

# CSCW 2000 WORKSHOP

## Shared Environments to Support Face-to-Face Collaboration

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# QueryKids: A Collaborative Digital Library Application for Children

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## Abstract

There is a wealth of digital information accessible through computers. However, most interfaces are oriented towards adults. To fill this void, we are developing a collaborative digital library application for young children. Our prototype system, QueryKids, offers a graphical interface for querying, browsing and reviewing search results for multiple children using multiple mice. Early studies show that QueryKids successfully supports one user searching for media, and our informal observations show that two users have difficulty. We are currently exploring ways of solving this problem on the screen with redesigned interactions and through the use of tangible user interfaces.

## Authors' Backgrounds and Motivations

**Juan-Pablo Hourcade**, University of Maryland

Juan-Pablo Hourcade is a Ph.D. student at the Computer Science Department at the University of Maryland. He has a B.S. in Computer Science from American University and an M.S. in Computer Science from the University of Maryland. Mr. Hourcade's research interests include Single Display Groupware, Multiple Input Devices, and other technologies that may be used to enable face-to-face collaboration. Mr. Hourcade is the leading author of MID, a Java architecture for enabling input from multiple devices. He has also been heavily involved in the development of KidPad.

Juan Pablo will attend the workshop.

**Benjamin B. Bederson**, University of Maryland

Benjamin B. Bederson is an Assistant Professor of Computer Science and director of the Human-Computer Interaction Lab at the Institute for Advanced Computer Studies at the University of Maryland, College Park. His work is on information visualization, interaction strategies, and collaborative applications. He has worked on Single Display Groupware (SDG) activities for a number of years at both the University of New Mexico and now at UMD.

**Allison Druin**, University of Maryland

Allison Druin is an Assistant Professor in the University of Maryland and a Visiting Senior Faculty Member at the Royal Institute of Technology (KTH), Sweden. Her research focuses on the impact technology can have on children and the impact children as design partners can have on the design of new technology. She is principal investigator from KTH in the KidStory project (funded under the EC ESPRIT i3, ESE initiative), where new collaborative storytelling environments for children are developed with the children. She is also involved in several other research projects, including developing digital libraries for young children (funded by the National Science Foundation) and developing new robotic animals to support physical therapy of children (funded by the Maryland Industrial Partnership). In addition to her research activities, she is the co-editor of the new book "Robots for Kids: Exploring new technologies for learning" (Morgan Kaufmann, 2000) and the editor of "The Design of Children's Technology" (Morgan Kaufmann, 1999). She received her Ph.D. from the University of New Mexico's College of Education in 1997 and a M.S. from the MIT Media Lab in 1987.

## **Research Description**

### **Introduction**

While there is a great amount of digital information available, it usually must be accessed through interfaces designed for adults. These interfaces often require typing, spelling, and reading skills or entail an understanding of abstract concepts such as Boolean logic that young elementary school children do not possess. QueryKids [6], a collaborative digital library application, attempts to fill this void by providing children with a graphical user interface for querying, browsing and reviewing search results from digital libraries.

QueryKids is the result of the efforts of an interdisciplinary, intergenerational team of researchers including computer scientists, educators, psychologists, artists, biologists, elementary school teachers, and children. We worked with two different groups of children. One group, seven children, 7-11 years old, met with us at our lab and participated in the design of QueryKids from the very early stages of brainstorming and paper prototyping. A bigger group made up of 120 children aged 6-9 years old from a local elementary school acted as informants, helping us to confirm whether our ideas were generalizable to a more diverse population.

QueryKids was built as a module of KidPad [2, 4, 7], a collaborative storytelling application. It currently accesses a database with media about animals. Like KidPad, QueryKids supports multiple users by getting input from multiple mice through MID [5]. The panning and zooming features in QueryKids' interface make use of Jazz, a Java toolkit we developed for research in Zoomable User Interfaces (ZUIs) [1].

Our child informants in school have used QueryKids (in single user mode) and the results have been encouraging. The children showed high levels of accuracy when posing queries involving a single query item, a union of two query items and an intersection of two query items [6].

## Description of the Interface

QueryKids consists of three areas through which children can look for media about animals. Figure 1 shows QueryKids' initial screen and the three areas. One of the areas is a virtual zoo. The zoo provides a way of browsing the contents of the animal database in a familiar setting. When entering the zoo area, children see the map of a virtual zoo. By zooming into parts of the zoo, children can find representations of the animals they are interested in and use these to specify search criteria. For example, children looking for media about lizards can zoom into the reptile house where they can find a representation of a lizard they can use to specify their search criteria. The zoo area is currently not fully implemented.

The world area provides a way for children to browse the animal database by looking for animals geographically. It presents children with a globe they can spin and zoom into. By zooming into a region of the world they can find representations of the animals that live in that part of the world and use them to specify search criteria. For example, if children wanted to look for media about polar bears, they could look near the North Pole, find a representation of a polar bear, and use it to specify their search criteria. The world area is currently not fully implemented.

The search area gives children the ability to visually specify and manipulate queries. It also provides a preview of the search results. The search area is the rightmost picture in Figure 1. The characters on the top left of the area are named Kyle and Dana. We call them "Query Kids." They provide a way of viewing the search criteria currently being used.

Most of the search area is made up by the query region. The items in this region are the components from which queries can be formed. The items on the left side of the region represent the types of media available through the database. Currently, only images are available and a camera represents them. The items on the right side of the region represent the hierarchies under which the animals in our database have been classified. They enable children to look for media about animals based on what they eat, where they live, how they move, and a biological taxonomy.

To explore these hierarchies, children can click on the shadows under the items. This enables them to drill down a hierarchy causing the items under the item that was selected to zoom into focus, replacing the items previously shown. To move up the hierarchy,



**Figure 1: From left to right:  
The prototype's initial screen, the zoo area, the world area, and the search area.**

children can click on the up arrow to the left of the hierarchical items.

When an item (media or hierarchical) is clicked on, it moves towards one of the query kids to hold around their neck. This item becomes part of the query criteria. Media items move towards Kyle while hierarchical items go to Dana. Clicking on an item that is on Kyle or Dana makes it go back to its original location therefore removing it as one of the criteria for the current query.

The search items on Kyle and Dana visually represent the queries children formulate. Our prototype performs an intersection between items selected from different categories and a union between items selected from the same category. We created our hierarchical categories so that items within a category do not overlap (i.e. an intersection would yield an empty set). Therefore, children need not be concerned if they need a union rather than an intersection.

The region to the right of Kyle and Dana shows the results of the current query. The children can zoom into the region by clicking on it. By seeing the results of their queries as they pose them, children can quickly tell whether the database has any items that correspond to their query criteria.

### **The Problem of Shared Navigation**

While our child informants at the public school haven't tried QueryKids with multiple mice, the team of kids at our labs has. When used with multiple mice, QueryKids provides each user with a "hand tool" that can be used to navigate through the QueryKids world and make selections. The kids at our lab had a hard time coordinating their actions as they tried to navigate to different parts of the QueryKids world. They often explored different hierarchies in the search area and would be very upset when the other child chose an area they were not interested in exploring. Another problem that often occurred is that one child would want to go to the results area while the other child would still want to add more items to the query criteria.

This is an instance of a common problem in Single Display Groupware systems typically known as a shared navigation problem where users share a space bigger than the screen. We have had similar problems with KidPad, where kids get upset if another kid zooms or pans while they are working on a drawing. We have yet to find a solution to this problem in KidPad.

### **Discussion of Solutions to the Shared Navigation Problem**

In video games, the shared navigation problem has typically been solved in two ways. The most common way is to divide the screen into portions (one per user) and give each user control of the navigation in their portion of the screen. Another way is to only move to another location if all users agree to do so.

Dividing up the screen would defeat the purpose of co-present collaboration as users might as well navigate separately in two or more computers. The approach of all users agreeing on where to navigate to holds more promise. After all, the problem of shared navigation arises when users don't agree on where to navigate. On the other hand, it would make the interface less efficient and more cumbersome because it requires all users to agree as to where to navigate, and then they must all navigate together.

We are exploring several options to support shared navigation in QueryKids. One option is for all users to agree on where to navigate in QueryKids. This option could be implemented by requiring all users to click on the area they want to navigate to. This approach would force users to collaborate having some similarity to Bricker's [3] approach to Single Display Groupware.

We have also considered giving users different tools with different capabilities so that navigation decisions by the users won't conflict. One tool would take care of the navigation between areas and inside hierarchies while the other tool would handle the selection of query items. In this way, kids would be forced to collaborate in order to pose queries, as one kid wouldn't be able to perform searches on his/her own. This approach would also make it cumbersome to pose queries and could negatively affect efficiency in cases when kids disagree on what to do as they could prevent each other from progressing towards their goals. This would also make an awkward interface when used by only one user.

Since we are not satisfied with our ideas for solutions on the screen, we are considering making the querying interface a tangible user interface. The technology we are exploring to help us accomplish this is MusicBlocks by Neurosmith, a commercial product aimed at children 2 years of age and above. As an input device, MusicBlocks consists of five cubes with a different tag on each side that can be put in five bases.

We believe MusicBlocks could be adapted to QueryKids. Four blocks could provide children with ways of specifying their choices under each of the four ways of looking for animals we have. The fifth block could be used for specifying the type of media of interest.

A MusicBlocks interface would have some limitations compared to the screen prototype. It would not support hierarchies and it would not support unions of items under the same category (although unions could also be composed by joining the results of two queries). It would also limit the number of possible categories and the number of items within a category.

On the other hand, a MusicBlocks interface would avoid the shared navigation problem. It would also make QueryKids accessible to younger kids, as the blocks are much easier to handle than a mouse. Furthermore, the lack of hierarchies would be less important if the users of the MusicBlocks interface were as young as two years old, as they would have a hard time understanding hierarchies at this age.

## Justification for Participation

QueryKids is a working Single Display Groupware application in a domain where Single Display Groupware has not been used before. QueryKids must also deal with a common yet unsolved problem in Single Display Groupware: shared navigation. Bringing up this issue is likely to generate a fruitful discussion that would be highly beneficial to the face-to-face collaboration research community.

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## The EDGE of Face-to-Face Collaborative Technology

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### Introduction

For centuries humans have been working together successfully to solve problems. The advent of the computer provided new opportunities for supporting collaboration. Computer Supported Cooperative Work (CSCW) research has traditionally focused on distributed collaboration, which was not feasible before computers. We believe it is equally important to investigate how emergent technologies can enrich our co-located collaborative activities. Advances in wireless, mobile computing are opening up new avenues for the support of face-to-face collaboration. The notion of a truly ubiquitous network is on the horizon. However, how users will effectively interact within this new environment, particularly when collaborating, remains an unanswered question. Many of the core assumptions and ways of interacting with single-user computers need to be re-thought. Merely adapting existing architectures to support this new interaction paradigm will inhibit the potential of these new environments. Innovative research on new metaphors and interaction strategies is essential to ensure seamless support for collaboration. We are currently exploring these metaphors and strategies to elucidate how technology can support users in their daily collaborative work practices. Through a series of vignettes, we will present some of our on-going research as well as our vision for emergent research directions.

