NetBoards: Investigating a Collection of Personal Noticeboard Displays in the Workplace

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ABSTRACT

NetBoards are situated displays designed to fulfil and augment the role of non-digital personal noticeboards in the workplace. Traditionally, these are small corkboards or whiteboards situated outside offices belonging to individuals or small groups of people. By replacing these with large, networked, high-fidelity touch-enabled displays, we attempt to replicate the existing physical systems' flexibility and ease-of-use, while enabling more expressive content creation techniques and remote connectivity. We have developed an understanding of the deployment environment and every-day noticeboard practices using an ethnographic study which guided system design. Users can write messages or sketch drawings on their NetBoard, as well as post images and other web-based media. NetBoards can be accessed over the internet, allowing remote viewing and modification. Initial observations of 9 deployed units demonstrate the system's flexibility, showing it being used for maintaining group awareness, workplace personalization, playful communication, and showcasing research.

Author Keywords

Ubiquitous Computing / Smart Environments; Multi-display environments; Human-centered design

ACM Classification Keywords

H.4.3. Communications Applications: Bulletin boards

INTRODUCTION

Personal non-digital information displays are ubiquitous in the workplace and play an important role in communicating group awareness, social grooming, and workplace personalization [2, 14]. Though past research has struggled with the practicalities of deploying large collections of displays, technology has steadily improved over the past years, becoming cheaper, larger, higher-resolution, and more power-efficient. As a result, we have developed and deployed NetBoards – digital equivalents of traditional personal noticeboards that aim to capture the ease of use and flexibility of the existing system, while using technology to offer enhanced expressiveness, interactivity, and connectivity.

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Figure 1: NetBoards are interactive personal noticeboards situated outside offices. They are used to maintain group awareness and build a sense of community in the workplace.

Although existing noticeboard practices are effective, several issues are apparent. As it is generally the office occupant's responsibility to maintain displayed information, postings can become out-of-date (or *stale*) when their owner forgets to remove them. In some cases, the effort of modifying one's noticeboard can seem too high, causing it to become neglected. Situations also arise where office-owners wish to post information about their whereabouts to their colleagues, but are unable to do so precisely because they are absent. While contacting someone at the office and instructing them to edit the noticeboard on their behalf is an option, this is disruptive and far from ideal.

The success of a situated display system depends on choosing the right types of content, and this requires an understanding of the social nature of its deployment environment. We therefore used a long-term ethnographic study to determine what is appropriate to display outside offices, and investigate typical interaction methods afforded by non-digital noticeboards. These obersvations guided our development of a framework optimized for what people are familiar with, while attempting to improve upon their flexibility and ease of use.

Following a survey of related work, we present our study on how existing non-digital noticeboards are used in our workplace, describing our observations and consequential design choices. We briefly discuss a prototype deployment, and then describe in detail the current system's features, installation, and operation. We finally share our initial experiences and discuss the system's reception in the workplace. The source code is available under an open source license for the benefit

of the research community and anyone who wishes to deploy the system themselves [15].

RELATED WORK

Situated displays outside offices

Though it has become easier and cheaper to deploy collections of displays, there are only a few previous works specifically concerning displays situated outside individual offices. McCarthy et al's *OutCast* system is the earliest such example – they embedded a touch-screen into the wall of a cubicle-office, enabling the occupant to display information to passers-by [11]. OutCast allows users to either passively cycle through content chosen by the office owner, or interactively explore content or leave text messages. Though they aimed to study a wide deployment of their systems, they only report a single installation of OutCast being deployed.

Cheverst et al. present a range of in-depth works describing the design, development, management, and longitudinal evaluation of two interactive office door display systems in an academic laboratory environment [1]. *Hermes 1* consists of 10 wall-mounted pen-enabled PDAs that allow office visitors to hand-write messages, and office-owners to create and display multi-media content including text and images [5]. Office-owners were also able to remotely create text-messages using email, and view the contents of their display through a web-portal. They later implemented *Hermes 2* consisting of 40 more advanced units equipped with larger screens, cameras, and microphones, enabling further message-types to be sent and displayed. Content from multiple users can also be displayed on a single device, important for shared offices. They also deployed a *Hermes Photo Display* – a larger display in a communual area where researchers and students could post photos for general viewing.

Nguyen at al. developed *Dynamic Door Displays* – door-mounted interactive displays that allowed visitors to check an office-owner's calendar or location [13]. However, work on this project halted before a significant deployment or evaluation was carried out.

