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# Design, experiences and user preferences for a web-based awareness tool

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We describe our experiences with the design, implementation, deployment and evaluation of a Portholes tool which provides group and collaboration awareness through the Web. The research objective was to explore as to how such a system would improve communication and facilitate a shared understanding among distributed development groups. During the deployment of our Portholes system, we conducted a naturalistic study by soliciting user feedback and evolving the system in response. Many of the initial reactions of potential users indicated that our system projected the wrong image so that we designed a new version that provided explicit cues about being in public and who is looking back to suggest a social rather than information interface. We implemented the new design as a Java applet and evaluated design choices with a preference study. Our experiences with different Portholes versions and user reactions to them provide insights for designing awareness tools beyond Portholes systems. Our approach is for the studies to guide and to provide feedback for the design and technical development of our system. 

## 1. Introduction

Geographically distributed groups are using mediated communication technologies (e.g. video conferencing) to support their group and work collaborations. Group and collaboration *awareness* tools are one such collection of tools (Root, 1988; Borning & Travers, 1991; Dourish & Bly, 1992; Gaver *et al.*, 1992; Harrison, Bly, Anderson & Minneman, 1993; Tang & Rua, 1994; Whittaker, Frohlich & Daly-Jones, 1994; Jancke, Venolia, Grudin, Cadiz & Gupta, 2001). They provide group and individual information to group members. This information allows the users to formulate a general and peripheral awareness of their co-workers and to re-create some of the information that are available to co-located group members. The information may include general information about the physical and social environment, knowledge of activities of individuals and groups and information relevant to opportunities for collaboration and coordination.

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*Portholes* and *glances* are two flavors of such tools and they largely use video images as the information kernel for awareness. *Portholes* provide an integrative view of one's community through a matrix of still video images (Dourish & Bly, 1992; Narine, Leganchuk, Mantei & Buxton, 1997). These images are snapped periodically and updated automatically. *Glances* are electronic analog of users strolling down a hallway and intentionally glancing into people's offices (Fish, Kraut & Chalfonte, 1990; Tang & Rua, 1994). Portholes provide users with passive awareness in the periphery of their attention, while glances are explicit, intentional, remote queries into a co-worker's work space (i.e. active awareness).

These tools also play a role in facilitating informal interactions at a distance by providing collaboration awareness information and mechanisms for engaging into an interaction (Abel, 1990; Fish *et al*., 1990; Dourish & Bly, 1992; Harrison *et al*., 1993; Tang & Rua, 1994). Informal interactions are unintended, unplanned, opportunistic or spontaneous encounters that have been shown to be important for the social and production aspects of group work (Kraut, Fish, Root & Chalfonte, 1990; Whittaker *et al*., 1994). They support a number of different functions, such as, execution of work tasks, coordination of group activities, communication of organizational culture, development and maintenance of the integrity of the group and development of relationships with other groups and among group members. Physical proximity is crucial for such informal interactions (Kraut *et al*., 1990). Aside from the aforementioned desktop-based system for point-to-point interaction, efforts to support such interactions at a distance have also included public displays to link common areas (Abel, 1990; Fish, Kraut, Root & Rice, 1992; Jancke *et al*., 2001).

The decreasing cost of desktop audio/video hardware, the commercial availability of mediated communication applications, and the ease of linking people are enabling physically distributed organizations and individuals to pursue richer communication options. These advances open the possibility for a broader base of users to use these technologies and for a user study of these technologies among a heterogeneous user population.

For a broader user base, there is a need to have a scalable and cost-effective solution that can leverage on existing, off-the-shelf tools and hardware. The early awareness experiments were deployed using specialized analog hardware at considerable cost and effort and were in general, difficult to scale to large numbers or multiple sites (Mantei, Baecker, Sellen, Buxton & Milligan, 1991; Harrison *et al*., 1993). Subsequent experiments with digital technologies enabled the development of more scalable and network-based solutions (Tang & Rua, 1994; Jancke *et al*., 2001). However, many users were already using off-the-shelf tools and hardware for their mediated communication such as video conferencing and did not want to use another such tool; particularly, a proprietary one. To enable users to use their existing tools and hardware, it was necessary to use a development and services infrastructure that allows them to be accessible and interoperable. The World Wide Web provides such a flexible testbed platform for the development of group and collaboration awareness tools and for delivering such awareness information through the Web.

A broader base of users also provides an opportunity to study and address the issues that limit the widespread acceptance of such technologies. Poor acceptance of such

technologies can limit the research on and the potential for technology to facilitate the formation of virtual work communities. If we are not aware of the barriers to user adoption, we risk building group tools that few will use.

This paper presents our experiences with designing, developing, deploying, and evaluating a Web-based version of Portholes.† The research objective was to explore as to how it improves communication and facilitates a shared understanding among distributed development groups. We chose this tool because the early experiences with using awareness tools to support distant groups showed promise (Borning & Travers, 1991; Dourish & Bly, 1992; Fish *et al*., 1992; Tang & Rua, 1994). Several groups, inside and outside of NYNEX, used this system. However, despite its availability, we found that gaining universal adoption by all group members or recruiting whole new groups remained difficult. We had to repeatedly address the initial reactions to the system. These reactions centered around the use of cameras and video images to provide information for group and collaboration awareness. Understanding and addressing these initial perceptions is critical to the adoption of the system and to being able to assess the value of the technology.

Section 2 presents the initial state of Portholes. Section 3 describes the naturalistic study and evolution of Portholes. We describe the nature of the various user groups in our study, the five recurring user reactions that we encountered, the issues underlying them, the resolution approaches and their effectiveness. Section 4 describes the current design and implementation of Portholes, a redesign of our original Portholes, to include critical information in response to user concerns about surveillance and lack of reciprocity and awareness of audience. Section 5 investigates the effectiveness of the redesign through a preference experiment exploring users' initial impressions which were so critical in influencing their adoption of the tool. Section 6 takes stock of what we learned from both the naturalistic study and preference experiment and discusses the behavioral, design and technical explorations that are under way and that need to be pursued to guide future developments of such group and collaboration awareness tools. We close with the contributions provided by the research described in the paper.

## 2. Initial design of NYNEX Portholes

Portholes share many of the features of the original Xerox Polyscope (Borning & Travers, 1991) and Portholes (Dourish & Bly, 1992) systems but differ in ways related to the needs and requirements of our user base. The reasons for these differences and for the additional capabilities will be apparent when we discuss user reactions and our resolutions. The primary user view in Portholes is the user's customized Viewer (see Figure 1). It displays a matrix of the video images that a user has selected. Clicking on any of the video images results in the display of the Communicator page (see Figure 2) for the selected video image. This page displays additional information about the selected

†Much of this work was conducted during 1995–1997 while the authors were at NYNEX Science and Technology which is now part of Verizon. We will use Portholes to refer to the Web-based version of Portholes built at NYNEX and a redesigned version built in response to the NYNEX experience.

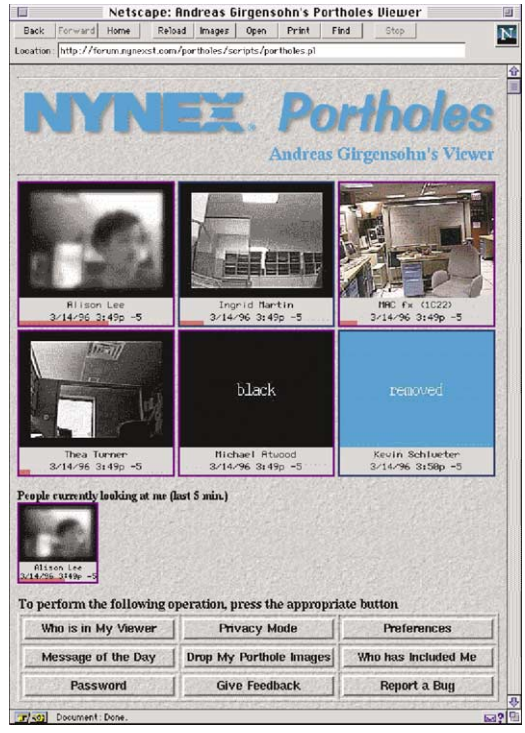



FIGURE 1. Portholes Viewer.

image. Users can customize Portholes and control its functionality by making modifications through the Preferences page (see Figure 3). In the remainder of this section, we provide an overview of the key features and capabilities of the Viewer, Communicator and Preferences to establish a context for initial system. They include the following.

(1) Disclosure of awareness information.
(2) Membership in virtual groups.
(3) Informal interaction.
(4) Portholes functions and user control and customization.
(5) Ubiquitous access to Portholes.