#### *In the Field*



*Colleen and Greg are amusement park designers working for Ferris Inc. on the design of the new “Extreme Park”. Sean, the park owner, and Kelly, the geological consultant, are scheduled to meet Colleen and Greg at the proposed site to discuss their initial design layout of the park. Colleen’s handheld computer recognizes that Sean and Greg are nearby and automatically sends the new layout plan their handheld computers over a wireless network. Kelly also joins them from the future site of the Tunnel of Love and the handheld computers recognize that she is a privileged user in the group and sends her the information as well. Now that everyone is present, all four team members open the proposed park layout on their handhelds. Each of the handhelds displays*

*global information augmented with information pertinent to each person's job. For example, Kelly's handheld displays the Ferris Inc. park design as well as geological information of the proposed site. Because Sean is present when Kelly opens the application, a note she had made earlier (reminding her to discuss the Loop-D Loo roller coaster with him) appears. She mentions to the group that there is a significant incline in the bedrock at the proposed site of the Loop-D-Loo roller coaster. Greg, the ride engineer, mentions that blasting would be necessary. Sean checks the budget on his handheld and realizes that blasting would bring them over budget. Colleen and Greg decide to head back to the office to modify the design.*

Our group has been conducting research to facilitate the kinds of collaborative activities that our fictitious characters perform on handheld computers. One of the main advantages of handheld computers is that they are portable. However, their form factor has encouraged personal rather than collaborative use. Most applications of handheld computers often reinforce the idea of a handheld computer as a personal digital assistant (PDA). Our work focuses on using handheld technology to support face-to-face collaboration. The three main threads of this work include: collaborating across handhelds; visualizing information across handhelds; and how wireless technologies can facilitate collaboration using handhelds.

### **Collaborating Across Handheld Computers**

Our initial work involved the design of a collaborative activity to be played on multiple handheld computers [2]. Geney™ was developed to assist children in exploring the concept of genetics using an interactive game medium. Geney simulates a population of fish representing a gene pool. The fish are distributed across multiple handheld computers, with each handheld representing a single pond of fish. Students can exchange fish with their friends through the handheld computer's infrared port. These fish will produce offspring that have genetic traits derived from their parents' genes. The children must work collaboratively to breed a fish that matches a set of target characteristics. There is also functionality present in the game to sync up with a desktop computer to visualize family tree information.

### **Visualizing Information Across Handheld Computers**

Limitations of handheld computers for collaboration include their small screen and limited viewing angle. This makes it difficult for multiple people to collaborate around a shared display. An initial solution was investigated using low-fidelity prototypes, which used multiple handhelds to create a tiled display. In this way, large displays could be simulated when access to a desktop or wall display is unavailable.

Another solution to the screen real estate problem is to distribute detailed information across multiple handhelds. Each handheld displays a subset of the information that the users collectively synthesize. The initial prototypes were very similar to the way our fictitious design team interacted when looking at the layout of the Loop-D-Loo at the amusement park site. This idea was explored through Geney by incorporating a WHAT-IF analysis [4]. The WHAT-IF feature provides information that children can use to make collaborative decisions leading to the desired outcome of Geney. Children form ad-hoc groups of two to five players to use the feature. One child's display would show global information while the other displays would show detailed information about the potential outcome of mating specific fish. WHAT-IF does not provide an answer to which fish should be mated, but is a tool to help the children make informed decisions to aid them in attaining the goal of the game.

### **Implications of Wireless Technologies**

Other disadvantages of current handheld technology are that users must actively engage in the transfer of information, and that communication is primarily peer-to-peer. Thus, users must switch their focus from an application to the act of transferring the information. We are presently exploring how wireless communication between handheld computers can better facilitate face-to-face collaboration. The advent of the Bluetooth™ specification will provide new opportunities in this area. Protocols for ad-hoc group formation are being considered along with the implications of passive data transfer.

### *At the Office*



*Returning from the field to modify their park design, Colleen and Greg sit down at a workstation and both put on their co-view glasses. These glasses provide them with private views augmented on a shared display. In addition, this workstation is equipped with multiple input devices to enable simultaneous interaction. Greg investigates the dimensions of the Loop-D-Lo roller coaster, while Colleen scans the park layout for rides that could be swapped with the roller coaster. During this process, both users can see the overall park layout (i.e. shared information), while each user can also explore specific aspects of the park, which may or may not be visible to the other user. For example, while Colleen is investigating the details of several rides this information is not visible to Greg. Once she has made her final selections, she makes this information public, enabling Greg to view it as well. Greg and Colleen are now ready to discuss their proposed changes with the park manager.*

### **Advances to Single Display Groupware**

We have already made significant research contributions in synchronous shared environments, especially in the area of Single Display Groupware (SDG). SDG systems provide support for small groups collaborating around a shared screen by offering simultaneous, multi-user input [8]. We have performed extensive investigations on how the use of multiple input devices can impact face-to-face collaboration. In particular, we have investigated its impact on achievement, motivation, engagement, and development of a shared understanding [3, 6, 5]. In general, this research suggests that support for simultaneous, multi-user interaction can provide positive benefits in each of these areas.

One of the limitations of Single Display Groupware systems is that by default all information is public. If users want to work in separate locations on the screen, they may quickly run out of screen real estate. Furthermore, pop-up menus or toolbars can clutter the display area and can be distracting. We have developed a technique that enables private information to be augmented on a shared display [7]. This allows users to seamlessly multi-task, while still maintaining the benefits of working on a shared display. This offers users flexibility in their collaborative work strategies.

We have also explored the use of detail-in-context techniques to help overcome screen real estate issues. We have utilized detail-in-context to provide multiple users with views on a shared information space. This was accomplished by extending Carpendale's [1] detail-in-context technique, Elastic Presentation Space (EPS), to provide support for multiple users. Multi-user EPS (MEPS) allows local magnification for each user while still maintaining the overall context of the information space.

Finally, we have begun to explore face-to-face collaboration with users working around a tabletop display system. There are many important questions about shared information, integration with other devices, and suitable interfaces for a large collaborative screen that need to be addressed.

### ***In a Meeting***



*An all-day working group session is booked with Sean, the park owner, and Kelly, the geological consultant. The meeting is being held in the brainstorming room at Ferris Inc. Colleen brings her laptop and Kelly brings her handheld computer. The brainstorming room at Ferris Inc. is equipped with two large wall-projection displays and the conference table also has the capability of becoming a display. Sean grabs one of the electronic tablets also available in the room. Wireless networking is enabled for all of the devices.*

*The topic of the day is the proposed park re-organization related to the relocation of the Loop-D-Loo. Colleen and Greg bring up their suggested modifications on the central display. Kelly synchronizes her handheld with the coordinates of the new location to view the geological data for that area. This allows her to easily make informed comments related to the presentation. Kelly notices an unstable area of land and requests that the central display be augmented with this information. Analysis of this new information reveals that minor re-positioning of the Loop-D-Loo will be required. While the group debates this new scenario, Greg runs the waiting-line simulation on the laptop to ensure that this new layout will not impact queues for the rides (note, because the devices are connected, the suggested change is automatically available in the simulation). Great, it works! He opens up a second window on the shared display and runs the simulation for the group.*

*Throughout the day, an automatic outline has been created, documenting activities that have taken place. Sean has been adding personal annotations to his version of the outline on the electronic tablet. Even though he is accessing a 'borrowed' tablet, it is connected to the network, so his document will be available back at his office.*

*After a productive but exhausting session, the group has made substantial progress and most importantly, the technology facilitated the group's interactions in a seamless manner. It looks like the project will be finished on-time and under-budget!*

### **Collaboration Across Displays**

With wireless, mobile networking capabilities, and a plethora of new computer technologies, we are no longer tied to our desktop computer. New advances will allow us access and utilize technology in new ways. Given that we often want or need to collaborate with others in a multitude of scenarios, it is important that we take advantage of

the potential of each technology. In a group collaborative process, such as in the scenario above, we may want to take advantage of handheld computers, laptops, electronic tablets, as well as table or wall displays. Each of these devices has strengths and weaknesses, which should be utilized to support the collaborative activity. This not only requires communication between the devices, but more importantly, it requires an understanding of “how” users can best take advantage of multiple technologies. How should information be distributed across devices? What information is best displayed where? How do the users interact with the devices as well as with each other? We are currently developing a testbed environment to begin exploration of this new paradigm of interaction where users seamlessly collaborate in a technology-rich environment.

## Conclusions

As illustrated in the aforementioned scenarios, there are many potential technological advances that can better facilitate face-to-face collaboration. As these new technologies become ubiquitous, it is imperative that they are designed to effectively support collaborative as well as individual use. Research in this area needs to examine how users interact not only with the technology, but also with each other. A paradigm shift is needed to move away from the constraints of personal computing, where technology is an extension of our individual and interpersonal processes. Our past, current, and future work will help define this vision of computing for the future.

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# A Tangible Difference: Participatory Design Studies Informing a Designers' Outpost

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## ABSTRACT

In our previous studies into web design [11], we found that pens, paper, walls, and tables were the primary tools used for explaining, developing, and communicating ideas during the early phases of design. One common practice was to produce information architectures using paper on walls. This practice inspired us to work towards The Designers' Outpost, a tangible user interface that combines the affordances of paper and large physical workspaces with the advantages of electronic media to support information design. In this paper, we describe a series of three participatory design studies that explored the combination of physical and electronic media.

## Keywords

Tangible Interfaces, Web Design, Sketching, Information Architecture, Computer Vision, Informal Interfaces, CSCW

## BACKGROUND AND MOTIVATION

In our previous studies into web design [11], we found that pens, whiteboards, paper, walls, and tables were primary tools used during the early phases of design. Later phase design, where detailed page mockups are generated, occurs mostly on the computer. This finding is not surprising, and is consistent with work practice studies across many design and engineering domains [2, 5, 23]. In one common early-phase practice, designers collect ideas about what should be in a web site onto Post-it notes, and arrange them on the wall into categories. This technique, often called affinity diagramming, [3] is a form of collaborative sketching used to determine the site structure.

The large workspace offers several clear benefits for the task. It permits the representation of large, complex information spaces without the loss of contextual, peripheral information. Collaboration is aided both by the persistence of the artifact, which supports asynchronous collaboration and constant awareness of the state of the project, as well as by the greater-than-human-sized space allowing multiple people to simultaneously view, discuss, and modify the artifact.

However, there are drawbacks to a paper-centric representation. Much of the information exists in the *relationship* between information chunks (Post-it notes).

Because structure must be maintained manually, marks the designers make about the data, such as links or groups, often fall out of sync as notes are shifted around. At some point, the paper is removed and the site structure display is lost. The designers in our studies also lamented that versioning is unfeasible in a paper only representation.

This work practice offers few opportunities for remote participants. We also found, as others have, the transition from the early paper-centric design stages to the later pixel-centric stages to be highly problematic [15]. Those who worked hard to architect the site feel a sense of lost ownership as the project is "thrown over the wall" to graphic designers and developers.

We describe a series of three participatory design studies to develop The Designers' Outpost. We first evaluated the basic concept with a paper prototype study. Next, we built interface mock-ups that envisioned the combination of physical artifact state with interactive feedback. Finally, we created a wall-scale prototype for a set of participatory design sessions with fifteen professional interface designers.

With Outpost, paper in the physical world becomes an input device for the electronic world. Projectors output electronic information onto surfaces in the physical world. A user has the same fundamental capabilities as in a paper-based system: she can create new pages by writing on Post-it notes and organize a site by moving notes around the wall. In addition to easing basic information architecture tasks, our system will support the transition from this early representation to later electronic artifacts, such as a formal sitemap.

## RELATED WORK

Our research is inspired by previous work in two areas – early stage web site design and tangible user interfaces, a technology that seems well suited to this domain. We describe these two areas next.

### Web Site Design Practice

The purpose of our earlier ethnographic study [11] was to inform the design of systems to better support web design practices. The study consisted of interviews with eleven professional web site designers from five different

companies. Each interview consisted of asking the designer to choose a recent project and walk the interviewer through the entire project, explaining what happened at each phase.

Three important observations were made during the course of this study. First, designers create many different representations of a web site. Second, the production and use of these *intermediate artifacts* dominate the day-to-day work practice for most of the design process. Third, we learned that web design is comprised of several sub-specialties, including information architecture and visual design, each of which has its own tools, products, and concerns. We found that information architecture is not well supported by current software tools.