Situated displays in the workplace

There is a rich body of literature exploring how workplace situated displays can improve awareness, promote collaboration, and enlighten community. We present a brief review of some milestone works with relevant findings.

Alongside OutCast, McCarthy et al. present *GroupCast* – a TV-based situated display that invokes spontaneous conversation between passers-by [11]. It does this by choosing content it knows to be of interest to passing users, hoping to generate serendipitous discussion. The *Notification Collage* system allows distributed and co-located colleagues to post assorted media messages including live video, photo slideshows and text messages onto a large public screen [6]. They found it was often used like a bulletin board, with posted items generating discussions. *MessyBoard* is a large projected shared bulletin board that can be collaboratively decorated by shared office occupants [3]. Its creators found that usage patterns differ widely between user-groups, with one group focussing on work, while another preferred posting humorous pictures and playing games. By facilitating playful behaviour, they claim to make communication more enjoyable, reducing the boredom of work-related communication [4].

(a) A notice of absence outside a shared office (b) A playful sketch and printed humourous item. (c) A notice of absence with humorous images

Figure 2: Sample photos from our non-digital noticeboard survey, showing typical use patterns.

SURVEY OF EXISTING NOTICEBOARD USE

For a situated system to become accepted by users in their daily routines, it must be carefully designed to minimize the disruption of existing every-day practices. If it does not fit in with the existing behavioural expectations and associations of its deployed location, successful user adoption is unlikely.

We therefore conducted a pre-deployment study to provide an understanding of how the existing non-digital noticeboards are used. If we explore how people use existing technology, we can develop an experience optimized for what they want and are familiar with. Over the course of six months we recorded the content of existing office noticeboards by periodically taking photographs of them whenever they were modified. This resulted in a comprehensive corpus of 47 photos exhibiting both the *methods* used to create and modify content, and the *categories* of content left or put on display.

Environmental context

NetBoards is deployed throughout the Graphics & Interaction Group space at the University of Cambridge Computer Laboratory. The research group consists of 22 members, most of whom are PhD students, and is situated along a single corridor with 13 offices. Most offices are therefore multi-occupancy, generally shared between two people. This is a different workplace environment from previous peripheral display research conducted in large, shared offices [3] or cubicle environments [11], and comes with different behavioural expectations. Each office has a small non-digital whiteboard situated outside its doorway – these semi-personal noticeboards inspired the development of the NetBoards project. The group has several shared spaces with larger noticeboards – a meeting room, experimental laboratory, and a kitchen.

Non-digital methods for creating content

We found that noticeboard content is created and modified using two methods only: *inking* – people use coloured whiteboard markers to write messages and sketch small pictures;

and *printing and sticking* – people print out text and images, and affix them to a noticeboard with sticky-tape. The whiteboard medium primarily affords inking, thus making it the most used method of content creation and modification. While printed items are popular and attract attention, printed content has a longer average lifetime, often being left for months without modification or removal. On discussing this with users, they revealed that they dont't want to frequently replace printed items as they are wary of wasting paper, and put off by the effort involved.

As many noticeboards are shared, users follow simple protocols to reduce author ambiguitiy when necessary. Messages are often preceeded by the author's name (Figure 2c), or noticeboards are separated with horizontal lines into multiple panes – one for each office occupant (Figure 2a).

Typical categories of content

Despite the wide range of possible message-types that could be posted using inking or printing, we discovered that most fit into three broad categories:

Notice of absence – brief messages announcing someone's current or forthcoming absence, either long or short-term.

Humour – jokes or printed content (e.g. comics, images), sometimes posted in reaction to a previous message.

Play – written, sketched, or printed items of a playful nature.

We discuss the nature of each message-category in turn:

Notices of absence

The most frequently left type of message concerned office absences. In a large research group, someone is always away on vacation or at a conference. Even when not actually abroad, group members are often away on university-related business in town, or conducting off-site experiments. It may seem archaic to rely on non-digital noticeboards for announcing these absences, especially considering the ubiquitous use of online calendars and internet messaging. However, it can be undesirable to message an entire research group or department – this would be seen as spam to those not interested. Also, even if someone lets their colleagues know about an upcoming absence, it is easy to forget such matters.

Displaying an office absence outside an office has natural benefits: people looking for the occupant immediately have an idea of when they'll be back or how to appropriately contact them, and colleagues passively learn about each other's activities, assisting group coordination. These messages are always inked, and are removed when the occupant returns.