## 2.1. DISCLOSURE OF AWARENESS INFORMATION

We use video images to explore the information available in the visual channel that people find valuable for awareness and that could be disclosed with little effort. Experiences with Xerox Portholes (Dourish & Bly, 1992) indicate that presence and availability are information that users seek out. Video images are automatically snapped every 5 min and are supplemented with the person's name, a time-stamp, and a red activity bar. The length of the activity bar is a measure of the amount of change

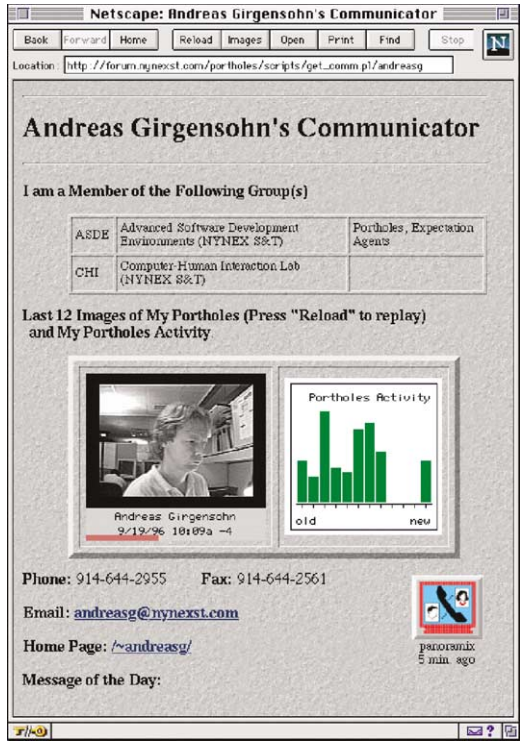



FIGURE 2. ANDREAS' Portholes Communicator.

between two successive video images. This measure provides an approximate indication of activity in an office.

We link the images to other possible forms of group and collaboration awareness information for the individual through the user's Communicator page (see Figure 2). This page provides a flexible framework for exploring the *variety of group awareness information* that people find useful and that are useful awareness information for collaboration and building relationships. It includes *prescribed, formal* information such as the groups (i.e. organizational and project), the roles in the groups that the person belongs to and their public calendar. Also, it includes information about how they can be contacted (e.g. email, phone number, fax number and physical address).

The Communicator page also includes *pre-communication* information for negotiating, coordinating and facilitating communication and interaction among the users. It exists in the form of video images, time-lapse animation and activity indicators. Specifically, the 12 most recent video images are kept and provide an integrative view of the last hour of activity. They can be viewed through the Communicator as a crude time-lapse animation. A different perspective on the last hour's activities can be obtained from the activity bars and a graphical plot of the activity information. Our users use this information to determine, for example, the present status of a co-worker

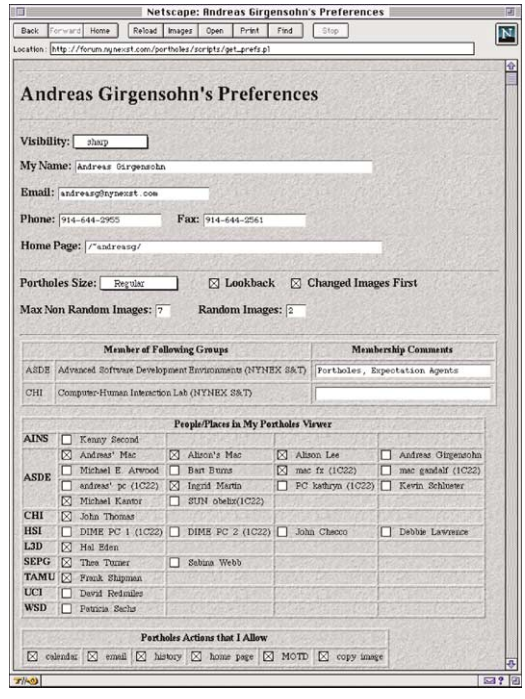



FIGURE 3. User preferences for Portholes.

that they are trying to telephone. From the co-worker's video image, they gain some idea of whether that person is in their office or is engaged in an activity (e.g. the person is talking to someone) that might influence their willingness to communicate (Tang & Rua, 1994). This information can be used to decide if that person should be called or if another means of communication would be more effective.

Finally, users may also disclose *free-formed, informal* information to co-workers. It may include a link to their home pages which can contain personal information such as hobbies or artefacts of their work (e.g. published papers and reports). It may also include a message of the day which our users use to disclose, for example, personal tidbits, interesting quotes and vacation notifications.

### 2.2. MEMBERSHIP IN VIRTUAL WORK GROUPS

Users are members of an organization's group as well as one or more project-related groups. The group information is both a piece of group awareness information about the individual and a means for regulating the set of video snapshots that other users may access. All users within a group can access the video snapshots of their group members. They choose the images from a list that is partitioned into the groups that the user belongs to (see "People in My Portholes Viewer" in Figure 3). Also, users can

designate which other groups may view their images by settings the ''Groups I Export to'' option in their Preferences page (see Figure 3).

### 2.3. INFORMAL INTERACTIONS

Portholes allows users to initiate informal interactions with another user through the other user's communicator page. Users can send electronic mail, export their Portholes image to their home page, and obtain phone, fax numbers, and if the users have the capability, desktop video and audio conferencing initiated at a click of a button.

### 2.4. PORTHOLES FUNCTIONS AND USER CONTROL AND CUSTOMIZATION

In addition to the display of video images, the Viewer provides a number of frequently accessed functions. They include, for example, the ability to change one's privacy setting by altering the image quality of their video images. This allows those desiring more privacy to decrease the amount of detail in their image (and hence information about their current status) (Bellotti & Sellen, 1993). Another function allows users to inspect any of their video images and replace any embarrassing or inappropriate ones with ''removed'' frames (see Kevin Schlueter's image in Figure 1).

From the user's Preferences page, a user has control over which information is disclosed to other users (see ''Portholes Actions that I Allow'' in Figure 3). The Preferences page also enables users to customize their Viewer. Users may order the selected video image in their Viewer by name or by changes in activity. The latter has the effect of drawing the user's attention to potential developments, such as people arriving or leaving. Sorting images by the amount of motion can also be useful for dealing with the problem of a large community and a small viewer. This means that out of a large number of selected images, only the images with the most motion are shown, presumably the most interesting ones.

### 2.5. UBIQUITOUS ACCESS

To support ubiquitous access to Portholes, we chose to implement the Viewer, Communicator and Preferences as Web pages. This allows users to request them from any workstation computing platform (Macintosh, Unix and Windows) that has access to the Portholes Web server.

The requirements for capturing images of the Portholes user are somewhat less ubiquitous but can be met by any system that is set up for desktop video conferences. Cameras are attached to workstations. Image acquisition software, known as Portholes Grabber, digitizes local video input and transmits the snapshot to an image server via the network. No additional cables (i.e. video cables) from each location need to be installed and no separate video network needs to be built. Supporting a new user at a site simply involves making sure that the Portholes Web server is accessible from the workstation and that the camera and image acquisition software are installed on the workstation.

## 3. User feedback and experience

Through a process of user participation, we evolved our initial prototype to create an acceptable, usable, useful and reliable system (Girgensohn, Lee & Schlueter, 1996). Our naturalistic approach of evolving Portholes varies from other approaches in several ways (e.g. Cool, Fish, Kraut & Lowery, 1992; Tang & Rua, 1994). First, the system provides a focal point for discussing and experiencing the value of video-based, background awareness. Second, right from the beginning, we took guidance from prior work on video awareness and media-space tools and theories of social and work relationships to develop the features in our initial prototype. Third, user feedback was obtained in several ways including: (1) users emailing their comments directly from within the application (see ''Give Feedback'' and ''Report a Bug'' in Figure 1), (2) polling users informally and (3) eliciting comments through regular meetings with several of our user groups. With this informal approach, we learned several important issues about the design of and the introduction of video-based, portholes-like, awareness tools as well as the implications for the redesign of such tools.

### 3.1. USERS

We recruited user groups throughout the development of Portholes and after it was released. Table 1 provides a profile of the Portholes user groups. The individuals came from different groups at S&T and are based at one of three sites. Two of these sites were separate buildings (1, 2) located in White Plains that were about a fifth of a mile apart; the third site was located in Manhattan about 25 miles away. We added Texas A&M University and the University of California at Irvine in 1996 while the University of Colorado site was involved from the outset.

Many users were not familiar with CSCW research and technologies. On seeing and hearing about Portholes, most of them were generally ambivalent. Tang and Rua (1994) noted similar sorts of reactions when they described such tools to focus groups prior to developing Montage. We believe that these reactions are typical of those that will be encountered if video-based awareness tools are made widely available. Thus, their findings and our experiences provide some valuable insights into the design of video awareness tools and the introduction of this type of tool into the workplace.

The final user group included people who saw demonstrations of Portholes. While these people were not users, we include them because they represent a diverse set of people that provided us with feedback.