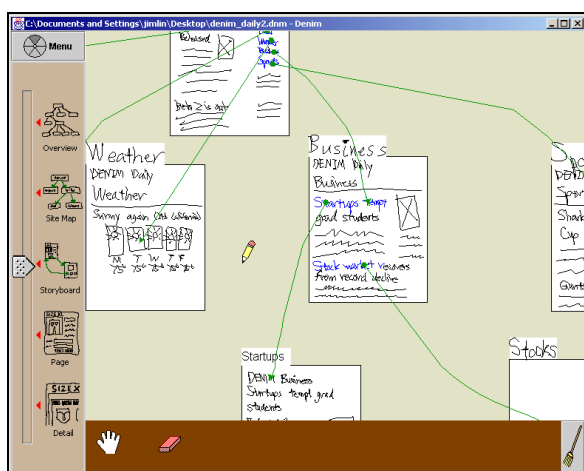
## DENIM

Based on the results of our studies, we developed DENIM, a sketch-based tool supporting information and navigation design of web sites [9]. DENIM (see Figure 1) supports sketching input, allows design at different refinement levels, and unifies the levels through zooming. In particular, DENIM supports visualizations matching the *sitemap*, *storyboard*, and *schematic* representations of a web site. While DENIM supports authoring site maps, it is best suited for storyboards and page schematics.

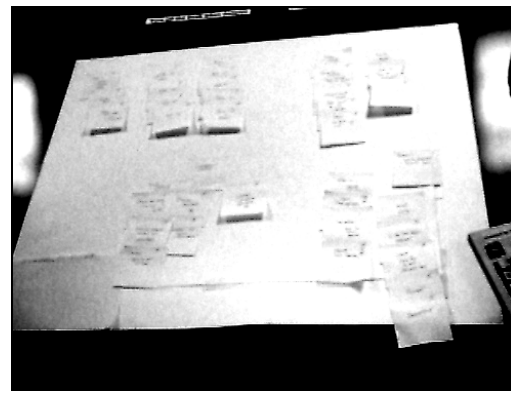
## Tangible User Interfaces

Wellner and colleagues produced several prototypes of a DigitalDesk system that used ceiling mounted cameras to track documents and hands, and a ceiling mounted projector to augment a real desk with electronic information [15]. MIT's Tangible Media Group created the metaDESK [6], a digital desk employing tangible interfaces as the controls for and views of a map of the MIT campus. Another project, transBOARD [6], uses tagged whiteboard markers so remote users can view whiteboard contents on their desktop.

Researchers at Xerox PARC have investigated interactions



**Figure 1.** DENIM, shown here in “Storyboard View,” allows designers to design web sites by sketching and integrates sitemap, storyboard, and individual page representations through zooming. Information spaces created in Outpost will be imported into DENIM, serving as baseline sitemaps.



**Figure 2.** The low-fidelity Designers' Outpost.

on walls and whiteboards, including the LiveBoard [4]. Recently, they developed Collaborage, “a collaborative collage of physically represented information on a surface that is connected with electronic information.” [10]

Several other researchers have made important contributions in this area, including Streitz [13], Winograd [16], and Rekimoto [12]. This body of work motivates the concept that for many tasks, computer input is best performed by manipulating physical objects on large surfaces.

## LOW-FIDELITY DESK: DESIGN STUDY

We created our initial low-fidelity prototype using cardboard the size of an ITI Digital Desk (41” diagonal), evaluating this paper prototype with two individual participants. The participants wrote on a pad of Post-it notes using an inking pen (see Figure 2). We gave the task of creating the information architecture for a web site about off-campus housing for college students. A wizard acting as the computer gave verbal feedback about what the computer recognized as groups, which groupings were being selected, and displayed widgets and dialog boxes when appropriate.

There were two key results. The participants forgot to upload new notes to the system explicitly; therefore the real system should do this automatically. The participants also wanted one pen, for both real and virtual inking.

## PIXEL AND PAPER MOCK-UP

We then created an interface mock-up showing physical notes and corresponding system feedback [7] (see Figure 3). It became evident that a desk is too small a space for web information architecture; it affords for a maximum of fifty Post-its and two or three users. Information architects often use upwards of two hundred Post-its and four to eight people might be simultaneous participants in design sessions. To build the Designers' Outpost at a full collaborative scale, we moved to a SMART Board, a rear-projected surface in the form factor of a whiteboard [1].

## INTERACTIVE WALL: INTERFACE PROTOTYPE

Our low-fidelity and mock-up prototypes informed the design of our first interactive prototype. We used this



**Figure 3.** Mock-up of the Designers' Outpost: Collaborating on an information hierarchy with Post-its on a digital desk.

system for design studies with fifteen professional interface designers.

The prototype was implemented as a Java application running on a rear-projected 72" diagonal touch-sensitive SMART Board [1] with a 1280x1024 LCD projector. Drawing a line from one note to another with the stylus creates a link. The stylus can also be used to create freehand electronic ink on the board.

Tapping on a note brings up a context menu that lets users either delete the note or define it as the label note for its group. (In the full Outpost, removing a note from the board will delete it.) Individual notes are outlined in gray. Notes that are close to each other are deemed to be in a group; these notes are outlined in blue.

#### **INTERACTIVE WALL: DESIGN STUDY**

We ran five design sessions with between two and five designers per session for a total of fifteen participants. Two of the five groups were information architects, two groups visual designers, and the fifth group had individuals who performed both roles. Information architects are mainly concerned with the information and navigation design of a web site. Visual designers typically focus on interaction and graphic design.

The sessions started with a high-level overview of the project and a demo of the prototype. The designers were then given an information architecture design task. During the session the researchers and designers often engaged in dialog. These design sessions lasted 45-60 minutes, followed by a fifteen demonstration of DENIM, a 45-minute discussion, and finishing with a written questionnaire.

#### **INTERACTIVE WALL: DESIGN FINDINGS**

Our findings from this study offer insight into the designers' collaborative process and suggest an appropriate interactivity model.

#### **Existing Board Work Process**

Every participant currently works with groups on whiteboards early in the site design process. The information architects all said they currently create sitemaps by placing Post-it notes on the board, while the visual designers talked about sketching page designs directly on the board. Whiteboard meeting capture was highly valued by all five teams. Three of the design teams currently use a digital camera, one uses a whiteboard capture device (the Virtual Ink Mimio), and one team assigns a scribe. Also, every designer said that they currently use either the Visio or Inspiration software packages for site map creation and refinement.

#### **Interactive Board Work Process**

We observed groups going through three general phases of design.

##### *Phase I: Brainstorming*

The goal of this phase is to quickly put a large number of concepts on the board. Similar information was placed close together. The designers were adamant about not wanting system feedback during this phase. "We didn't do anything here that we couldn't do on a normal whiteboard." One team actually turned off the board.

##### *Phase II: Creating a Top-Level Information Architecture*

In this phase, designers migrate from notes on the board to a high level information architecture by clustering related information, pruning unnecessary concepts, and linking notes together. The tool support was well suited to this phase. This was evident in how smoothly we observed the designers working, by their enthusiastic comments while designing, and on the post-test questionnaire.

##### *Phase III: Drilling Down- Adding Information with Free Ink*

The goal of the third phase is to "drill down to more detail." We saw work process differences begin to emerge. The visual designers began page-level design using the stylus. In contrast, the information architects fully fleshed out the page structure of the site, continuing to add notes. The key design implication from this phase is the ability to associate freeform ink with individual notes.

##### *Overall Process*

We observed two styles of interacting with the board. In the "facilitator" style, one person, usually the senior-most individual, stood at the board (see Figure 4). The second style was "open board." Here, several designers wrote notes simultaneously and everyone had a chance to put notes on the board (see Figure 5). We started the sessions with a single pad of notes and a single marker next to the board. One design team requested one pad and marker per person. In this paradigm, each person has his or her own "input device."





**Figure 4.** This is an example of the “facilitator” style.

### OUTPOST DESIGN IMPLICATIONS

This study underscored several important points about how “calm” [14] an informal design tool must be. The system feedback should not interrupt the designers flow state.

We originally felt that one of the benefits of the prototype was that the system automatically recognized groups based on note proximity and provided visual feedback. The designers unanimously felt that grouping by proximity was not useful; they already know where the notes are. The designers liked the idea of explicitly circling a set of objects to group them.

Furthermore, the feedback was considered distracting. One designer said, “I’m totally disturbed while I’m trying to concentrate on what we are doing. There are too many things flashing.” In hindsight, this result is consistent with the negative user opinion about design time feedback in SILK [8], an informal GUI design tool.

### Sweet Spot on the Tangible/Virtual Spectrum

We have seen wall-scale interfaces that are completely virtual [4] and we have seen interfaces that are completely physical [10]. One of our research goals was to leverage the advantages of both.

#### *Fluidity and Physicality*

One facilitator began authoring the sitemap virtually, sketching out square notes and their content. This has the advantage that there is no need to switch between an ink-based pen and a board stylus. The drawback is that the work process was noticeably slower. The low projector resolution and stylus difficulty impacted the artifact creation process, encouraging minimal input.

One of our concerns about a tangible/virtual interface was that designers would find it tedious to remove physical objects from the board as they began to flesh out the design in detail (phase III). We asked designers about this issue directly and also watched for frustration with this during the design sessions. Surprisingly, the designers did not



**Figure 5.** This is an example of the “open board” style.

mind removing the physical objects; on the contrary, removing them was a natural signifier of a shift in the design process.

### Extending the Existing Work Process

For a system like Outpost to be successful, it must both support existing work practices and offer designers advantages that only electronic tools can provide.

#### *Versioning*

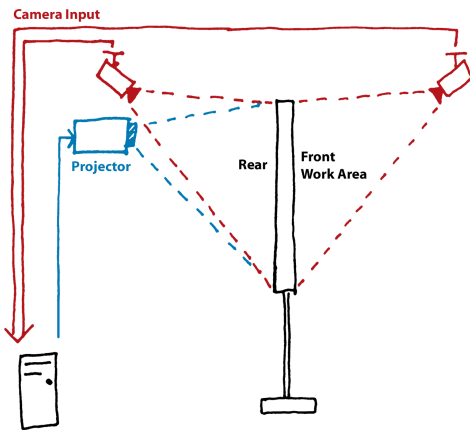
Our earlier study into web design practice showed that designers desired a way to manage different *versions* of design ideas [11]. Several of the design teams said they would like to replay a design meeting at a faster pace. The design solution of a shuttle dial, a la video editing, seemed natural to almost everyone. One designer said that replaying, “gives you an insight into the process you wouldn’t normally get.” People also liked the idea of a physical version jar to explicitly save checkpoints or finished designs; versioning is a central enough issue that having both techniques makes sense.

#### *Transitioning to Other Tools*

Every group mentioned that migrating the design artifact to other tools for further refinement would be an essential advantage of Outpost. We propose that an appropriate tool to transition to is DENIM. We intend to make Outpost and DENIM interoperable by using the same XML file format. This will also enable remote members of a design team to collaborate with the rest of the team.

#### *Integrating Physical Images*

During the sessions, the design teams often referenced earlier projects, work they’d seen, and personal experiences. As we discussed this referral process with them, we discovered that they often bring in photographs, pages of magazines, and other visual aids to help them design. Outpost should allow designers to stick these visual artifacts on the board, and associate them with pages in the information architecture.



**Figure 6.** The Outpost system infrastructure.

### OUTPOST SYSTEM INFRASTRUCTURE

Given what we learned from these design studies, we are now revising the interface, and improving the vision back-end. We are building a full Outpost using three sensors: a touch sensitive SMART Board, a rear-mounted 640x480 industrial digital video camera, and a front-mounted three megapixel USB still camera (see Figure 6). Our current goal is to build an Outpost prototype that is robust enough for us to deploy at a design firm.

### CONCLUSION

We have described a sequence of three design studies, culminating in a study with fifteen professional designers. These studies show that the interaction techniques for working with electronic whiteboards should be calm and that there is substantial merit in a system that is simultaneously tangible and virtual. The designers we spoke with encouraged our pursuit of a versioning system for information architectures, and were enthusiastic about fluid transition to tools such as DENIM.