Humorous images and jokes

Humor is pervasive and provides many benefits in the workplace, including stress relief, team unification, motivation, and idea generation [10]. *Photocopylore* is a typical office phenomenon enabled by technology, where folklore-style humor is printed[1] out and displayed or passed between individuals [7]. Workers use it to exercise creativity and it can be a part of social processes such as boundary crossing and community-forming [7]. We found that workers display a range of such material on their noticeboards, including both work-related humor (e.g. jokes about programming) and more generic humor (e.g. popular comic strips). Some occupants also *elaborated* on photocopylore – inking onto it their own additions (Figure 2c). Once put up, these printed items have long life-times, and eventually become a form of permanent decoration. Jokes are also sometimes handwritten, but this is less common.

[1]Before printers became commonplace, photocopiers were used.

Playful content

Playful content differs from humor in that it is not necessarily designed to make someone laugh, but rather provide light-hearted amusement and distraction in what can sometimes be a serious environment. These often involve inked sketches, and can sometimes accompany messages of a different category, e.g. drawings of Chinese New Year festivities accompanying a notice of absence (Figure 2a). These represent semi-permanent personalizations of the workplace. Workers personalize their environment to express their identity and individuality, and make the workplace more pleasing to inhabit. Research has shown that personalization is significantly associated with work environment satisfaction [14].

Non-noticeboard displayed content

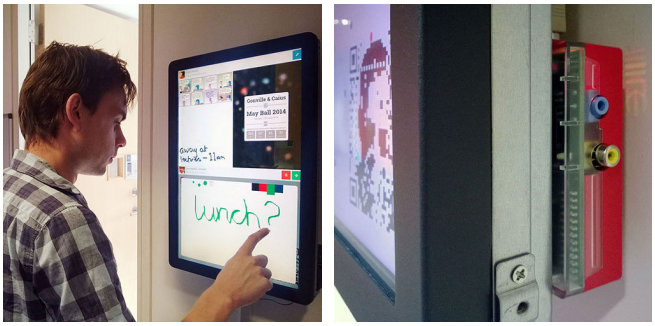
A small plate that displays occupant names is embedded in each office door. Some office occupants also decorated this with pictures of themselves or other sentimental material. We discovered the larger shared whiteboards in the group exhibited two further types of content: advertisments promoting work related to a group member, and work-related content, e.g. maths and sketches used to explain a geometric concept.

Resulting design choices

The flexibility of non-digital noticeboards enables them to support a variety of uses. Rather than implement a set of rigid and disjoint noticeboard applications, we should rather attempt to replicate and extend this flexibility. Inking gives users freedom in the level of expression and abstraction they use in their messages – rather than have an application display the detailed contents of someone's online calendar, people can instead leave more discreet messages to control personal information.

It is also apparent that group members value the creativity and aesthetics of what they choose to display. Though some messages could be simply posted as text, they instead choose more expressive approaches including sketches and drawings. This can also be seen in the printed photocopylore they put on display, especially for items left up for long periods of time. We should therefore aim to improve the expressivenes of inking, without making it overly complex, and make it easier for people to post images.

Notices of absence were the most frequently left type of message. Allowing some form of remote access is therefore important since it can sometimes be inconvenient or even impossible to post a notice of absence in person.



(a) A group member inking a message using a system prototype.

(b) Prototypes were driven by rear-mounted Raspberry Pi computers.

Figure 3: We conducted a prototype system deployment to gague interest and assess user-acceptance.

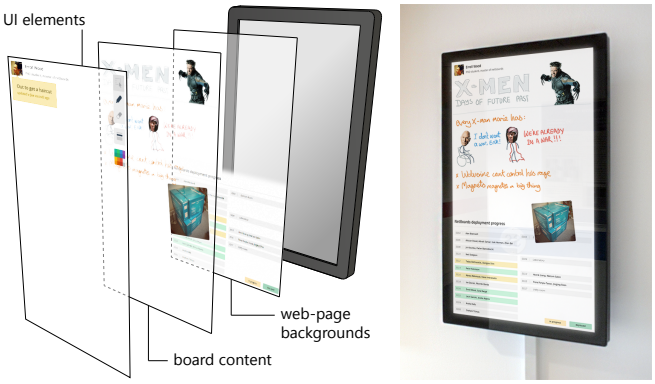


Figure 4: NetBoards display layers: UI elements (controls and office occupant details), board content (inked items and raster images), and optional web-page backgrounds.