### 3.2. INITIAL USER REACTIONS

Despite the diversity of users, there was a consistency in their initial reactions to Portholes and the use of cameras and video images to support awareness. We found that these initial reactions recurred whenever we attempted to recruit new Portholes users. Understanding these reactions and finding ways to address them are important if we are to be able to truly explore where the value of video images lie in support of

TABLE 1
*Portholes' user group size and sites involved*

| Groups | Size | Sites(s) | Disciplines | Job function |
|---|---|---|---|---|
| Own group | 9 of 12 | Building 1 | Computer science (CS) Psychology | Researchers (8), student intern (1) |
| Exploratory project | 10 of 16 | Buildings 1 & 2, Manhattan | Anthropology, CS, Mechanical engineering, Geographic information systems, graphic design, development | Managers (3), researchers (3), developers (3), student intern (1) |
| Extended colleagues | 6 | Manhattan, Texas A&M, U of Colorado, UC Irvine | CS, Electrical engineering, Telecom | Researchers (3), student intern (1), developers (2) |
| Development project | 2 of 2 | Building 2, UC Irvine | Writer, CS | Document writer (1), student intern (1) |
| Demo groups | ~20 | N/A | Varied | Researchers, developers, vendors, managers |

group and collaboration awareness. The five recurring initial user reactions are as follows:

(1) Camera shyness.
(2) Threat of surveillance.
(3) Loss of control over privacy.
(4) Lack of feedback and control of video images.
(5) Lack of support for awareness of audience.

With each reaction, we explored the issues underlying it, the limitations existing in Portholes, and several resolution approaches and the limitations associated with them. Some issues and resolutions were proposed by the users, some emerged through participative design, some involved the introduction of technical enhancements and others became evident through mutual education and understanding of users and designers about the technology. In many cases, the issues and the resolutions were rarely obvious. Having Portholes to illustrate and use was useful for focussing discussions on what users were uncomfortable with.

*3.2.1. Reaction: camera shyness.* Some users were uncomfortable with having cameras aimed at them and seeing video images of themselves in Portholes or even in the monitor of their video phone.† They felt that they were constantly in front of a mirror. They had a heightened sense of self-awareness, were more self-conscious about their appearance, and felt that the camera captures unflattering images of them. We found that these people were also uncomfortable about having their photograph taken.

*Reposition camera*: We discussed with our users ways in which Portholes could be changed or redesigned to address this concern. One user suggestion was to place the camera at a distance from the user. By being at a distance, the image of the user is smaller and facial details are less discernible. One of the users wanted to place the camera on the frame of his office door. This idea appealed to some users because it puts the camera in the familiar position of a co-worker who is looking into one's office.

*No image mirror*: Users who had the most discomfort with being in front of the camera attributed it, in part, to the monitor on their video phone camera or to their image in the Porthole Grabber window. They did not want their image conspicuously available to constantly draw their attention. We replaced the video phone cameras with a monitorless camera and added a user-selectable option to the Porthole Grabber software to suppress the display of the snapped image.

*Sharpen image*: A third approach was to digitally improve the image grabbed from the camera (see Figure 4). We found that we could compensate for many of the defects in the grabbed images by increasing the contrast and applying a sharpening filter. The resulting images were more aesthetically pleasing and appealed to some of our camera-shy users. This was serendipitously discovered during our efforts to provide more user control over privacy by decreasing the clarity of their image through image blur.

†The early cameras deployed to the users consisted of a camera with a video monitor reflecting the images transmitted by the camera. Cameras, deployed later, did not have this feature which has its pluses and minuses.

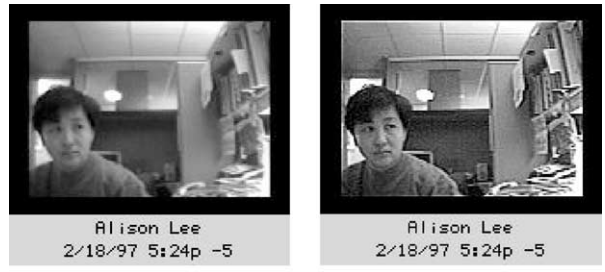



FIGURE 4. A normal and a sharpened image.

*Snap new image*: Occasionally, embarrassing images were seen because they were captured at unexpected times. We assumed initially that if these images were captured, users would not mind because the images were available only briefly and viewed only by other Portholes users whom the user allowed access. However, one user angrily stopped using the system after it caught the person in an embarrassing pose. In response, we added a feature that allowed users to snap a new image that replaced the current video image.

*3.2.2. Reaction: threat of surveillance*. Many people we discussed Portholes with, including those who declined to participate, were simply unwilling to have the system capture their images while they work because they view it as a method of surveillance; one such person has referred to our system as ''Peepholes''. They worried that their superiors would use Portholes to see if they were working. The developers of the NYNEX Shuttle (a high-quality video conferencing system) encountered extreme resistance to Shuttle nodes in public places (e.g. cafeterias) for much the same reason. We checked several public Shuttle nodes and found that all their cameras have lens caps in place. More recently, an effort to develop a public display system within Microsoft reported similar reactions and controversies among its user base (Jancke *et al*., 2001). An approach, which we began using, in response to this reaction, has been to introduce the technology and walkthrough its functionality with new users.

*Technology introduction and walkthrough approach*. When potential users were solicited or they inquired about using our system, we made it a practice to sit down and show them the system, to explain our motives behind designing it, and to discuss their concerns. We wanted the users to understand the goals of Portholes, and how it functions, so that they could understand and trust the technology. In our discussions, the privacy-related issues of capture, construction, accessibility and purposes, as discussed in Bellotti and Sellen (1993), were addressed. Specifically, we underscored that the purpose of Portholes was to provide awareness of one's virtual work group and of potential occasions for collaboration, not surveillance. This was effective with some of our users but others remained suspicious. In conversations with Steven Poltrock (pers. comm.), he related similar concerns among his users of a similar awareness tool. At issue, is the fact that while the system is not intended for

management to monitor the users, some users are not confident that it will not be misused by some for this purpose.

*3.2.3. Reaction: loss of control over privacy.* We opted to continue to use video images in Portholes because of the rich awareness information available from the visual channel and the minimal effort required by the owner to disclose this information. However, the availability of this awareness information can lead to a loss of privacy. When this was first discussed, we suggested, based on other media-space experiences, that users should feel free to point the camera at a wall or out a window whenever they desire privacy. However, this suggestion was not adequate for all users. At issue is not only the need for privacy but also the need for a lightweight mechanism to control privacy. Ideally, this mechanism would allow users to increase or decrease privacy, to inform other users of their new privacy state and to provide immediate feedback of the change. Through discussions and user experimentation, three alternatives emerged which addressed the feedback and interaction issues.

*Video messages*: Nearly all the early users had video phones as their cameras. A feature of these video phones was the ability to freeze an image and transmit it as the video signal. Several users began experimenting with this feature, including one user who made up index cards containing text such as "Out to Lunch", "Do Not Disturb", etc. It had the virtue of being simple, and the monitor on the video phone reminded people about the image being transmitted.

*Image Blur*: In an effort to address some users' concerns about the amount of detail revealed in the video images and their ability to retain control over image capture, we introduced a number of gradations for image clarity that users can select from (see Figure 5). However, we found that our users prefer to disable their cameras when privacy is desired and use the sharp, clear image when it is not. While a more easily accessible blur control might have changed that behavior, it may be that users who desired privacy did not trust the process in which the blurred image was constructed. Alan Borning (pers. comm.) suggested another possible explanation; it is sometimes important to provide options not only because they add functionality but because they provide a sense of reassurance that users' concerns have been recognized and addressed.

*Door cam*: Some users suggested that a "door-cam" solution could be adapted to facilitate privacy so that a closed door would block the camera. This provides an ideal user interface because closing the door is often the physical means by which one

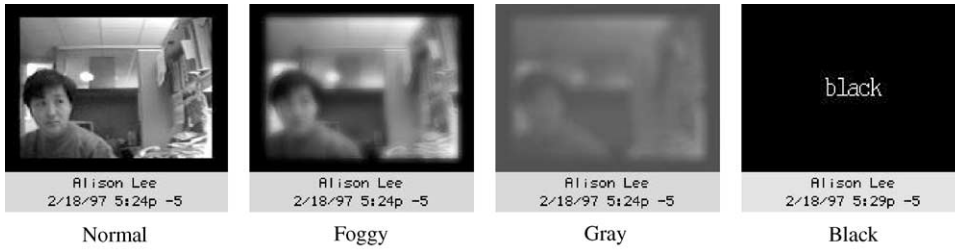



FIGURE 5. Successive image blurs from "normal".

indicates that privacy is desired. This proposal is similar to the active sensing door-state capability experimented with in the University of Toronto Telepresence Project (Mantei *et al*., 1991). In our opinion, it is the most effective solution because it provides the requisite affordances for control and feedback.

*3.2.4. Reaction: lack of feedback and control of images*. Portholes captured a frame from a user's camera once every 5 min. Some users in the second group objected to the lack of control over their images. They perceived this automated feature as someone else "controlling" their camera. A basic characteristic of portholes-like awareness tool is this automatic image capture and the passive update of the video images matrix. We needed to find ways to give users more feedback and control without handicapping this interaction model. Aside from the image blur capability mentioned in the previous section, we identified four additional capabilities.

*Activity sensing*: We interviewed users who blocked or turned off their cameras as well as several people who refused to use our system. A common suggestion was that we permit a "motion only" Portholes which only gives information about the presence or absence of a person but no visual information about the person's activities. In response, we implemented the activity sensing capability which measures the amount of change between two successive images (Lee, Schlueter & Girgensohn, 1997).