### ACKNOWLEDGMENTS

Thanks to John Canny for everything from giving us lab space to vision help to soldering advice. Thanks to Marti Hearst for helping to conceive the original concept for Outpost. Thanks to Jimmy Lin and Jason Hong for Java programming advice. Thanks to Gerelee Goltsev, Bjorn Liljequist, Shilpa Sood, and Michael Toomim for early design ideas on properties. Thanks to Smart Technologies for the donation of the SMART Board. Thanks to the support of Trevor Pering, Mark Holler, and Gary Bradski at Intel. This work is supported by a grant from the National Science Foundation. Finally, a big shout out to all the designers who participated in our design studies.

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# **SUPPORTING COLLABORATION AND ENGAGEMENT USING A WHITEBOARD-LIKE DISPLAY**

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## **Abstract**

Large interactive display surfaces have the potential to combine the simplicity, spontaneity and presence of a conventional whiteboard with the convenience, clarity, and archiving and retrieval capabilities of a computer display. Recent developments in display projection and large surface digitising have brought the cost of such displays to a level where they can be utilised to support a range of everyday activities. This paper describes the LIDS (Large Interactive Display Surfaces) project, recently commenced at the University of Waikato. LIDS focuses on the use of low-cost whiteboard-like shared interactive displays, and is exploring whiteboard metaphors and lightweight interaction techniques to support group collaboration and engagement. Three closely related application areas are being studied: (i) support for single and multiple site meetings and informal discussions, (ii) the use of such displays in teaching, and (iii) their use in personal information management.

## **Authors' Backgrounds and Motivations**

**Mark Apperley** has more than 25 years of research and publication experience in the field of HCI. Previous work has focused on interactive systems design, interaction techniques, information visualisation, visual languages and collaborative systems. He is Principal Investigator for the Large Interactive Display Surfaces (LIDS) and Collaborative Information Gathering (CIG) projects at the University of Waikato, both supported by government grants through the New Economy Research Fund. The LIDS project focuses on applications of low cost large interactive display screens, with specific reference to single and multiple site meeting/collaboration support, in addition to applications in teaching and personal information management.

**Masood Masoodian** (attending author) has been doing research in the field of CSCW for several years. The primary focus of his research has been the study of the effectiveness of different human-to-human communication media in supporting group interaction in synchronous computer-based shared workspaces. He has also been involved in design, development, and evaluation of a number of computer-supported collaborative work environments. He is a member of the LIDS research team.

## **Research Description**

LIDS (Large Interactive Display Surfaces) is a joint project between the University of Waikato and Auckland University of Technology, funded by the Foundation for Research, Science and Technology through the New Economy Research Fund. Work on the project commenced in May, 2000. This paper provides an overview of the project, and its underlying general philosophy. The research objectives are described, with a particular emphasis on those objectives relating to face-to-face collaboration, along with preliminary outcomes and results.

### ***Overview and Philosophy***

Large display screens have long been an important medium for teaching and business presentations. They enable the presenter to share a visual space with the audience. Simple passive systems, such as blackboards and whiteboards, offer transparency of use and permit spontaneity in presentation. Projection systems offer superior quality images, sound and animation, but with the cost that the material must be prepared in advance, and cannot be altered significantly during a presentation. More recently, video projection from a computer has become a popular large screen presentation tool. It offers more flexibility than film or slides, in that the presenter can interact with the presentation and make changes on the fly, but this usually means disengaging from the audience in order to “fiddle” with the keyboard or mouse. In the research described here, the intention is to foster engagement and participation through direct interaction with the display, emulating the use of a conventional whiteboard.

A number of studies in recent years have explored the potential of large screen displays, both passive and interactive. These have considered such diverse applications as office whiteboards [7], meeting support [1, 6, 9] and remote site collaboration [10]. A common characteristic of all of these studies has been the high cost of the display technology. Recent developments in display projection and digitising devices have meant that truly interactive large screen displays, resembling whiteboards both in appearance and style of use, can now be assembled at a relatively low cost. In the LIDS programme, we are exploring and developing the application of such displays in supporting teaching (both face-to-face and distance modes), meetings and discussions (face-to-face and remote collaboration) and personal information management (the individual office environment). This is being achieved through the utilisation of existing low-cost technology, the development of new software and interaction paradigms, and the modification and exploitation of existing software, and by drawing on results and experience from the earlier research already mentioned.

Our general approach is to emphasise “lightweight” interaction, and a matching of the supporting technology to the task. For example, teachers already prepare class material using presentation software such as PowerPoint™; they often annotate this material with a felt-marker as it is delivered. An ideal record of the class is a combination of these two,

synchronised with the spoken delivery, without being unduly formalised or sanitised by the requirement to record it. Similar considerations relate to meeting records, and to the informal use of a whiteboard in an individual's office. This is the approach we are taking, to provide tools which combine the informality and utility of a whiteboard with the convenience and recall of computer-based applications.

### ***Research Objectives***

Within the LIDS programme, three closely related application areas are being explored: teaching and distance learning, meeting support, and personal information management. In all three of these areas, large display surfaces have the potential to be used both in collaborative and stand-alone modes. In teaching, and particularly distance learning, we intend to demonstrate the ability to efficiently record, retrieve and disseminate lectures, seminars and tutorials, with almost no additional effort on the part of the teacher. Similar technology will be applied to the support of meetings and tutorials conducted over multiple sites, and this technology will be adapted to support both informal and formal face-to-face discussions and meetings. Related developments will be shown to be applicable in managing information and informal discussions within a personal office environment.

Common threads which run through these application areas, and which are particularly relevant to the support of face-to-face collaboration, include:

- (i) The underlying display technology, comprising a wall mounted display surface and pen-like interaction devices. The emphasis here is on a simple, inexpensive display system and interaction device(s), which are consistent with the whiteboard model.
- (ii) The development of a "whiteboard" metaphor, utilising tools and interaction techniques consistent with this informal tool, but which exploit the dynamic nature and retrieval capabilities of a computer display. We are particularly interested in the informal early design styles seen in SILK [2] and DENIM [3], and in assessing the relative merits of free-form versus OCR'd text, in this context.
- (iii) The sharing of the display real estate, allowing face-to-face participants to interact with the shared space from individual laptops, PDAs or WAP devices. We see this extending beyond the interactions described for iRoom [1], to allow multiple users to interact with a common document or screen, providing annotations, moving material, or claiming sections of real estate on which to present their own arguments or views.
- (iv) The development of tools which can operate transparently with standard desktop applications. We consider it important to allow the integration of standard applications into our environment, so that previously prepared documents or diagrams can be discussed and annotated, and that early designs can be gracefully transformed into completed solutions.

Other aspects of the project, of less direct relevance here, include the recognition of hand-drawn mathematical expressions [4], and “through the window” views of participants at remote locations [10]. This research is still in its very early stages, and only modest outcomes can yet be reported.

### ***Progress to Date***

At this stage two display systems have been constructed, one at each of the two sites involved. These comprise a rear projected glass screen and a Mimio™ whiteboard digitiser [11]. Each screen is approximately 900mm high by 1200mm wide. In one case frosted glass has been used for the screen, and in the other, clear glass with a tracing paper underlay. In both cases, projection is from a standard data projector. The Mimio digitiser has proved an inexpensive yet very effective means of providing pen-based interaction directly on the screen surface.

Evaluation of the display prototypes has been carried out using the Mimio™ mouse software, PenOffice for Windows [8], standard Windows applications, and the DENIM software[3]. The performance of the display system is more than satisfactory for the proposed research.

Work is now beginning on the main objectives of the programme (ii, iii and iv above).

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### **Justification for Participation**

Although the research described in this paper is in its very early stages, the research programme is directly concerned with the topic of the workshop. It is concerned with *novel environments that support users' natural collaborative behaviour, and issues surrounding shared environments for face-to-face collaboration*, and it exploits *wall style displays, alternative collaborative input devices, multiple input devices and collaborative interfaces*. Both the workshop itself and the research programme described will benefit from the work being presented at the workshop.

# **UNICAST and GROUPCAST: An Exploration of Personal and Shared Peripheral Displays**

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## ***Introduction***

We often hear predictions of a technology-rich future in which our environments will be filled with artifacts that can sense and respond to us in new ways – a world filled with cameras, microphones, visual displays and audio speakers, to name but a few. Although such a world may seem threatening or menacing in some depictions, it may be possible that such developments will lead to more accommodating environments, encouraging more frequent and beneficial interactions among the inhabitants of such spaces.

A physical space that can sense people in the vicinity, and has knowledge of their interests, can use this information to create new informal interaction opportunities for these people. For example, a shared public display in a workplace, combined with a tracking system, can display information of mutual interest to the people passing by the display. People may choose to take advantage of this information to initiate a conversation with someone about whom they may know very little, leading to an increased sense of community in the workplace.

We have built two applications to explore the use and effects of peripheral displays in two different workplace contexts: UNICAST, a personal display within an individual's office; and GROUPCAST, a shared display in an open area of an office building. These will each be described briefly below.

## ***UNICAST***

UNICAST is an application that allows users to specify content they would like to see on a peripheral display located within their primary workspace. In some respects, UNICAST is an extension of PointCast™, which allows people to specify news topics and stock symbols about which they would like to stay informed while their desktop computer is in screensaver mode. UNICAST is different in two key aspects: it allows broader content and runs all the time on a peripheral display.

The content for UNICAST does include headlines and stock information, but it includes many other types of content as well. The current implementation includes user-configurable modules for each of the following types of content:

- Web pages
- Headlines
- Stocks
- Factoids
- Weather
- Horoscope
- Flashcards
- Announcements
- Reminders
- Artwork
- Pictures
- Webcams



Users first select a module to install, then configure the module according to the type of content it is associated with. For example, for the web page module, any number of URLs can be specified, for headlines, there is a form with checkboxes for each topic, and for weather, the user enters one or more U.S. zip codes. At present, users can not create their own new modules (unless they want to write Java code), but we are hoping to create module templates that users can use to create their own modules in the future.

Each user's content configuration is specified in his or her UNICAST Profile, which can be modified at any time. The current implementation of UNICAST randomly cycles through a user's profile, displaying each page for fixed time period (default is 15 seconds) before moving on to the next. We are considering allowing a finer level of customization, so that different content can be displayed for different periods of time. However, want to balance this desire for finer customization against the need to maintain a simple, intuitive interface for specifying content.

Although UNICAST can be configured to run as a screensaver, we have installed a number of flat-panel displays in individual offices throughout our workplace environment, so that in each office, peripheral content can be displayed all the time on a device other than the user's primary workstation. UNICAST was recently released to ten people within our lab, and we hope to do a study of people's experiences with the system after a longer period of use.

Our model of interaction is of an ambient display [Weiser & Brown, 1997] rather than the primary workstation display used for supporting a user's primary work tasks. UNICAST was designed to explore what kinds of content people would be interested in seeing on a peripheral display. The hypothesis is that this content would be interesting, but not terribly important or urgent, since important or urgent information is (or could be) sought out directly on the primary workstation. For example, the first author uses UNICAST to cycle through his favorite on-line comics, which help to brighten his day, but are rather peripheral to his work, and which he therefore rarely seeks out on his primary workstation.

## **GROUPCAST**

The goal of GROUPCAST is to explore what kinds of content would create opportunities for informal interactions in open areas in the workplace. By using our ArialView awareness system – a network of infrared badges and sensors throughout the workplace – we know who is near a large, shared display, and can use information about those people to display content that may provide opportunities for those people to start a conversation.

For example, Joe and Teresa do not know each other very well; however, the “Wine of the Day” web site pops up as they both pass by a large, shared display, leading to a spontaneous and serendipitous discussion about the merits of old-vine zinfandels. After the discussion, they both go away, knowing a little more about each other, and are more likely to have conversations in the future.