PROTOTYPE DEPLOYMENT

When experimenting with large collections of expensive hardware, iterative cycles of design, development, deployment, and observation are critical in ensuring the system fulfils its goals and ends up being well-received.

We deployed five prototypes to gauge the acceptance of digital noticeboards and determine their typical use patterns. We chose a representative demographic of PhD students, postdocs, and a professor to see how different group members would use their display. Each board consisted of a 22-inch touchscreen powered by a Raspberry Pi (700MHz processor, 512MB RAM)[2]. Users could ink messages and sketches using their hands, add pictures using a web-interface, and set up web-pages to appear as a background. Following observations of prototype use, we re-implemented the system with improved software and superior hardware.

Prototype observations

The large displays lining the corridor caught the attention of passers-by frequently, and often piqued their curiosity enough for them to spontaneously interact with the screens and enter discussion with their owners. By generating excitement, the system overcomes major thresholds that can cause situated display system to fall into disuse [12]. However, various issues detracted from the prototype deployment.

We found that two important factors governed the acceptance and uptake of NetBoards prototypes: *dependability* – users will only bother to use a new digital system if they expect it to work; and *ease-of-use* – system adoption is unlikely if it is hard to use or requires much learning.

The prototype touchscreens were old models and operated using surface-acoustic-wave (SAW) technology. This meant users had to press harder on panels than they expected, and could not interact with the system accurately using their fingers. This lack of touch-accuracy influenced interface design choices that further affected ease-of-use – users had to switch between interface modes where they first wrote in large letters, and then shrunk messages down. This mode-switching became confusing and tedious, discouraging the types of spontaneous interaction we'd hoped for. These SAW panels cannot register multiple touch-points, so we could not support typical multi-touch interaction techniques and gestures that users are used to, e.g. pinch to scale and translate. We therefore decided to use superior capacitive multi-touch panels for the current installation.

While the Raspberry Pi's low price and power requirements make it ideal for large scale deployments, we found its limited computational resources were insufficient for a responsive and feature-rich inking interface, making them frustrating to use. We also experienced intermittent hardware failure following long periods of uptime. A robust hardware and software framework is critical for a system to be deemed dependable enough for daily use. We therefore decided to upgrade to more powerful and reliable PC systems.

[2]Raspberry Pi – **`www.raspberrypi.org`** (accessed 27/06/14)

THE NETBOARDS SYSTEM

Each NetBoard is a 22-inch portrait-oriented wall-mounted touchscreen (capacitive multi-touch, 1080×1920 px.) driven by a PC (Windows 8.1, 3.40 GHz processor, 4Gb RAM). Each PC drives two NetBoards. There are currently nine NetBoards deployed over the corridor, shared between seventeen people. As shown in Figure 4, each display consists of three layers: *UI elements* with interface widgets and details of office occupants; a *board content* layer contains inked messages, sketches, and raster images; and optional *web-page backgrounds* that can display any web-page chosen by the user. NetBoards can also be viewed and edited using web-apps, so can be accessed remotely or by desktop computers.

NetBoard displays are split up vertically between separate occupants in shared offices, showing a profile picture, name, and description for each individual. This approach was influenced by existing practices (Figure 2a), and resolves potential author ambiguity issues.

Creating content

Inking is the primary method of *board content* creation – users can write or draw on NetBoards using their hands (finger painting) or a passive stylus. As is typical for inking applications, users can choose between a range of different colours

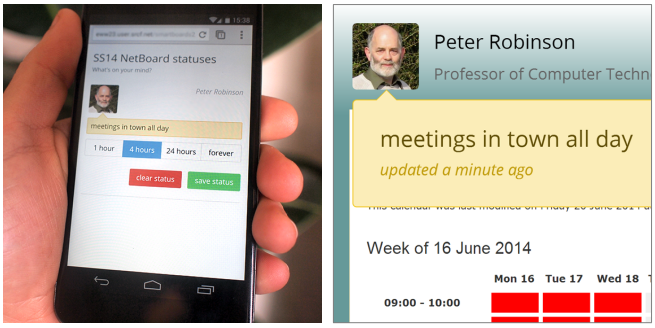


Figure 5: Remote inking may be inconvenient, so users can write a short text *status* to share contextual information.

and pen thicknesses. Inked strokes are stored as vector paths which are optimized and simplified to reduce memory usage and speed up rendering. When editing remotely, users can ink with a mouse or active stylus. When editing from a desktop machine, users can also drag and drop images from their PC or a web browser into their NetBoard– this fulfils the role of printing and sticking.