*Increased feedback*: Users demanded more feedback about when an image is grabbed and what the captured image looks like. First, we added a user-selectable option in the Porthole Grabber to play a sound before grabbing an image. We then gave the user the additional option to specify a lag between the sound and the image grab. Next, we added a user-selectable option in the Porthole Grabber to display the most recently captured image (i.e. similar to the monitor feature in video phones).

*Delete video images*: Users in our second group pointed out that merely having the feature of snapping a new image to supplant the last image is insufficient. In their view, the embarrassing image was still around for an entire hour, instead of just a few minutes as in other Portholes systems. In response to this concern, users could select the video images in the image set and replace them with a blue frame containing the word "removed" (Kevin Schlueter's image in Figure 1). This change, along with the other improvements, seemed to address concerns about embarrassing images as there were no further objections.

*User customization*: As some of our users became more accustomed to the system, they began to want more control over their images than simply the ability to eliminate embarrassing ones. Two of our users would point their cameras out their office windows, and one user pointed the camera at the crest of a favored NHL team. Another user, who had a video phone with a freeze-frame capability, would use the camera to show the book cover, conference schedule, etc. When we met with our users, they often requested the ability to set their Portholes image to an arbitrary image file. We responded to this by providing an extended analogue to the video-phone freeze-frame option in the Microsoft Windows version of the Portholes Grabber.

*3.2.5. Reaction: lack of support for awareness of audience*. Often, when we showed Portholes to visitors and potential new users, they commented about the uneasy feeling of having unseen eyes looking at them. Similarly, their discomfort with cameras and

video images were in part attributed to the fact that they did not know where the images were being projected to and who saw their images. In subsequent discussions, it became apparent that the image matrix presentation emphasizes group awareness to the total exclusion of support for awareness or active feedback related to who the audience is and what the size and makeup of the audience is. The lack of this kind of awareness support contributes to the uneasiness that new users or visitors have with a portholes-like system.

At the root of this issue is the fact that portholes-like systems as well as media spaces in general, fail to provide cues to users about being in public (Goffman, 1959) and contextual cues to allow users to frame their interactive behaviors (Harrison & Dourish, 1996). Bellotti and Sellen (1993) describe the former deficiency as "*disembodiment from the context into and from which one projects information*" and the latter deficiency as "*dissociation of actions from the actions' results*". Based on the feedback from and the discussions with our users, there are two kinds of awareness information about one's audience that are lacking in portholes-like systems. They are two different aspects of "reciprocity".

*Who is in the audience*: From the outset of our Portholes development, we considered reciprocity to be an essential element because previous research has suggested that users can monitor and control their self-presentation and behavior (Mantei *et al.*, 1991; Cool *et al.*, 1992; Tang & Rua, 1994). When properly implemented, reciprocity is also a form of feedback (Bellotti & Sellen, 1993). In Portholes, we initially implemented reciprocity by providing users with two lists. The first is a list of people who select their image in their viewer and when they last accessed it — "Who is Looking at Me". The second is the complete list of people who can view the user's images (see "People/Places in My Portholes Viewer" in Figure 3). While our initial group of users was satisfied by this, we were repeatedly told by later users that they wanted to know "who could view their images." While the information they desired was accessible via an explicit request, our users actually wanted it in the main display.

*Lookback*: As we gradually expanded our user base, we also heard objections along the lines of "I want to know who is looking at me." We initially misunderstood these comments and thought that our users simply did not know about the existing features such as the "Who is Looking at Me" list. In actual fact, the users wanted to know more than who had access to their pictures; they wanted to know who was presently looking at them. One exasperated user, after being told about the existing reciprocity features summed this up well when he said, "but I want to know who is looking at me NOW!" Our users want an immediate indication that they are being looked at, similar to someone looking in through their door. They also wanted an image of the person looking in and that the image should conspicuously "pop up" on the display to attract their attention.

This capability required additional functionality in our image grabber and an overhaul of our Portholes architecture. In the interim, we developed the "lookback" capability which displayed small images of those who have accessed one's Portholes image in the previous 5 min (see the bottom of Figure 1). Our users were more satisfied with this than we expected and commented that they like the persistence of the small images. As a result of this "lookback" feature, we relabelled the original "Who is Looking at Me" button to "Who has Included Me" (see Figure 1).

## 4. Portholes re-designed

### 4.1. PORTHOLES LIMITATIONS

Despite our efforts to involve users throughout and to make Portholes accessible and useful, it was difficult to gain adoption by all users or to recruit new groups. In discussions with people ambivalent about this tool, we found at least two design limitations.

(1) Sense of being in public — cues about being in public that help users frame their behavior.

(2) Reciprocity — information about who can see a user and who is currently looking at the user.

*4.1.1. Sense of being in public.* In an effort to lower the barriers to communication and collaboration posed by physical distance, awareness tools have created new channels of access to distant co-workers. However, these channels have brought many formerly private and public situations found in a person's office into a new unitary public setting (Meyrowitz, 1985). This blurring of public and private situations changes their structure and reveals information once exchanged only among people under each other's direct observation. That is, Portholes users have gained a ''side-stage'' view into their co-workers' offices. Meyrowitz (1985) suggests that when new electronic media widens the on-stage (public) region onto the backstage (private) region, a new ''middle region'' is formed which leads to new social behaviors.

While the effect of Portholes has been to make offices more public, many who used it are uncertain as to whether this places them in a public forum. The image matrix display did not clarify their concerns (e.g. Figure 6). If anything, some drew an incorrect association between the layout and a security-monitor setup. This resulted in negative impressions that amplified rather than clarified their concerns about

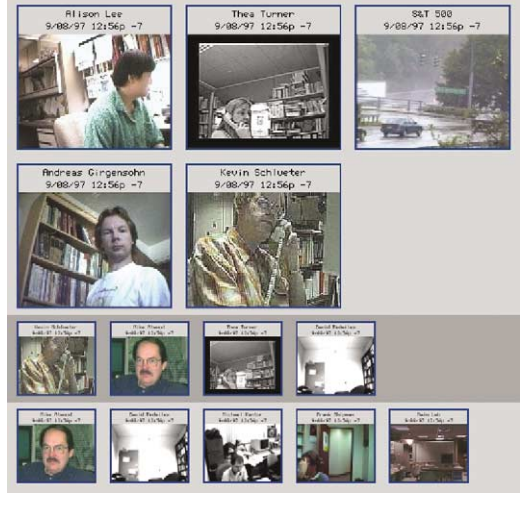



FIGURE 6. Traditional design with pictures for non-core team at the bottom.

surveillance and privacy. Such uneasiness supports Meyrowitz' argument that electronic media has "undermined the traditional relationship between physical setting and social situation". Their uncertainties highlight the need to make the situation, being in public, more explicit in a social interface.

*4.1.2. Reciprocity.* In the physical world, we have access to cues that other people are around when we are out in public (Goffman, 1959, Bellotti & Sellen, 1993). These cues let us regulate our behavior accordingly. However, the Portholes designs focus on making users aware of their co-workers and opportunities for collaboration but not on the reciprocal information about when and which of these people are looking in on the user.

Reciprocity describes the situation where all communications are two way. If you are able to see or hear others, they can see or hear you, at the same time. It is an essential element of communication, allowing users to monitor behavior and to control how others perceive them (Cool *et al.*, 1992; Tang & Rua, 1994). We described earlier that users wanted two pieces of reciprocity information prominently displayed in the Viewer.

(1) Audience — people who can see a user's image.
(2) Lookback — people looking at a user's image.

### 4.2. PORTHOLES ENHANCEMENTS

We developed a new design for the Portholes Viewer to address the lack of a sense of being in public and reciprocity. Harrison and Dourish (1996) suggested that a meaningful location can be useful to frame behavior. They argued that the notion of a place is in fact based on a cultural and social understanding of the behavior and actions appropriate to the space. This idea that "we act in a place" is not unlike Goffman's view (1959) that a setting and an audience shape people's behavior in public situations.

Building on the notion of a place to frame behavior (Harrison & Dourish, 1996) and in particular the theater (Goffman, 1959), our screen layout recreates a theater setting. This setting is a purer metaphor for being in a public forum. In addition to conveying a sense of being in public, the actor and audience interaction aligns strongly with the performance behaviors that people exhibit in public as they regulate the image and behavior that they project to others in public. We neither make the claim that the theater metaphor is a familiar one for work groups nor consider the familiarity to work group to be the primary user concern to be addressed. The theater setting also provides a context for the placement of certain social information. The theater's various regions contain the audience and lookback reciprocity cues that other people are present and looking in. The combination of the theater setting and reciprocity cues addresses the two primary user concerns. This design blueprint was used to construct several designs that differ in two characteristics:

(1) Screen layout of the various regions of a theater.
(2) Detail of the audience information.

*4.2.1. Screen layout.* Each user has a customized Portholes display containing a 3D presentation that places the user on stage and looking out to an audience encompassing


FIGURE 7. Theater design with orchestra for reciprocity and blue rectangles for non-core.