One of the stumbling blocks we encountered in the initial design of GROUPCAST was how to acquire content that would be of mutual interest. We considered a large profile containing content that people could rate with respect to their interest level. When people passed each other in front of the GROUPCAST display, content in the intersection of their interests would be displayed.

However, we soon discovered we had conflicting goals: having a profile that would be broad enough to include content of potential interest to a large number of people, and yet still be small enough so that we could reasonably expect people to specify that content, e.g., by filling out a form. By the time we had amassed enough potential content in our profile form, we were fairly confident that no one (besides those working on the project) would take the time to fill it out.

After we launched UNICAST, we had an insight: instead of using the intersection of known interests of both (or all) people near the display, just display content that one of the people had already specified in his or her UNICAST profile. Although that content might not match the profile of the other people, it is still of

interest to at least one person passing by, and may still generate the desired conversation between the passersby. Using the UNICAST profile, we can rely on people's own self-interest in customizing content that they will see regularly (in their office), rather than struggling with the somewhat less rewarding task of specifying content that only is available when they are in a public area.

Eventually, we'd like to investigate other ways of using the profiles, such as using an intersection of the profiles (returning to the original design) or the set difference between profiles (since that would ensure novelty on at least one person's part). We also look forward to investigating the contrast, if any, between what kind of content people want to see in their own workspace and what they want to see (and share) in a public area.

We'd like to design an interface that allows people to pick up content from other people's profiles, based on serendipitous encounters at the GROUPCAST display; perhaps we could use a speaker identification system, triggered on the keyword "Cool!" A speech recognition capability might allow us to not only create conversations but also facilitate their continuation by eavesdropping on conversations and bring up new content related to words spotted in those conversations.

## **Background and Motivation**

Most environments are *passive* – deaf, dumb and blind, unaware of their inhabitants and unable to assist or engage them in a meaningful way. However, with the advent of ubiquitous computing – ever smaller, cheaper and faster computational devices embedded in a growing variety of "smart" objects (beyond desktop computers) – it is becoming increasingly possible to create *active* environments: physical spaces that can sense and respond appropriately to the people and activities taking place within them. Most of the early UbiComp applications focus on how *individuals* interact with their environments as they work on *foreground* tasks. In contrast, I am interested on how *groups* of people affect and are affected by *background* aspects of their environments.

The Active Environments research group at Andersen Consulting's Center for Strategic Technology Research (CSTaR) has developed a number of applications that create examples of active environments. Our first application, MusicFX [McCarthy & Anagnost, CSCW98, CSCW2000], is an example of an active environment that senses who is present in a fitness center, knows the musical preferences of all its members, and chooses music that is best suited to the current set of inhabitants. We have subsequently explored new techniques for group preference arbitration [Nagendra Prasad & McCarthy, IAAI99] and other potential environmental contexts for adaptive music, such as retail stores and restaurants.

We are also developing new applications that focus on the workplace (rather than the workout place). One such application, ActiveMap [McCarthy & Meidel, HUC99], is a visualization tool that enables people to gain greater awareness of the location and activities of coworkers, creating opportunities for seeking out colleagues for informal, face-to-face interactions. Another application, EventManager [McCarthy & Anagnost, HUC 2000], is an asynchronous awareness tool, enabling people to specify events of interest involving people and locations (e.g., "Tell me when Ted returns to his office"), so that users can find opportunities to find (ambush?) people with whom they would like to initiate face-to-face conversations.

Technology can have an isolating effect on people, as people spend more time with electronic gadgets and less time with other people. Our larger goal is to explore how technology can create, enhance and take advantage of group activities and relationships in the real world. We would welcome an opportunity to meet with other members of the CSCW community to discuss any/all of these issues at the workshop on Shared Environments.

If this paper is accepted, the first author would attend the workshop.

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Position Paper for the CSCW-2000 Workshop on

## **Shared Environments to Support Face-to-Face Collaboration**

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Most of the work in CSCW has been focused on technologies for electronic information spaces for sharing and disseminating information, collaborating through electronic “virtual workspaces,” and creating communication technologies for collaboration at a distance. While these technologies are valuable, there has recently been a reassessment of the basic value of working co-located in physical spaces (e.g., Olson and Olson, 2000). This workshop is timely.

Over the last decade, I have been exploring various “wall” technologies, both electronic and physical walls. The electronic wall technology was the whiteboard metaphor-based Tivoli software running on the Xerox LiveBoard hardware. Tivoli served as a platform to explore wall-scale, pen-based, user interface techniques (e.g., Moran et al., 1995), multimedia meeting capture (e.g., Moran et al., 1996), and domain-specific meeting tools (e.g., Moran et al., 1998). The physical wall technologies were based on camera capture. The ZombieBoard (Saund, 1999) captured freeform scribbling on large whiteboards. The Collaborage system (Moran et al., 1999) captured and interpreted spatially arranged collages of information elements on tackboard walls, such as arrangements for collaborative project planning and coordination.

However, I'd like to approach this workshop from a different tack. This Summer I spent a sabbatical at Carnegie Mellon University, where I worked in the Computer Science Department HCI Institute, the School of Architecture, and the School of Design. I led an effort to formulate a research program exploring flexible and effective collaborative workspaces. What was especially interesting to me was to approach this as an architectural, not a technology, problem – that is, as a problem of creating effective collaborative places from space-defining physical elements. Pragmatically, I took this approach, because the effort was centered at the Intelligent Workplace building in Architecture. But I think this perspective is also valuable for the workshop to help define the environment in which information technologies can get embedded.

As some background, consider the study of “The New Design Studio: Understanding Collaborative Spaces,” conducted by the CMU Design Department (Boyarski et al., 1999). This study observed several Pittsburgh design firms to understand how office space is used to promote collaboration and support the work process in their design practices. They found that firms use several open-style office plans that reflect differing workplace cultures. Often the spatial arrangements were critical in promoting informal spontaneous interactions, a vital component of collaboration (cf. Kraut et al., 1990). These interactions happened in different kinds of spaces in the offices. There was also a tension in the need for privacy and quiet for much of the work; and people in different disciplines had different needs. Another finding was that the offices were undergoing

constant change, and space was being rearranged and redefined to meet changing project needs. Thus, the study concluded that flexibility of spaces and facilities is critical.

The program I helped formulate built on lessons from this study to explore innovative ways to create collaborative work spaces, addressing several issues – the need to balance private work and collaborative work, and the need to be able to flexibly reshape work spaces, and the need to integrate information technologies. The program was called “Project Places.”

We conceived of the physical workplace as consisting of several kinds of locales or places: individual places (such as personal offices), meeting places (such as shared conference rooms), and social places (such as the coffee area or copier area). The focus of this program is to explore the notion of project places. A Project Place (PP) is a collaborative physical place dedicated to a project for a period of time. Corporations sometimes give PPs to critical projects (Covi et al., 1998), often called “war rooms.” However, PPs are always under scrutiny for whether they are good investments compared to shared meeting rooms. Yet the concept of a PP brings the issue of effectively supporting collaboration to the fore. PPs support a number of critical functions:

- residence for workers (primary or secondary)
- project work center (unique project tools, references, products)
- small informal meetings (ad hoc, long, asynchronous)
- storage (and organization of project materials)
- palimpsest (“residue” of activities reflects history of project)
- display (manifests state of work, presents work to shareholders)

The CSCW literature often describes collaborative activity as a conversational unfolding of events. Collaborators engage in sharing, proposing, discussing, ratifying, and disseminating to create and maintain a “common ground” among an interdisciplinary team (Clark and Brennan, 1991; Geisler et al., 1999). To this we want to add a “making” point of view, where collaborators not only converse, but actively create, design, and iteratively refine solutions to problems. In this way, the PP supports constructive work, as well as the conversations around work.

PPs flexibly support a variety of project types. PPs bring the most value to tightly coupled projects where interdisciplinary work is required, and more creative projects, where new conceptualizations are forged from close collaboration. Projects can also be classified by the kinds of materials they use and produce. “Soft” projects deal with electronic representations (such as software/web development). “Hard” projects involve physical artifacts (such as designing an appliance). Of course, most projects are both soft and hard to some extent. Hard and soft projects require different kinds of PPs, creating different requirements for size of space, horizontal and vertical surfaces, storage and display needs, technology requirements, visual and acoustic privacy, security, and so on. PPs will adapt to this variety of needs.

We proposed exploring a variety of strategies for designing PPs: fixed spaces with critical infrastructures to support a range of project types; mobile components that allow flexible reshaping of spaces (“just-in-time”); or temporarily expandable spaces for shared meeting places. All three strategies will be prototyped, used, and evaluated. The goal is to find the appropriate modular architectural components for customizing PPs. One

interesting aspect of this early work was the notion of an “object design” methodology for discovering modular physical components. Another aspect is the usability issues arising from customizable technologies.

Hopefully, this perspective should provide for some interesting discussions at the workshop.

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# Collaboration Using Multiple PDAs Connected to a PC

*Short Paper as a Proposal to attend the  
Workshop on [Shared Environments to Support Face-to-Face Collaboration](#) at [CSCW '2000](#)*

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## Abstract

The Pebbles research project is investigating how the functionality and the user interface can be spread across all of the computing and input / output devices that one or more users have available. In this way, the hand-held devices can be used to augment the other computers rather than just being a replacement when other computers are not available. As part of this research, we are looking at how multiple people can use their hand-helds to share control of a main computer running either legacy applications, or custom multi-person applications. We are also looking at how information and control can be fluidly moved between the main screen and the individual hand-held screens.

**Keywords:** Personal Digital Assistants (PDAs), Palm Pilot, Windows CE, Pocket PC, Single Display Groupware, Pebbles, Multi-Computer User Interfaces, Command Post of the Future (CPOF).

## Introduction

The Pebbles research project (<http://www.cs.cmu.edu/~pebbles>) has been studying the use of mobile hand-held computers at the *same time* as other computing devices. As people move about, they will be entering and leaving spaces where there are embedded or desktop computers, such as offices, conference rooms, and even "smart homes." We are exploring the many issues surrounding how to have the user interface, functionality, and information spread across multiple devices that are used simultaneously. For example, there are many ways that a personal digital assistant (PDA), such as a Palm Pilot or Pocket PC device, can serve as a useful adjunct to a personal computer to enhance the interaction with existing desktop applications. New applications may distribute their user interfaces across multiple devices so the user can choose the appropriate device for each part of the interaction. We call these kinds of applications "multi-computer user interfaces (MCUIs)." Important attributes of MCUIs are that they use heterogeneous devices for both input and output, that many of the devices have their own embedded processors, that the devices are all connected and share information synchronously, and that the devices are all co-located and are used by individuals or groups. A key focus of our research is that the hand-held computers are used both as output devices and as input devices to *control* the activities on the other computers. This research is being performed as part of the *Pebbles* project. Pebbles stands for: **P**DAs for **E**ntry of **B**oth **B**ytes and **L**ocations from **E**xternal **S**ources. This paper gives a brief overview of the

Pebbles research as it relates to the workshop themes. For more information on Pebbles, see our other publications [\[Myers 1998\]](#) [\[Myers 2000a\]](#) [\[Myers 2000b\]](#), or the Pebbles web site.

## Single-Display Groupware

When multiple people are in a meeting, each with their own hand-held, the hand-held might be used to control the main display. This is often called *Single Display Groupware (SDG)*, since all users are sharing the same screen and therefore the same widgets. We created a shared drawing program, named PebblesDraw, that allows everyone to draw simultaneously [\[Myers 1998\]](#). In creating PebblesDraw (shown in [Figure 1](#)), we had to solve a number of interesting problems with the standard widgets such as selection handles, menubars and palettes. Palettes, such as those to show the current drawing mode or the current color, normally show the current mode by highlighting one of the items in the palette. This no longer works if there are multiple people with *different* modes. Furthermore, the conventional menubars at the top of the window or screen are difficult to use in multi-user situations because they may pop up on top of a different user's activities. The conventional way to identify different users is by assigning each a different color, but in a drawing program, each user might want to select what color is being used to draw, causing confusion between the color identifying the user, and the color with which the user will draw. We therefore developed a new set of interaction techniques to more effectively support Single Display Groupware.