Modifying content

One of our aims is to improve upon the flexibility of non-digital noticeboards, and let users express themselves in better ways. Non-digital noticeboards allow few methods for modification once content has been created. Non-digital inked content cannot be moved, and only be erased. Printed items may be moved and re-stuck elsewhere (this was never observed in practice), but cannot be resized.

Instead we allow greater freedom of expression by implementing a range of typical content modification techniques. These include content re-ordering and multi-touch gestures for translation, rotation, and resizing. Users can easily reorganize and decorate their board using these familiar interaction techniques. While before their content was limited by how small they could write, users can now selectively adjust the saliency of items based on age and importance. The web-apps also support typical mouse-based editing techniques.

Secondary features

As well as implementing digital equivalents of non-digital interaction techniques, we included additional features to make editing easier and extend system flexibility. Instead of inking handwritten messages, users can set up a short text message *status* for display using web-apps, e.g. "Out for a haircut 11am". They can also set a *duration* for each status, after which the status will be removed. This avoids confusion arising from stale messages. Inking a notice of absence remotely on a small device might be challenging, so users can type short status messages instead (Figure 5).

Some previous works have implemented numerous disjoint applications or modules for peripheral situated workplace displays [8, 11]. Instead we let users choose a web-page for display behind their board content. This decision was made considering the technical nature of the group – most members have the skills to write their own scripts and web-pages for

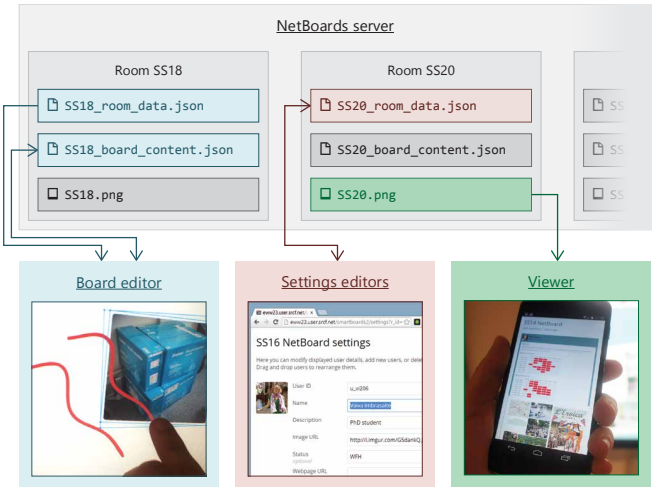


Figure 6: Our client-server architecture. *Board editors* load room data, and update content data following changes. *Settings editors* update room data, e.g. user details. Lightweight *viewer* clients download an image only.

custom content. This allows users finer grained control over what they choose to display, though it requires additional effort on their part.

Underlying architecture

We chose to implement NetBoards using web-based technologies. Mobile phones and tablet computers have become ubiquitous, and it is important to let users access the system regardless of their chosen device. Web-apps allow instant and remote interaction without the hassles of installation or software updates, and function across a range of devices.

Each wall-mounted NetBoards installation runs a web-browser in *kiosk-mode* – a full-screen mode that prevents users from tampering with the machines. Scripts and a custom written browser plugin are configured to load and initialize NetBoards on PC startup. Users create and modify content using a web-app editor. Inked content and pictures are processed by *Paper.js*[3], a vector graphics scripting framework for the HTML5 Canvas element.

Data storage and synchronization

NetBoards allows users to view and edit content remotely, so data must be synchronized across distributed devices. When a user modifies NetBoard content, the inked vector paths and raster images are exported to JSON and uploaded to our server. This file can then be parsed by Paper.js for display in most web-browsers. We use Lamport timestamps with file version numbers to determine a partial order of content updates with minimal overhead [9]. While this cannot handle multi-user real-time editing, it was deemed sufficient considering the asynchronous nature of communication.

Portable devices generally have lower computation resources than NetBoards installations and desktop machines, so it may

[3]PaperJs – `http://paperjs.org/` (accessed 27/06/14)

(a) A NetBoard movie review. Collaborative comments made by visitors are highlighted (yellow).

(b) A weekly schedule showing office occupant availability, and photos from a recent vacation.

(c) Notices of absence and playful sketches on a NetBoard shared by four occupants.

(d) Showcased research (green). A visitor jokes that the equipment resembles a "nose-picker" (yellow).