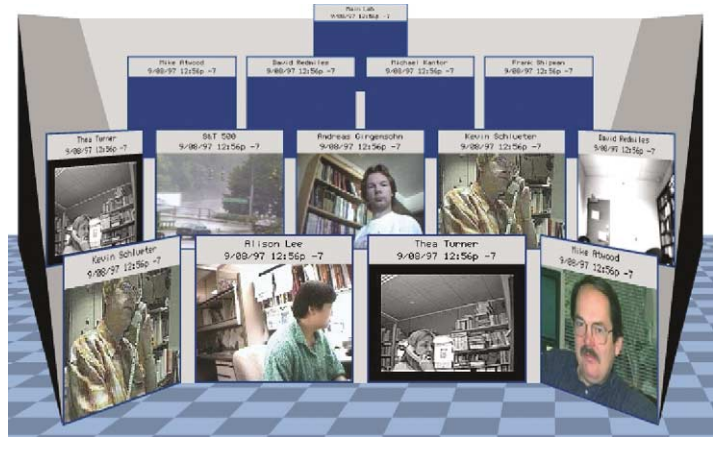



FIGURE 8. Theater design with side rows for reciprocity and named rectangles for non-core team.

all the Portholes users that can view the user's image (see Figures 7 and 8). The theater metaphor makes it explicit that use of Portholes positions them in a public forum; albeit to their co-workers only. Furthermore, their view is from the stage looking out at their audience and this allows them to see how public the distribution of their images is (e.g. size of their audience) and to whom they are being distributed to.

The images in the front and back rows reflect different *audience* reciprocity information (see Figures 7 and 8). The images in the front rows include the people in a user's core workgroup (i.e., images appearing in the traditional image matrix). The images in the back rows are the remaining people in a user's formal workgroup (i.e. people whom the user does not consider to be in her core workgroup — non-core team members). These non-core team members have access to a user's image just as the user has access to their images by virtue of being in the same formal workgroup.

We explored two configurations of the theater layout for presenting the *lookback* reciprocity information; one with images placed in an orchestra pit and the other with angled images at the sides (see Figures 7 and 8). These images represent the people in the user's workgroup that are currently running Portholes and thus, looking in on the user. The first layout, `Theater/Orchestra`, localizes the images in one place—orchestra pit — to allow an efficient visual scan of the lookback information (see Figure 7). The second layout, `Theater/Side`, positions the images at the sides to differentiate lookback information from audience information (see Figure 8). More importantly, the images are angled and not face-on and positioned at the periphery to reflect the fact that this lookback reciprocity is not a two-way exchange.

*4.2.2. Secondary audience information*. An important goal of the redesign was to provide users with information about their complete audience. However, the addition of many images can be distracting. Hence, we explored the notion of providing pictures for core team members and using one of four alternatives for representing non-core team members: `None`, `Size`, `Names`, and `Pictures`. Each successive option presents additional information.

The first option excludes the display of one's non-core team members (`None`). The second option presents the size of one's non-core team (`Size`) using a collection of blue rectangles to represent occupied theater seats. In keeping with the graphical and theatrical metaphor, the occupied blue seats provide a Gestalt of the non-core team member size (see Figure 7). The third option adds name labels to the blue seats (see Figure 8) to allow the user to find out who is seated in the back rows. The fourth alternative uses pictures to provide views into non-core team member's offices (`Pictures`).

### 4.3. IMPLEMENTATION DETAILS

The new design of the display described above was implemented as a new version of Portholes. The implementation also improved on the user interaction aspect to make it easier to use and to make it quicker to access information about another Portholes user.

*4.3.1. Portholes user interface*. For improved interactivity, the user interface is implemented as a Java applet while the original version was implemented as Perl CGI scripts generating HTML. The applet periodically checks whether new images of a user's group members are available or whether group membership or image sharing has changed. After a change, the applet requests the Portholes server to generate a new composite image based on the user's layout preferences and displays it. This two-step approach allows for frequent checks for changes while only using the bandwidth for transmitting and the resources for generating an image after a change.

Even if users are willing to provide a non-blurred image, they now have the option to deny other users of images of a higher quality than they receive in return. This means that different users can receive the same image filtered with different privacy settings. To accommodate this, images are stored in a directory not accessible via the Web and privacy filters are applied when the composite image is generated.

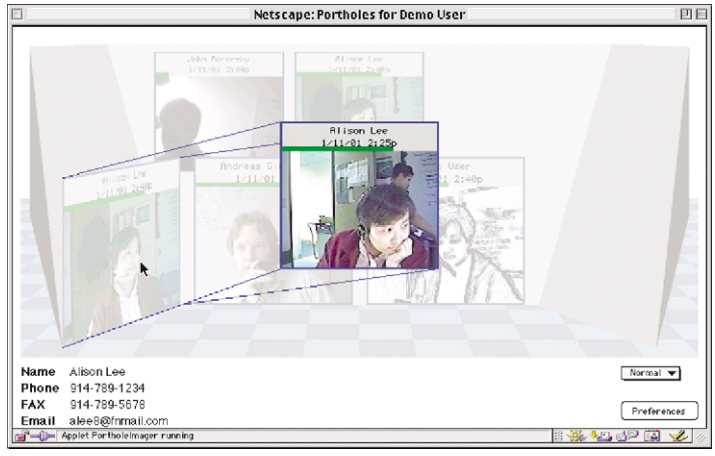



FIGURE 9. Time-lapse animation of Porthole images.

Additional information about team members can be accessed by moving the cursor over an image. In the area below the image display, information such as the phone number and email address is displayed for the image under the mouse (see Figure 9). This approach replaces the Communicator page (see Figure 2) that required a different Web page to be fetched. Common actions such as sending email or copying the email address to the clipboard can be initiated from the popup menu associated with each image.

The time-lapse animation of past images is also available from the main display. After a mouse click on an image, the main display is faded out and the animation is shown in the center of the display (see Figure 9). Clicking on the animated image stops or resumes the animation whereas clicking anywhere else restores the normal display.

Responding to our users' request for Portholes to consume less screen real estate (Lee *et al.*, 1997), this implementation can create a browser window without navigation controls that is just large enough to contain the Portholes display (see Figure 9). In this mode, users can use their main browser window for their regular work and keep a Portholes window in a corner of the screen.

*4.3.2. Controlling the audience*. Including the audience of a user as non-core team members in the display requires careful consideration of different scenarios. A user's audience consists of all the people who could see that user, i.e., all people who share a group membership with the user or who are members of a group the user exports to. However, if one would select the audience in this fashion, users could gain access to the members of a group just by exporting to that group. We could avoid this problem by removing the export feature but we feel that it is a nice means to express affinity with a group without becoming a member. Instead, we only include those members of groups the user exports to that actually include the user in their core teams. This also meets the basic principle of reciprocity that nobody can see somebody else without being seen in return.

*4.3.3. Using portholes across sites.* As in our original Portholes implementation, we addressed firewall access and network performances issues (i.e. bandwidth and lag) by having a separate Portholes server for each site that can exchange images. We provide a central Web server outside a firewall with CGI scripts for uploading and downloading archives of images. To conserve bandwidth and to keep Portholes servers more independent of each other, only images of users with a remote audience are included in the archive uploaded to the central server. Because we use HTTP as the transport protocol, we can use proxy servers inside of firewalls and take advantage of HTTP status codes, for example, to indicate that an image archive has not changed since the last download. To keep uploads and downloads synchronized, the clocks of all Portholes servers need to be accurate to within a few seconds, which is easily accomplished by using the Network Time Protocol.

## 5. Preference experiment

The previous section discusses a redesign of Portholes intended to influence people's initial reactions and to establish a sense of place. To judge the effectiveness of the redesign, we wanted to determine the preferences of first-time users. The reason for examining people's first-time preferences is because our experiences, described in Section 3, with recruiting users have shown that their initial perceptions and reactions play a critical role in the impressions they formulate and their willingness to use the technology (Lee *et al.*, 1997). Thus, our redesign is an effort to make Portholes not only useful and usable but also more acceptable to first-time prospects. We conducted a preference experiment to see which of the different screen layouts and audience options a first-time user would like. This first evaluation of the design is to examine its effectiveness in guiding new users to formulate appropriate impressions and expectations about Portholes and thus to improve its uptake. If people use it, then it would be appropriate to conduct a longitudinal study of its impact.

In the experiment, we explored the design space consisting of the old and the redesigned versions of Portholes with different options for visualizing the audience. We divided the design space along two dimensions (layout and audience — the two variables in the new Portholes design) with three and four variations, respectively. We had our evaluators conduct pairwise comparisons of all the permutations of the designs (12 permutations in total resulting in 66 comparisons) to determine the factors that might influence their preferences. By revealing the design permutations in this manner, rather than all at once, evaluators could carefully consider as to which of the two they preferred and the resulting preference judgements would be more objective in actual fact.