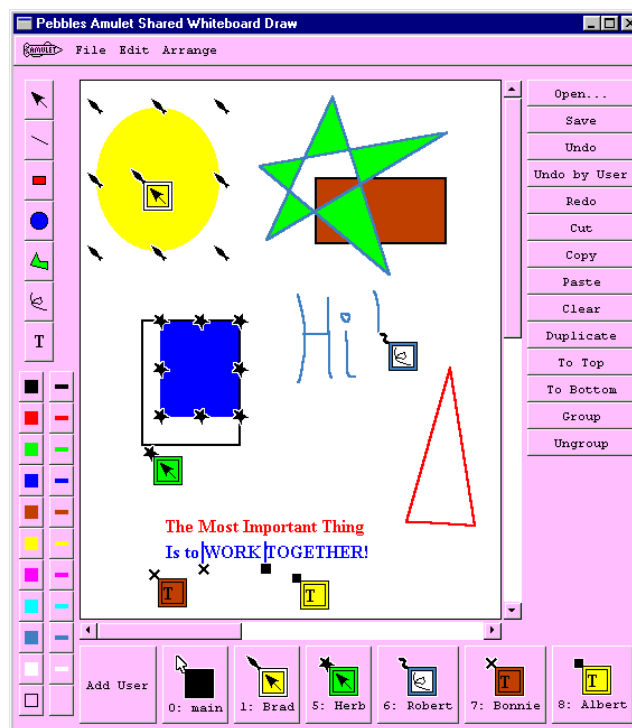


Figure 1. The PebblesDraw shared drawing tool. Each person has their own cursor shape, and the user's modes are shown in that user's cursor, as well as in the home area at the bottom.

In other cases, users might want to collaborate over legacy applications that only support a single cursor. Our "RemoteCommander" application allows each hand-held to pretend to be the mouse and keyboard of the main computer. This brings up a number of interesting issues of *floor control*, which is the protocol which determines which user has control and how to take turns when multiple people share a



limited resource such as a single cursor in a synchronous task. We are in the process of doing some studies about sharing mechanisms, in a highly-collaborative computer-based task, where all the subjects were co-located. This included two techniques where all users have their own cursor, and five floor control techniques for sharing one cursor. The floor control techniques include: having a moderator decide the turn, averaging all inputs together, blocking the other's input while the cursor was in use, explicit release, and explicit grab. We found no previous studies of all these mechanisms. Our study uses a jigsaw puzzle game (see [Figure 2](#)) where multiple people can use hand-helds to control either their own or the shared cursor. Our preliminary results suggest that giving everyone a separate cursor works best, and of the floor-control mechanisms, using a time-out to block the interference works best.

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Figure 2. Jigsaw puzzle task for the floor control user study.

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Another possibility for collaborating on legacy applications is to just "scribble" on top of the screen, and not interfere with the real cursor. Our "Scribble" application for the PDA does this.

## Other Applications for Groups

We created a Chat program, which allows users to send side messages to each other. A user can switch to PebblesChat on the PDA and send a message to all the other connected users or to a specific user by name. In certain types of meetings, such as negotiations or legal proceedings, it is very important for people to be able to send private messages to people on their "own side" without the other side knowing what is being said.

Our "SlideShowCommander" application [\[Myers 2000b\]](#), allows the presenter to control the presentation using the PDA. While the main computer is driving the public display and running

PowerPoint, the hand-held displays a thumbnail of the current slide, the notes of the current slide, and the list of titles (see [Figure 3](#)). The user can easily go forward or backwards slides or jump to a particular slide. Scribbling on the thumbnail picture causes the same picture to appear on the main screen. The groupware aspects of this are that multiple people can be running SlideShowCommander at the same time. In the future, we plan to investigate how this might be useful to enhance note-taking and question-asking by the audience.

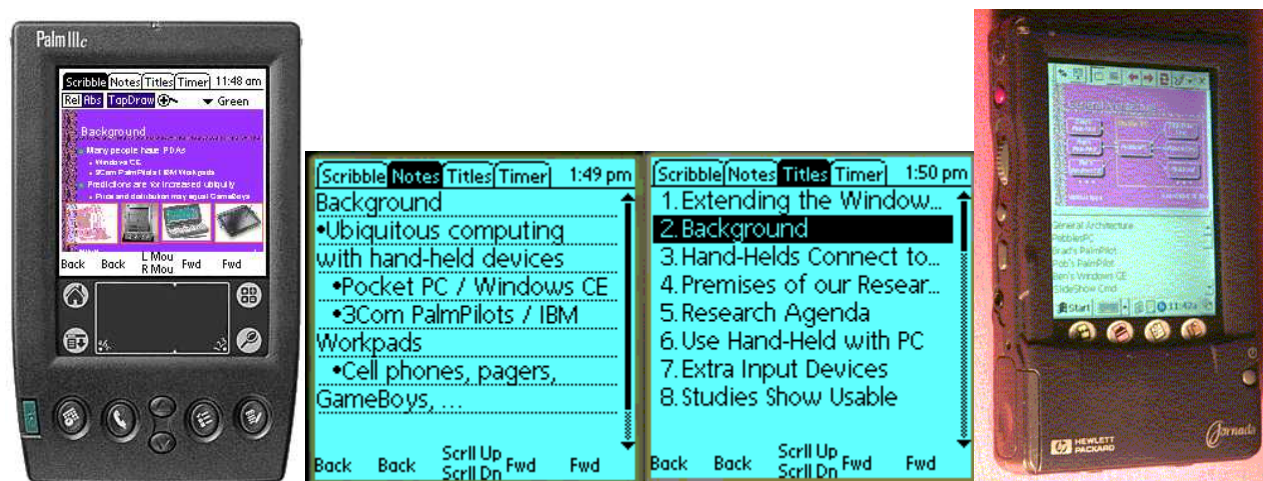


Figure 3. SlideShow Commander on the Palm and Windows CE.

## Public-Private Displays

As part of the “Command Post of the Future” project (see <http://www.cs.cmu.edu/~cpof>), we are investigating the uses of hand-helds in a large shared space. In a military command center, several large displays show maps, schedules, and other visualizations of the current situation that will be useful to the group. Individuals carry a personal PDA. While in the command center, someone might want more details on an item displayed on a large display. Rather than disrupting the main activities and the main display, the PDA can be pulled out, and a special unobtrusive cursor will appear on the main display, so the user can point to the item of interest. Then the user can privately “drill-down” to get the additional specialized information displayed on the PDA. The display of the information is appropriately adjusted to the limited size of the PDA screen.

In cooperation with the MayaViz company, we have created a PDA-based visualization and control program that runs on Windows CE and Palm. On the PDA, you can see a view of a map on which you can scribble and select objects, and a table view of the detailed information. The user can operate connected so operations on the PDA are immediately reflected on the main screen, or disconnected. Figure 4 shows some example screens.

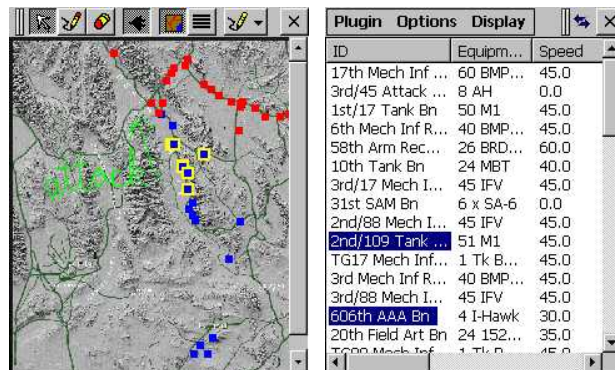
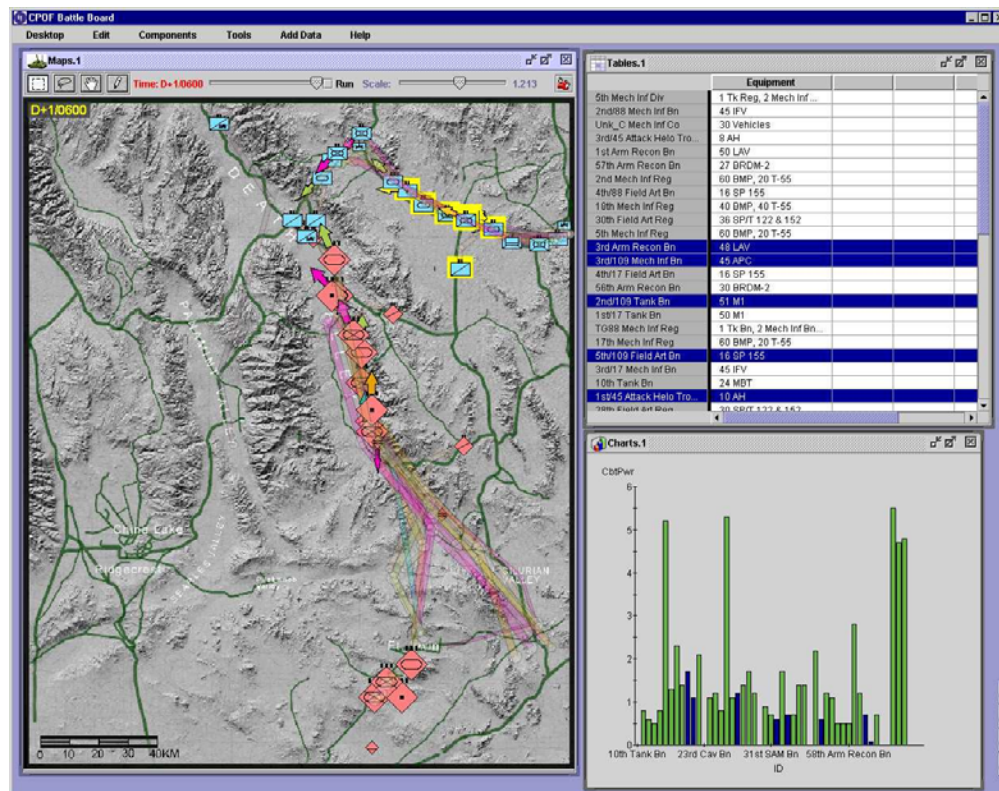


Figure 4. On the top is what appears on the main PC screen, and on the bottom is what is shown on the hand-helds.

## Conclusions

We believe in distributing the results of our research, to help collect useful feedback and aid in technology transfer. Our software has been available for about 2 years, and has been downloaded about 25,000 times (see <http://www.cs.cmu.edu/~pebbles>). The SlideShowCommander program was licensed for commercial sale (see <http://www.slideshowcommander.com>).

We are currently investigating many different issues of multi-computer user interfaces. We would like to generalize from the specific applications to develop lessons and rules-of-thumb to help guide future user interface designs. With the coming wireless technologies, connecting the PCs and PDAs together will no longer be an occasional event for synchronization. Instead, the devices will frequently be in close,

interactive communication. We are pursuing the research needed to help guide the design of interfaces that will run in this environment and span multiple computers, both for individuals and for groups.

## Acknowledgements

Also working on the Pebbles research project have been many other people. See our web site for a complete list.

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## Short Biography

Brad A. Myers is a Senior Research Scientist in the Human-Computer Interaction Institute in the School of Computer Science at Carnegie Mellon University, where he is the principal investigator for various projects including: User Interface Software, Demonstrational Interfaces, Natural Programming, and the Pebbles PalmPilot Project. He is the author or editor of over 200 publications, including the books "Creating User Interfaces by Demonstration" and "Languages for Developing User Interfaces," and he is on the editorial board of five journals. He has been a consultant on user interface design and implementation to 40 companies. Myers received a PhD in computer science at the University of Toronto where he developed the Peridot UIMS. He received the MS and BSc degrees from the Massachusetts Institute of Technology during which time he was a research intern at Xerox PARC. From 1980 until 1983, he worked at PERQ Systems Corporation. His research interests include User Interface Development Systems, user interfaces, Programming by Example, programming languages for kids, Visual Programming, interaction techniques, window management, and programming environments. He belongs to SIGCHI, ACM, IEEE Computer Society, IEEE, and Computer Professionals for Social Responsibility.

