Patterns of contact and communication in scientific research collaboration. In *Proceedings of the 1988 ACM Conference on Computer-Supported Cooperative Work* (Portland, Oregon, United States, September 26 - 28, 1988). CSCW '88. ACM, New York, NY, 1-12.

[20] Siau, K., Shen, Z.: Building customer trust in mobile commerce. *Communications of the ACM* **46** (2003) 91-94

[21] Sillence, E., Briggs, P., Fishwick, L., Harris, P.: Trust and mistrust of online health sites. Proceedings of the SIGCHI Conference on Human factors in Computing Systems (CHI '04). Vienna, Austria (2004) 663-670

[22] Consolvo, S., Smith, I.E., Matthews, T., LaMarca, A., Tabert, J., Powledge, P.: Location Disclosure to Social Relations: Why, When, & What People Want to Share. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '05), Portland, Oregon, USA (2005) 81-90

[23] Weiser, M., Brown, J.: The Coming Age of Calm Technology. In: Denning, P.J., Metcalfe, R.M. (eds.): *Beyond Calculation - The Next Fifty Years of Computing*. Springer-Verlag (1997) 75 - 85