The preferences were analyzed using multi-dimensional unfolding (MDU) (Shepard, 1972) to surface the evaluators' reactions to the different layout and audience options. This was done in the belief that each person approaches the layouts from an individual perspective, as suggested by Coombs (1950) in formalizing unfolding techniques for a single dimension. Unfolding assumes that stimuli are aligned along one or several dimensions and that individuals observe the experimental conditions from their own perspectives. It places objects, conditions and evaluators, in a spatial model in such a

way that the significant features of the data about these objects are revealed in geometrical relations among the objects. By "unfolding" these individual preferences and getting estimates of their position in the space, our intention was to reveal the factor(s) (layout or audience or both) and weights influencing individual preferences. Also, the technique could be used to reveal the various preference clusters that existed because we believed no individual design would be preferred by all evaluators.

In addition to obtaining people's preferences, we asked the evaluators to fill out a design requirements survey. This survey provided complementary data to interpret their preference choices as well as insights for the redesign. In particular, when the survey data is analysed in light of the results on preference factors and clusters identified by MDU, it enhanced the interpretation of the survey and provided feedback on the preference judgements and how to carry the design forward in the implementation of a new Portholes display.

### 5.1. EVALUATORS

Twenty-eight evaluators (14 males and 14 females) were recruited through an electronic call for volunteers. All evaluators worked at NYNEX S&T and willingly volunteered for the experiment. None of them used Portholes but a few had heard about it from their colleagues. Some of them worked together on past projects and others were unknown to each other. This is not unlike the situation of how workgroups are assembled, in general. It is also not unlike the context in which we intended Portholes to be used (i.e. among people who knew each other and those who did not). As compensation for their time and feedback, each evaluator was rewarded with a Swiss chocolate bar.

### 5.2. LAYOUT AND AUDIENCE EFFECTS

There are two principal effects examined in the experiment through the different design options for the new Portholes display: layout and audience. The layout options provide cues to the users that they are in public and on the stage of a theater. The audience options provide different views on both the people who could see the user but might not look right now and the people who currently have the Portholes user in their viewers (lookback).

Three different layout options for organizing the information in the Portholes display were compared: `Portholes`, `Theater/Orchestra`, and `Theater/Side` (Figures 6–8). The `Portholes` layout displays images in a two-dimensional grid, with sections designated as core team members, lookback and non-core team members. Its layout is simpler, but is ambiguous about the issue of being in public. It was included to see if evaluators would prefer it over the theater designs. This layout is essentially the same as the one used in Portholes, except that the non-core team member information was added at the bottom of the layout; differentiated from the other quarter-size, lookback images by having the same background color as the images for the user's core group members.

The two theater designs were described in the Portholes Re-designed section. They use perspective cues to create a 3D appearance and place the lookback images in

different locations. The theater setting conveys a sense of being in public and on-stage. The `Theater/Orchestra` is in between the other two layouts; it is visually simpler than `Theater/Side` but more three-dimensional than `Portholes`.

Four different audience options were shown for presenting people who were not explicitly selected by the user (non-core team members). These four options correspond to the four audience options presented earlier: `None`, `Size`, `Names`, `Pictures`.

### 5.3. MATERIALS

Nine co-workers (five males and four females) permitted us to use their pictures as part of the collection of video images used to assemble the various screen designs used in the experiment. We took color JPEG pictures ($160 \times 120$ pixels) just like Portholes would take them. Also, we took a color picture of each evaluator in the same fashion at the beginning of the experiment. The evaluator's picture appears among the images of co-workers who were part of the evaluator's core team. From past experiences, we learned that including the individual's own picture into the Portholes display subtly affected the individual's perception of the tool; from one of looking in at others to one of being among the group of people who can view as well as be viewed. We wanted the evaluators to experience a group awareness tool as a typical Portholes user would.

The 10 pictures were used to assemble the 12 different screen designs (three layout and four audience conditions). Evaluators were told as to which co-workers filled the role of core team and non-core team members. They were told that all co-workers had access to Portholes. The various options for the display of the information about the non-core team members were introduced to the evaluators. Evaluators were shown the three layouts and where the information about core and non-core team members and lookback would appear in each of the layouts.

### 5.4. PROCEDURE

In the first part of the experiment, 72 pairs of designs were shown to the evaluators. An initial warm-up block of comparisons was presented, in which all 12 designs were displayed as six pairs. Then evaluators saw each design 11 more times over 66 paired comparisons, once with each other's design. To avoid biases, each design was shown five times on one side and six times on the other. Also, each design appeared only once within every blocked sequence of six comparisons.

At the conclusion of the paired comparison phase, evaluators were given a three-part survey. Parts 1 and 2 will not be discussed here. Part 3 assessed the importance of a set of 18 design requirements.

### 5.5. RESULTS

The data from the warm-up block were discarded. Preference scores were calculated for each evaluator by totalling the number of times a design, layout option, or audience option was preferred, normalized to a range between 0 and 1. Also, the "dissimilarities" between evaluators and designs were described as the rank of the design preferences for each evaluator, based on the number of times a design was chosen. In a few cases, an

evaluator did not exhibit a clear preference for one design over the other or was inconsistent. These ties were resolved based on the choice made by the evaluator in the direct comparison between the two designs. Most evaluators exhibited strong internal consistency in their preferences. An interaction between Audience and Layout was seen in three evaluators.

*5.5.1. Audience*. Preferences were significantly influenced by the audience information ($F_{(3,81)} = 11.59$, $p < 0.05$). However, it was not the case that preferences increased as the amount of information provided about the audience increased (see Figure 10). Evaluators overwhelmingly disliked the use of blue rectangles to represent seats occupied by non-core team members. The sum of these images and those of the core team members represents one's audience size. The survey results underscored the undesirability of the use of blue images to indicate audience size (26% preferred the use of blue images while 67% preferred the use of a number — see Q3 and Q14 in Table 2). Evaluators preferred `Names` over `None`, but were mixed as to the desirability of `Pictures` over `Names` or `None`.

*5.5.2. Layout*. Personal preferences were expected to surface in the reactions of the evaluators to the three layouts. Patterns of preference were varied, resulting in a statistically insignificant effect of Layout ($F_{(2,54)} = 0.906$). We used multidimensional weighted unfolding (MDU) (Shepard, 1972) to analyze the underlying structure in the individual preferences. The MDU analysis was performed using ALSCAL (SPSS 6.1.4 for Windows) which yielded an RSQ of 0.870 — the amount of variance in the data accounted for by their distances. The inputs to the analysis were the positions of the layout and audience conditions and the "dissimilarities" between evaluators and designs. The screen layout conditions were positioned on the grid based on our assessment of the dissimilarity among the conditions. The `Portholes` condition is more dissimilar than the `Theater/Side` because of the 3D nature of the design while the `Theater/Orchestra` was placed between them because of its hybrid 2D/3D design. The placement of the audience conditions made use of the observation that `Size` was the

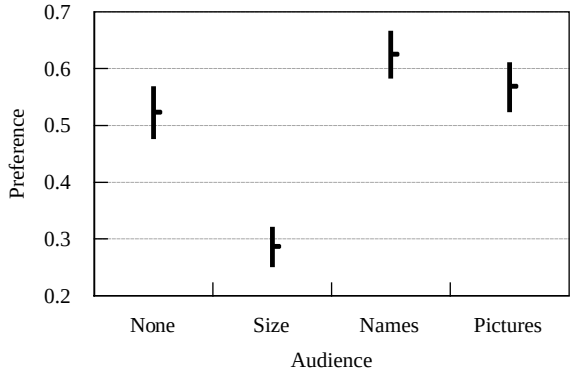



FIGURE 10. Audience preferences.

TABLE 2
*Results of requirements survey*

| Item | Requirement | Important or nice to have (%) |
|---|---|---|
| Q1 | See my non-core team members along with my core team members at all times | 61 |
| Q2 | Assess how many people on my non-core team | 68 |
| Q3 | See a set of blue images for my non-core team members instead of a number for size of non-core team | 26 |
| Q4 | See the names of my non-core team members at all times | 71 |
| Q5 | See the pictures of my non-core team members at all times | 46 |
| Q6 | See not only the blue images but also the names of my non-core team members at all times | 64 |
| Q7 | See not only the names but also the pictures of my non-core team members at all times | 57 |
| Q8 | See my own image in the layout | 64 |
| Q9 | Control whether I see my own image | 89 |
| Q10 | Control the placement of my image | 75 |
| Q11 | Control the placement of core and non-core team member images in the layout | 86 |
| Q12 | Control of placement of images of team members looking back right now | 89 |
| Q13 | Assess how many people can potentially see my image | 71 |
| Q14 | See a number for how many people can potentially see my image | 67 |
| Q15 | See team members of looking back right now at all times | 86 |
| Q16 | Look in one place to see the team members looking back right now | 89 |
| Q17 | Display information about team members looking back right now separately | 54 |
| Q18 | Display a marker on the images of the team members looking back right now instead of duplicate images | 68 |

least preferred condition and thus placed at one endpoint. The other three conditions were then placed in the order of increasing information value with the `Pictures` condition being placed at the other endpoint.