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# Using the Notification Collage for Casual Interaction

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## INTRODUCTION

The Notification Collage (NC) is a groupware system designed to support casual interaction between both co-located and distributed members of a small group [1]. The NC uses the metaphor of a public bulletin board, where instances of the board appear on individuals' workstations and on a large rear-projected display located in the group's public space. People post items to the NC (annotated in Figure 1) which displays them as a collage. Posted items are dynamic multi-media elements including:

- periodically updated video captured by cameras located on the public display and on individual computers;
- sticky notes showing characters as they are typed;
- thumbnails displaying web pages a person has visited;

- slide shows that cycle through a collection of images;
- desktop snapshots that present an image of an individual's screen contents;
- activity indicators graphing a person's presence over time.

We designed NC to promote casual interaction: through its visual elements, people can see who is around, can nonchalantly share information, and can move into casual interaction. We also intended the Notification Collage to serve as a peripheral display of (mostly) ephemeral information; we expect that since people might be absent or their attention could be focused elsewhere that they may or may not see elements as they are posted.



Figure 1: The Notification Collage with various media elements pictured.

NC users can have different, personalized views of the collage. First, the NC creates the collage by randomly positioning media elements as they are posted onto the left side of the vertical bar that splits the board. Second, individuals can move items around their own instance without affecting others: if a person moves items he or she considers important to the right of the vertical bar, they will never be covered by newly posted items. Third, people can hide items they are no longer interested in seeing.

### USER EXPERIENCES

The first version of the Notification Collage was created in May 2000. Because it was new software still under active development, we initially deployed it only to our own research group. What follows is a summary of some experiences.

**The group and its setting.** Our group comprised mostly research assistants, graduates, and faculty: only two were directly involved in the NC project. Much of the group inhabited a research laboratory whose floor plan is shown in Figure 2. The left side of the laboratory comprised workstations and workbenches for graduates and research assistants. Computers were typically equipped with a camera and two monitors. The right side was a small, public meeting area containing a 72" rear-projected Smart Board, also equipped with its own camera. Partitions are short, so people anywhere in the laboratory had some peripheral awareness of activity elsewhere in the room, including what was on the Smart Board. The Smart Board (which had its own 'user identity') always ran NC and a client that would post the video from its camera (a panorama of the room).

While some group members regularly worked in the laboratory, others did not. Faculty had separate offices. Other members were telecommuters: one regularly worked at his home office 110 km away, coming into the laboratory only occasionally. Another group member was on a work internship 1000km away for part of the evaluation period. A few others alternated between work and home offices.

**Bootstrapping.** Our first version of the Notification Collage was accessible only by co-located group members. Not surprisingly, we saw very little activity on it since these people could see each other directly. A dramatic change happened as soon as people could easily access NC across the Internet. There was a noticeable buzz of excitement: people wanted to join in, and those connected became evangelists for getting other team members to join. People saw and used NC as a way for dispersed group members to reconnect with each other and to those in the laboratory.

**A sense of presence.** People's first instinct was to post their visible presence to the NC via the *Video* element. This mimicked what is usually seen in most media spaces and instant messengers: all could sense who was around. Typically, people would move video images to the right side of their NC so they would not be covered up. As telecommuters became visible and reachable, the people

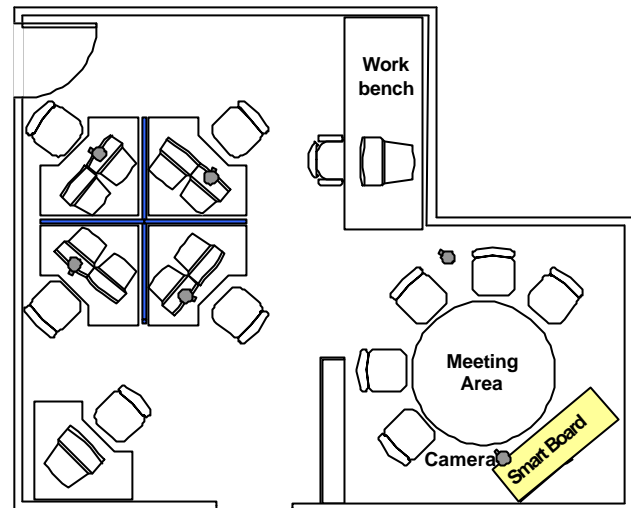


Figure 2. Floor plan of the laboratory.

inside the laboratory also became highly interested in the NC i.e., they would connect to it and stay connected to it.

**The role of the personal display.** Our expectation of NC was that people would run it only on the single large public display in the research laboratory, and that those outside the laboratory would connect to it every now and then from their personal machines. In practice, the NC quickly found its way to almost permanent display on everyone's desktop, even if those people were in the same room as the public display. We saw that people with multiple monitors did their main work on one monitor and had their view of the Notification Collage running on the other display: this accords with Grudin's findings that second displays are often used to hold peripheral information [2]. While those in the laboratory could glance around to the Smart Board, it was not in their direct line of sight. They felt that having an instance of NC on their own machine made them more aware of changes, and they were better able to respond to particular events.

Those with only a single monitor were concerned about the screen space required by NC. Consequently, we added a transparency feature where people could see through any overlapping windows onto the NC underneath. People could solidify the NC for greater clarity at will. This was positively received, as people could now work in their full environment without sacrificing their knowledge of 'what was going on' in the NC community. Even people with dual monitors sometimes used transparency, at times overlaying other windows holding peripheral information they wanted to track [2].

**The role of the public display.** When the NC appeared on the public display, people used it somewhat differently than when it appeared on their personal computers.

First, people not at their workstations used the public display as another means of tracking and posting information to the NC. This depended on several things: whether they were logged onto a workstation in the room,

whether they were closer to the public display than to their workstation, and so on. As expected, people would also bring other people's attention to items on the public display and would converse around them.

Second, telecommuters used the video generated by the camera attached to the Smart Board as a means to monitor and communicate with people seated at the meeting table or workbench, and with people wandering about the laboratory. This was a particularly important way for telecommuters to contact laboratory inhabitants when they were *not* at their workstations, as well as laboratory visitors and associates who did not have a personal NC. For example, we saw telecommuters notice and contact part-time members of the group who appeared occasionally in the laboratory.

#### ***One-to-one, overheard, and broadcast communication***

People often took advantage of the presence information by using the NC as an instant messenger. We saw people directly message each other by raising the context menu on a media element and invoking Microsoft Messenger on them (giving one-to-one communication with the person who posted the element). More often we saw people communicate within the NC through *Sticky Notes*. These typically began with the other person's name e.g., 'Hey Mike...'. While not designed as a chat tool, people would communicate to each other in real time by modifying their own note and by looking at changes to others.

Conversations over *Sticky Notes* differed from those over Microsoft Messenger. Since all could see the *Sticky Note* contents, the conversation could be overheard. This became an opportunity for casual interaction [3] where others would join the conversation. These others would sometimes just say hello, or would join in any bantering, or would contribute to the conversation when they felt they had something to add.

Seeing incoming *Sticky Notes* also meant that people in the laboratory could tell others about messages directed to them. This happened when the addressee did not notice the note, or when he/she was a room visitor.

We also saw *Sticky Notes* used for purely broadcast communication. People used them to inform the group about current or upcoming events, to annotate other media elements, or to elicit group comments. *Stickies* also served as a way to make general queries or requests which could be answered by anyone e.g., 'Does anyone know...'.

***Video as conversation and opportunity.*** We saw people use *Sticky Notes* and *Video* elements in tandem. They would sometimes wave to re-enforce a greeting, and would accentuate a note's message by exaggerating their body language (laughter, thumbs up, looks of shock, making faces at one-another). They also used the video to show others physical things being talked about. One person, for example, used the video to display the covers of a large number of boxes of software they had just purchased.

Aside from knowing that a person was around, the group used other things they saw on the video as opportunities for conversation. For example, one conversation stemmed from seeing a particularly ugly hat a person was wearing, with quite a few people eventually joining into the teasing. Seeing 'visitors' in the video also led to many conversations. One telecommuter introduced his children (who were visible on the video) to other group members. In another case, a person working at home recognized a visitor to another person's office that he had not seen for years. They began to chat; and since the telecommuter's wife had also met this person several years back, she came up and joined the conversation.

***Artifact display.*** People used the NC for displaying other artifacts to the group as different media elements. We saw one popular example where people would post digital photos to the NC via the *SlideShow* element for others to see. These included photos of personal vacations, families and friends, and group outings. People sometimes included *Sticky Notes* to explain the slide show.

People also used the NC to display occasional snapshots of their desktop, or pictures taken elsewhere and imported to the NC as a *single-element SlideShow*.

***Privacy issues.*** We saw several privacy issues accompany NC use. First, NC does not guarantee reciprocity. One can use it without signaling their presence through video. Alternatively, a person can have the video capture client running without having the NC displayed. While people did usually enforce reciprocity through social habit, we saw inadvertent reciprocity breakdowns. One example stemmed from the power-save facility that turned off the Smart Board projector. We noticed telecommuters sending a message to a person captured by the Smart Board camera. Of course, that person did not see the message as the display was dark.

We sometimes saw people on the *Video* element having no idea that their image was being broadcast. For example, one telecommuter reported seeing the lights come on after hours in the laboratory, and watching a cleaning person (unaware that they were on video) going about their duties.

Telecommuters who used NC video from home reported other privacy concerns. One telecommuter's home office doubled as a guest bedroom. While he felt video was essential (and had it always on), his wife (who was not part of this NC community) did not like the idea: she received no benefit from having the video on and saw it as a possible intrusion. Similarly, he was also more aware about his appearance: while he previously worked with his shirt off on warm days, he no longer did so. He was also concerned about inadvertently broadcasting situations visible within the room e.g., family members dropping in various states of undress, or who used the room for other purposes. As a partial solution, he habitually rotated the camera to face out the window when leaving the room.

**Distraction issues.** When many items were on the NC, people found it more difficult to find information they felt important. While people could post many elements to the collage—slide shows, photos, videos—most felt video to be the most essential element. Although *Video* elements always rose to the surface of the collage on every update, it was still effortful to find them. Related to this, people sometimes wanted a way to ‘filter’ items from the display, especially if the NC was on their personal computer. For example, one person commented that he wanted to remove a *SlideShow* element from the NC because he found the current set of photos uninteresting and the cycling of images distracting. As a consequence, we added the option for people to ‘hide’ elements. We also saw people regularly move elements they felt important – particularly videos – to the right side of the NC so they would not be covered up.

## DISCUSSION

We can distill several general points of NC use from these experiences.

1. NC became interesting only when the communication circle widened to people outside the immediate physical room. We had originally thought that NC would have been useful for even co-located people, as items could be left on it for others to see at a later time. This was not a strong enough impetus to warrant its use.
2. People’s first instinct was to create a visible presence for themselves: they wanted to see others, and others to see them.
3. People wanted direct as well as peripheral access to the NC. Having it on their personal workstation made it more accessible than just using the public display.
4. People running NC on their personal computer were concerned about the tradeoff between screen space vs the value of the information on the NC. Multiple monitors and transparency help.
5. Visitors and people not seated at their workstation used the public display as a convenient way to monitor and post information to the NC.
6. The public display acted as a way for telecommuters to reach people (including room visitors) visible from the its attached camera, and for those people to respond.
7. Making directed conversations visible to the group meant that anyone could monitor and join in, and that those inhabiting a public space can tell a person about a note addressed to them.