Figure 7: Screen captures from several NetBoards installations. Items of note, e.g. NetBoard visitor comments, are highlighted.

not be desirable to load Javascript libraries and render complex vector paths on-the-go. We therefore periodically render each NetBoard as a raster image server-side using PhantomJS – a WebKit layout and rendering engine[4]. These can be displayed natively on mobile devices. Each office's NetBoard also has associated *room data*. This includes occupant names, descriptions, profile pictures, and statuses. These are modified using simple web forms.

USER EXPERIENCES

NetBoards has been in use, though under continuous development, for a number of months. We have collected qualitative data about its use via informal feedback and interviews, and recorded snapshot data from the NetBoards themselves whenever changes were made. We summarize our observations in the following section.

NetBoards attract attention

NetBoards captures the attention of existing department members and visitors alike as they pass by, and they often enter discussion with group members about the system itself. Office occupants notice when passers-by pay attention to their NetBoard, particularly if they stop to examine it. This encourages them to decorate their board further, e.g. if an office occupant notices a passer-by enjoying a funny image they have put on display, they feel encouraged to share more humuorous content in the future.

NetBoards support awareness

Users frequently need to notify their colleagues about absences and often use their NetBoard to do so, either by inking messages (Figure 7c) or by setting a text status. They value being able to do this remotely and independently – without having to contact someone in the corridor to write a message for them. In this way NetBoards provides an improved mechanism for supporting group awareness and sharing knowledge of people's contexts and activities.

As well as simple notices of absence, one user written their own background webpage to display a weekly "diary" showing when they are busy or free (Figure 7b). To maintain privacy, they do not disclose the nature of appointments, just their own availability. Being one of group's senior members, they are often sought by students for discussion, so this displayed schedule information assists group members in scheduling communication and collaboration.

Images and pictures are popular decorations

Personalization and self-expression are psychologically important mechanisms that make places more pleasing to inhabit, help workers cope with stress by relaxing and inspiring them, and convey individuality [14]. As expected, images have become popular NetBoards decorations, ranging from funny comics (Figure 7d) to vacation photos (Figure 7b). When a pair of PhD students went abroad for a conference, they remotely updated their NetBoard almost daily with photo updates of research, culture, and social events. While printed items eventually became stale, NetBoard images experience frequent turn-over. Users sometimes annotate images, or ink elaborations onto them (Figure 7a).

People collaboratively decorate NetBoards

In the past people generally only wrote or sketched on their own non-digital noticeboards. However, group members and visitors now often edit or decorate each-others noticeboards in a playful manner. As shown in Figure 7a, one user put

[4]PhantomJS – **`http://phantomjs.org/`** (accessed 27/06/14)

together a review of a recent movie using a collage of pictures and inked bullet points – lists of "pros" and "cons". Other group members then added further bullet points to share their own opinions.

NetBoards are used to showcase work

Our research group frequently has visitors, and the NetBoards system often captures their attention as they tour offices in the corridor. One group member embedded a looped video of his current research as his NetBoard's background-webpage, as well as images of his custom-built research hardware (Figure 7d). NetBoards provides an ideal platform to passively and subtly introduce research to passers-by, potentially leading to resulting discussion.

FUTURE WORK

Though our early experiences with the system suggest it is valuable to group members, we are planning a longitudinal study to track the system's use and reception over time. A logging system will record how often people remotely view and modify NetBoard instances – this will give us a better idea of how well the system supports and enhances group awareness. We will also record data about individual changes to board content, revealing how people use inking and images for communication and decoration. Quantitative data can suggest courses of qualitative investigation, so we plan to conduct a series of further interviews and questionnaires.

We will continue to improve dependability and ease-of-use. Like all distributed systems, NetBoards will always be prone to network and hardware failures. The current course of action involves manual intervention so a more autonomous solution is preferred. Though choosing web-based technologies has many benefits, it leads to several challenges. One user wants to show off their research with webcam-based computer vision demos on their NetBoard, so we are looking for a way to support traditional PC applications in the system.

We are also keen to expand NetBoards's deployment elsewhere, and have had many requests to do so. Research has shown that different research groups use ubiquitous technologies in very different ways [4], and we would like to explore how use patterns change depending on the nature of co-located groups' projects and collaboration.

CONCLUSIONS

We have described the motivation, design, and early observations of NetBoards, showing how its flexibility enables a range of uses from communicating group awareness to workplace personalization and decoration. The system is still evolving with constant user feedback and feature requests, so we plan to continue our cycle of iterative re-design, deployment, and observation. We hope that others can learn from our experiences, and be inspired to deploy NetBoards or experiment with their own similar systems in different contexts.

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