Using the positions produced by the unfolding analysis, we performed a hierarchical cluster analysis using the Ward method. This produced four distinct clusters. An examination of the results from both analyses (see Figure 11) showed that people did differentiate the layouts. As expected from unfolding theory, the cluster analysis revealed that there was not one single preferred view but rather four.

Figure 12 shows the average layout preferences for each of the clusters. Individuals in Clusters A and D clearly prefer `Portholes` and `Theater/Side`, respectively. However, the placement of Clusters B and C near the center of the Layout dimension (see Figure 11) does not necessarily imply a preference for `Theater/Orchestra`; they

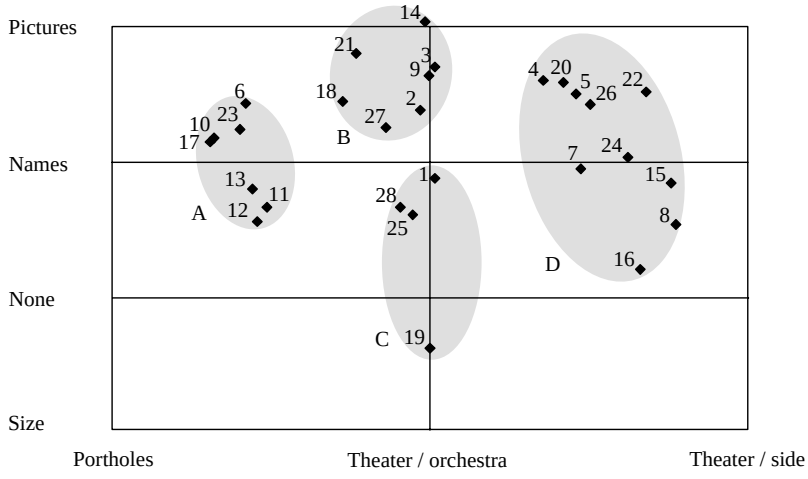



FIGURE 11. Two-dimensional unfolding of preferences.

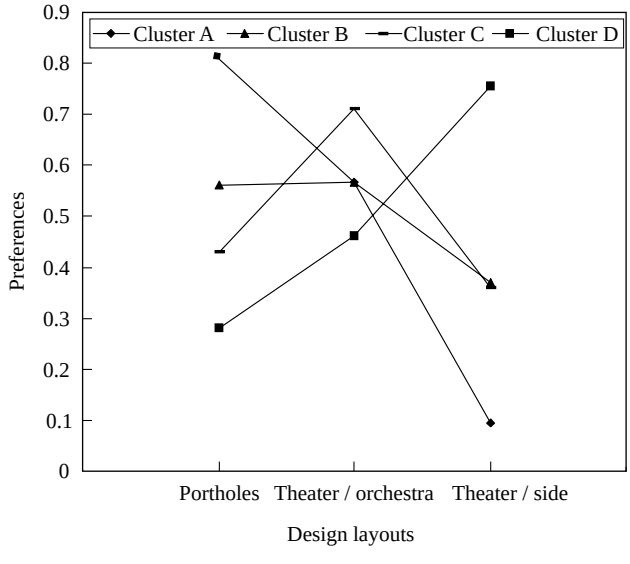



FIGURE 12. Preferences grouped by clusters.

include people who based their preference more strongly on the audience conditions (see Evaluators 14 and 19 as extreme examples of this). Overall, individuals in Clusters B and C have similar preferences for layout and could be combined if Evaluator 19 was treated as an outlier.

*5.5.3. Requirements survey*. Participants rated the importance of 18 design requirements for a Portholes display (see Table 2). The five-point rating scale was 1 for "No

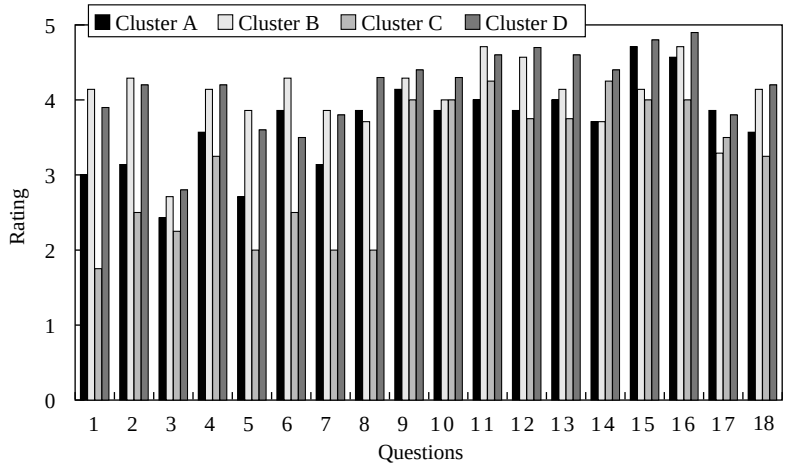



FIGURE 13. Average ratings by cluster.

Way'', 2 for ''Should Not Have'', 3 for ''Don't Care/Either Way'', 4 for ''Nice to Have'' and 5 for ''Important to Have''.

The requirement Q3 to use blue rectangles to complete the audience size information, was the only one generally rejected by evaluators, rated a 1 or a 2 by 18 out of 28 people. This corroborates the objective preference selection for the audience `Size` option, reported earlier (see Figure 10).

The universally agreed upon requirement was Q16; to be able to ''look in one place to see the team members looking back right now'', rated ''Important to Have'' by 23 evaluators. Interestingly enough, this includes all individuals in Cluster D — `Theater/Side` — whose most preferred design required the user to look to the right and to the left to see who was looking back (see Figure 13). Almost as highly rated was requirement Q15 to ''see team members looking back right now at all times''. Evaluators in Cluster C rated both of these requirements significantly below Clusters A and D. Meanwhile, evaluators in Cluster B rated Q16 higher than Q15.

Three questions addressed the issue of the non-core team member images: Q1 (show the images), Q5 (show as pictures), and Q7 (show with names and pictures). Clusters B and D evaluators wanted to see as much as possible (average preference = 3.95 and 3.77, respectively), while Cluster A evaluators were indifferent. Individuals in Cluster C did not want to see any of the information (average = 1.92).

The user's own image has been a concern to some Portholes users in the past. This issue was explored with three questions: Q8 (in own display), Q14 (on other's display), and Q13 (how many can see own image). Except for Q8 for Cluster C, these were rated nice to have by all evaluators. The people in Cluster D (`Theater/Side` preference) were more concerned about their image and who saw it than the people in the other three clusters. Looking at the survey data as a whole, most requirements were regarded as positive additions to Portholes by people in Clusters A, B, and D. Evaluators in Cluster C did not want to see much information in their display or for that matter, use an awareness tool.

### 5.6. SUMMARY AND DISCUSSION

The results reveal four different clusters of preferences regarding the layout and audience options to use; representing differences in importance of the information to different groups of people. Clusters A and D clearly prefer `Portholes` and `Theater/Side`, respectively. However, Clusters B and C based their preference strongly on the audience conditions; it was not necessarily the case that they preferred `Theater/Orchestra`. Clusters B and D wanted to see as much information as possible.

Evaluators indicated a strong universal dislike for the use of blue rectangles to represent occupied seats for non-core team members; with no information being more preferred. Our intuition is that people reacted strongly to the choice of representation rather than usability concerns; they viewed the blue images as nameless, faceless individuals. This result supports the argument for paying attention to how people relate to technologies (Reeves & Nass, 1996). This speculation could be validated in a preference study using a number in place of blue rectangles.

The preference and survey results show that there is no universal agreement on the choice of the layout and the level of detail for audience information. Evaluators want to see at least the names of the non-core team members. A large percentage ($> 75\%$) want to control the placement of the information. Evaluators differed also on which layout is preferred. This suggests that all three layouts should be provided as user-selectable options.

Finally, among long-term users of Portholes, we found that the needs for Portholes change (Lee et al., 1997). That is, the customization for new users differs from those who use it for a long time. This evolution can be, in part, attributed to the emergence of the new ''middle region'' behavior formed in response to the effect of using Portholes over time (Meyrowitz, 1985). See Dourish, Adler, Bellotti & Henderson (1996) for similar observations associated with long-term use of a media space. It would be useful to examine the structure of the users' preferences and its evolution over time.

For the new implementation, described in the previous section, we were guided by the experiment results to provide only the pictures option for the audience. Users can still suppress the audience by making the Portholes display too small to show the audience. We offer all layout options as user selectable choices with two additional compact layout options that do not allocate space for lookback but indicate somebody looking back by changing the color of the title area of that user.

## 6. Taking stock—initiatives and perspectives for further work

A major driving force underlying our efforts has been predicated on identifying user concerns and on developing design and technical initiatives to address them. We recognize that these initiatives are a part of a multi-disciplinary, multi-perspective approach. In this section, we review a broader range of initiatives that are necessary; some of which have already started. By its intended coverage, this review will incorporate other designs and technical initiatives beyond our own.

### 6.1. TECHNICAL INVESTIGATIONS—IMAGE FILTERING EXPERIMENTS

User concerns about self-presentation, surveillance and privacy are linked strongly to the use of video images. In attempting to resolve these concerns, different controls such

as image blur, image sharpening and activity sensing were acknowledged as being helpful. However, these capabilities should not be supported strictly as control mechanisms on video images. Some users would prefer them as alternative options for video images.

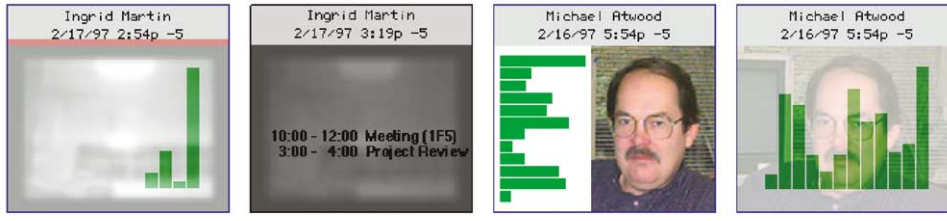
A number of researchers have also taken a lead from the image blur approach by developing and evaluating a number of different image filtering techniques that mask out sensitive information in the video images (Hudson & Smith, 1996; Coutaz, Crowley & Bérard, 1997; Zhao & Stasko, 1998; Boyle, Edwards & Greenberg, 2000). Several of these experiments are supplemented with user evaluations of the effectiveness of the techniques for conveying or suppressing awareness information. In particular, Zhao and Stasko (1998) explored the question of the effectiveness of a pixelization filter, an edge-detection filter, and a shadow-view filter to convey or suppress activity, identification and presence information. While the study is a useful start towards answering this question, the study is limited because of the way the questions were asked of the subjects which made their task be one of discrimination rather than interpretation. A recent follow-on investigation examined how well people are able to interpret a scene that has been manipulated by a combination of blur and pixelization filter at different fidelity levels (Boyle *et al*., 2000). These studies did not examine the willingness that users have to use the image filtering feature.

### 6.2. DESIGN INVESTIGATIONS — LOW-COST INDICATORS, COMPOSITES, COLLAGES

While image filtering provides a technical approach to the privacy and disruption issue, there have been efforts in the design arena to develop alternatives to video images. Also, recent research has shown that complex remote collaborations could be carried out with simple text-based tools only (e.g. Churchill & Bly, 1999) or instant messaging tools such as ICQ and AOL Instant Messenger. The alternative approaches use low-cost iconic indicators and abstract representations that provide more succinct information about presence, and availability while, in some cases, ensuring more privacy (Ackerman & Starr, 1995; Greenberg, 1996; Wax, 1996; Pedersen & Sokoler, 1997; Viegas & Donath, 1999).

Hudson and Smith (1996) took these ideas one step further by combining presence information and head and shoulder photos of people to create a synthetic group shot. We explored a generalization of this approach based on a lead from some of our creative users who created video messages using drawing and photographic tools. Specifically, we composited, as either overlays or non-overlapping compositions, various pieces of information such as the image blur, activity chart, video message, and photo. Figure 14 illustrates examples of such composites. Recently, Greenberg and Rounding (2001) proposed a Notification Collage which is a electronic-based public bulletin board where users post assorted media: live video; editable sticky notes; activity indicators; photo slide shows, and Web page thumbnails.

While these efforts are all intriguing, there are no formal evaluations of how valuable users find this information, what the trade-offs are for the user with respect to privacy and efficiency vs amount of information and disruptiveness or their willingness to use these designs. Such studies will provide better understanding of the limits of these approaches because anecdotal user experiences with them, including our own, have




foggy image overlaid with last hour's activity

gray image overlaid with video message of calendar

photo plus last hour's activity: adjacent & overlaid

FIGURE 14. Some alternatives to video images.

suggested that there are privacy, reciprocity and usability concerns (Greenberg & Rounding, 2001).

### 6.3. SOCIAL CONTROL AND SOCIAL NORMS

Our involvement both as researchers and developers in the Portholes project was necessary because of the investigative aspects of the work. However, in practice, it would be rare for both users and developers to be in close proximity of each other so that developers can shepherd the introduction of such technologies. Furthermore, we set a small number of Portholes usage rules (e.g. users could not subscribe to use Portholes if they were unwilling to publish their own images).

In practice, such rules, norms of behavior and their regulation are socially constructed. They emerge through negotiation among the users. This has been strongly argued for by a number of researchers (Bellotti & Sellen, 1993; Harrison *et al.*, 1993; Harrison & Dourish, 1996). They contend that such systems need to be designed in a flexible manner so that "*users may actively participate, adapt and appropriate the technology*" in order to truly facilitate the emergence of new and distributed forms of social organizations. In this research, we provided a user control and customization mechanism and identified some of the information that our users want to disclose. What we have not addressed in this research is how a system can facilitate the social construction of rules and norms. This remains an open research issue.

### 6.4. DIFFERENT LEVELS OF BEHAVIORAL ANALYSES

Our two studies in this paper focussed exclusively on two levels of analysis; inter-individual (dyads) and intra-individual. This has provided insights into user needs and user preferences. However, there is clearly a need to consider analyses at the group, community and organizational levels. Such analyses can provide better insights into factors influencing some user concerns or these concerns can be better understood when the group and organizational unit in which the group exists are studied. They also need to be done in relation to pre- and post-introduction of technology. In the pre-introduction of technology, a social unit can be examined for group, organizational and community issues pre-existing to predict the effectiveness with which a technology can help or hinder its development. For example, McKnight and Webster (2001) examined

the issue of the climate of organizational trust, or the general likelihood that people within organizations are willing to depend on others, as a key influence on the acceptance of awareness systems. People have also suggested that groups that do not function well are unlikely to function better with the aid of technology (Harrison *et al.*, 1993). Finally, the introduction of technology into a group or organization can greatly affect its dynamics and its proper functioning. A long-term study of the use of a media space (Dourish *et al.*, 1996) revealed not only the impact of the technology on individuals using the technology but also the social, organizational and communal members drawn in by the technology. Consequently, after the introduction of technology, group, community, and organizational levels of analysis are also important to examine and validate their impact.

## 7. Conclusion

A contribution of our study of Portholes is the initial user concerns raised within the context of deploying the tool within a workplace consisting of a larger and more heterogeneous mix of people. Our experiences provided insights into how it will be initially received by a broad base of users and what the tool should include to overcome the initial reactions to a portholes-like awareness tool. More importantly, the study has identified initial perceptions that people have to a video-image-based approach to group awareness, and provided insights and a better understanding into the issues underlying them. This understanding enabled us to make improvements into the design of Portholes.

The initial reactions that people have to Portholes were enlightening and valuable in helping us think about the crucial properties of portholes-based video awareness tools. First, the overview model needs to be supplemented to accommodate reciprocity and awareness of audience. Second, it is not only important to support privacy but it must be designed in such a way that it is easy to achieve and that immediate feedback of the change is provided. Third, it is important to design feedback and control capabilities within the system so that users retain control over their video images while still permitting the system to perform periodic, automatic, and passive capture, distribution and update of video images. Fourth, in addition to group and collaboration awareness, Portholes need to support activity awareness (Lee *et al.*, 1997). Fifth, it should be a property of Portholes to allow users to choose alternatives to video images.

Our experiences highlight the critical role that people's initial perceptions and reactions of the technology play in its acceptance. The knowledge gained in our effort to make Portholes available to a broader base of users adds to the current small body of literature on experiences with introducing, using and gaining acceptance of media space technologies. The factors that underlie these concerns are complex, difficult to pinpoint and only being gradually teased apart and understood. Hence, the need to experiment with a mix of diverse resolution approaches is important. Furthermore, without more comprehensive knowledge of the critical properties of the design of video-based, background awareness tool, there is a greater need to design these systems in a flexible manner for users to adapt and alter them in order for such technologies to support group work.

This paper argues for the importance of the social interface and its design. From a narrower perspective, it provides an understanding of these issues for Portholes and group awareness tools. It illustrates two pieces of information needed in such a social interface and how it appears in the user interface: the sense of being in public and reciprocity. The design uses a theater setting to provide a familiar behavioral context and uses different sections to present a user's community, their audience, and who is looking in on the user. We argue that without this information and a way to present and access it, users do not "know their place".

From a broader perspective, the paper provokes thinking about what the social information is in other computer-mediated communication tools and how to bring forth this information in the user interface to elicit the desired impressions and reactions. Concerns for surveillance and privacy are not unique to Portholes. Even technologies such as television and radio have wrought changes in social behaviors, roles, order and situations. In grounding the discussion with Portholes, we try to relate the studies of face-to-face and mediated interactions, to make the concepts of "sense of place", social information and social interface more concrete and applicable to the design of computer-mediated tools and to show that its design can be fraught with issues that we are just beginning to understand (Goffman, 1959; Meyrowitz, 1985; Dourish & Bly, 1992; Reeves & Nass, 1996).

Finally, Portholes make a number of technical contributions related to the use of the Web infrastructure and components in its implementation, to the architectural design for scaling the system to many users and sites, to the use of image blurring and activity sensing features, and to the introduction of a novel visual and social interface incorporating two pieces of reciprocity information (i.e. theater view).

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