8. People exploited media elements for tandem communication (especially video), using each channel to augment the other.
9. There remain outstanding privacy concerns that must be dealt with, particularly on how video is captured and displayed, and how reciprocity is managed.
10. People would adjust the visibility of items to make them more salient i.e., by moving chosen elements to the right side of the NC so they would not be covered up.
11. The collage metaphor represents all media elements equally, yet some people felt some media elements (e.g., video) to be more important than others. The NC interface should be tuned to recognize this.

In essence, we saw that people treated the NC as a virtual room/bulletin board encouraging interaction. One person would post a media element, and others would become aware of it and selectively react to it. What typically ensued was a sometimes brief, sometimes lengthy, sometimes parallel interaction between many people on the board. People made faces at each other, chatted through the *Sticky Notes*, and often posted other media elements onto the NC that were relevant to the conversation. These experiences suggest that NC affords uses spanning several types of collaborative tools: awareness notifiers, instant messengers, media spaces, and MOOs.

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**Related Publication.** This workshop submission is a modified extract of a paper to appear in the proceedings of ACM CHI 2001 [1].

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# Supporting Face-to-face Group Activities with a Sensor-Embedded Board

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## ABSTRACT

This paper describes a system called ePro for supporting face-to-face group activities. ePro connects a sensor-embedded board and a computer simulation, and is currently used to discuss urban planning and environmental problems. Group members collaboratively construct a town by placing pieces such as houses on the board. The computer simulation program automatically recognizes the arrangement of pieces on the board. It then visualizes environmental changes of the town through simulations. The visualization shown to the group members amplifies interaction between them, and gives them feedback for their further actions.

## Keywords

interaction, face-to-face collaboration, combining physical and virtual worlds, sensor-embedded board

## AUTHORS' BACKGROUNDS AND MOTIVATIONS

Our research group is composed of three main investigators. Their backgrounds are computer science, cognitive science, electrical engineering, respectively. The goal of our research is to develop a new computational medium for supporting group activities and evaluate it. We have constructed an electronically enhanced board that can quickly recognize objects placed on its surface. This board is applied to a system for supporting people working for urban planning and environmental problems in a “face-to-face” situation. In this workshop, we would like to talk about the technological aspects and effects of our system, and explore the possibility of new applications through discussions.

## INTRODUCTION

This paper describes a system called ePro for supporting group activities. Many systems that support group activities through digital media, such as email systems and virtual forum systems, have already been developed. Most

of them are used by people in different times or places, and not used in “face-to-face” situations. Studies, mainly by workers in the social sciences, have claimed that these systems often cause the decontextualization of communication, constraints on communication modes (difficulties in fully utilizing users’ gestures and expressions), lack of awareness [1], and breakdown of trust [6]. On the other hand, in systems for supporting group activities in face-to-face situations, users can directly interact by looking at each other’s faces and noting body movements.

However, face-to-face situations do not automatically work well for group activities. For example, group meetings in our daily lives are often boring: although a few members may be actively engaged in and committed to a meeting (for instance, they actively speak about their own opinions), others are not motivated to participate in the meeting or join discussions. This means that a system should be equipped with a function that can increase users’ motivation or encourage users to become active participants in their group activities. The proposed system in this paper, ePro [2][3], is used in face-to-face situations, and integrates physical and virtual worlds so that it can increase users’ engagement and commitment [4].

In ePro, a sensor-embedded board (a physical world) and a computer simulation (a virtual world) are linked together. Users can freely place or move objects on the sensor-embedded board, which can automatically recognize their arrangement. The computer simulation shows users how their manipulations of objects on the board change a virtual world. ePro can be used for multiple purposes, such as chess, *shogi* (Japanese chess), or *sugoroku* (Japanese variety of Parcheesi). In the present work, ePro is used to support group activities on urban planning and environmental problems.

Users of ePro collaboratively construct a town, considering its economic conditions, natural environment, their convenience and so on. They actually put pieces such as a

“house” or “factory” on the sensor-embedded board. The computer simulation then calculates values of parameters that describe the town (for example, financial conditions or pollution). The simulation results are visualized and given to the users. The board and pieces afford manipulations by users, and this enhances their participation. The computer simulation supports users in promoting externalization of users’ thinking and activating their discussion in their group activities.

## SYSTEM CONFIGURATION

### Overview

Figure 1 shows the configuration of ePro: a sensor-embedded board system and software modules. An overview of the board system is shown in Figure 2. It consists of a checkerboard, pieces, and geographic objects. The checkerboard, containing embedded sensors, has  $20 \times 24$  squares with sides three centimeters. There are three kinds of pieces: “houses”, “factories”, and “trees.” One piece is put in one square on the checkerboard. Geographic objects include “mountains,” “rivers” and other similar elements of nature. These objects are arranged on the checkerboard by users in order to construct a town resembling their own.

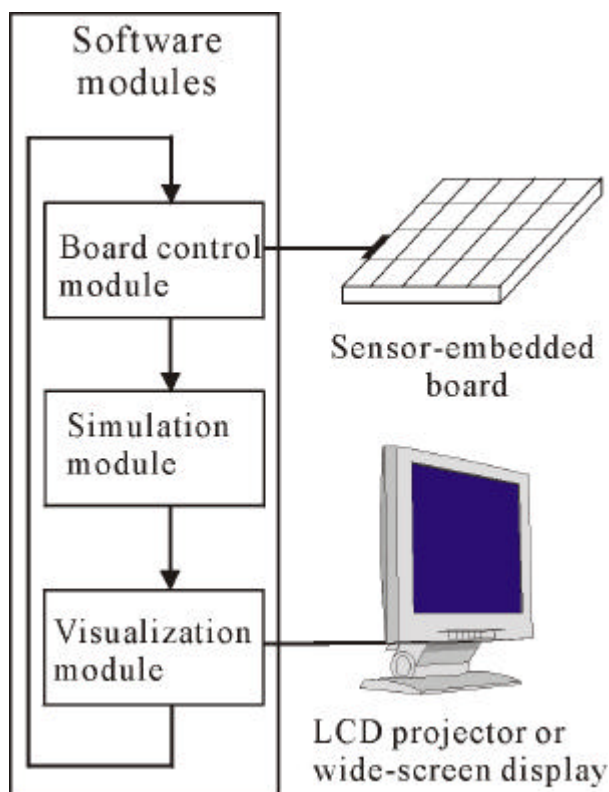


Figure 1. Configuration of ePro

The software modules of ePro consist of a board control module, a simulation module, and a visualization module. The board control module accesses the checkerboard and controls it (activates or inactivates its sensors). The simulation module then makes a simulation based on the arrangement of pieces acquired through the board control module. The visualization module receives the simulation results and updates the visualization of a town. Data communication between the board system and a personal computer is done through their RS-232C interfaces. When the system is used in a group setting, a LCD projector or a wide-screen display is attached to a personal computer.

### A Board that Identifies Objects

In our work, a technology that can quickly identify what kinds of objects are placed on the board and where they are is necessary, in order to integrate the physical and virtual worlds. The RFID (Radio Frequency IDentification) system is used in our system. RFID [5] is a non-contact object identification and data transfer technology. The RFID system consists of two components: an antenna (with a transceiver and decoder) and a tag. An antenna emits radio signals to activate a tag, and writes data to the tag or reads data from it in the electromagnetic field produced by the antenna. An antenna combined with the transceiver and decoder is called a reader. It decodes data encoded in a tag’s integrated circuit (IC) and passes the data to an attached personal computer. Tags are embedded in pieces and readers are embedded in the checkerboard. One reader is embedded in each square on the checkerboard, and identifies what tag, if any is on the square.

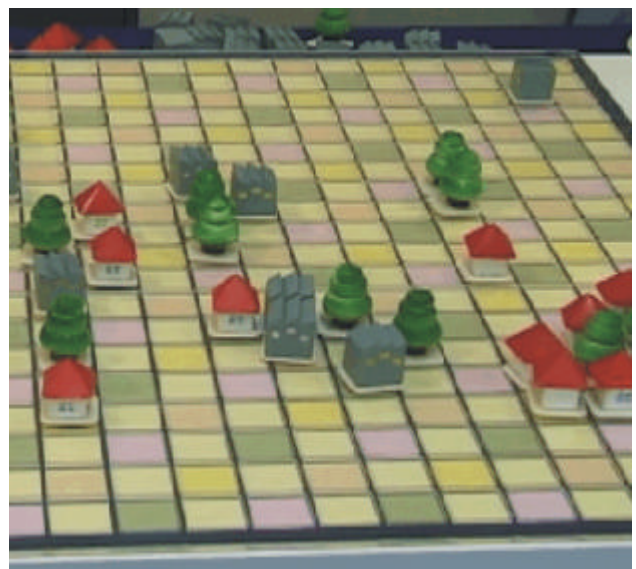


Figure 2. An overview of ePro

The data transmission between a tag and a reader is not very fast: it takes about 10 to 20 ms to transmit data between them. Users will have to wait for a few seconds, when there are hundreds of pieces on the board. Therefore we devised a new method for parallel processing of data transmission: a processing unit that comprises 16 readers recognizes tags on it and every unit in the board starts the recognition in parallel (Figure 3). Time required to identify all the tags on the board is within a half second. With this method, rapid recognition of numerous objects has become possible, and multiple users can place or move pieces on the board simultaneously.

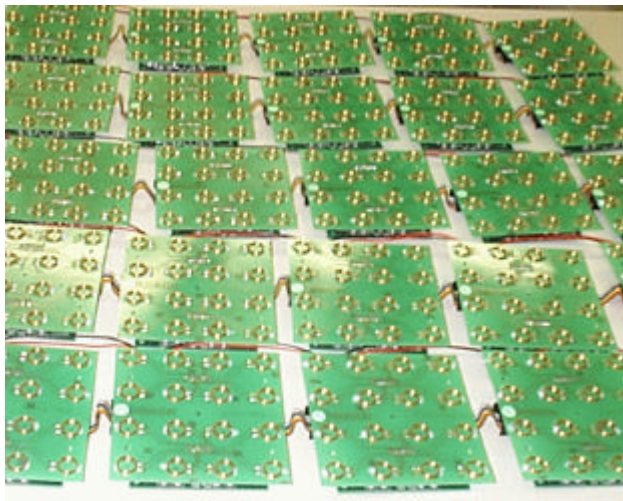


Figure 3. Processing units of the board. 16 readers are attached to each of them.

### Computer Simulation

The computer simulation (a simulation module and a visualization module) calculates the status of a town based on the arrangement of pieces on the board and visualizes it. Figure 4 is an example image that graphically represents the changes of the town's economy, air pollution, noises and so on

### Using the System

Users sit around a board and set it up by arranging geographic objects. Each user puts a piece on the board. Every time a user completes her move, the computer simulation recognizes the arrangement of pieces on the board, calculates the status of the town, and visualizes it through a LCD projector (or a wide-screen display). Users then discuss the simulation results and negotiate to change the arrangement of pieces to improve the status of the town. For example, when a user who has placed a "factory" piece, finds that air pollution will be a serious problem in future, she changes her initial idea and places a "tree" piece. A user

can interact with other users in both the physical and virtual worlds during their collaborative work.

### USER STUDIES

We have so far carried out several user studies with ePro. One of them was to ask users to functionally different systems: (1) a computer simulation (System A), and (2) a combination of a sensor-embedded board and a computer simulation (System B). System B corresponds to ePro. System A corresponds to ePro without a sensor-embedded board. Instead, an image of a board was shown on a computer display. All the manipulations to System A were done by using a mouse.

Through questionnaire surveys, we have confirmed that users were satisfied with the performance of the sensor-embedded board (recognizing numerous pieces on its surface and giving users feedback quickly). We have not completely analyzed the behaviors and protocols of users in both systems recorded by video cameras. Users of System B, however, were much engaged in their activities: they were excited with the system as they would when playing a game, and actively discussed with others.

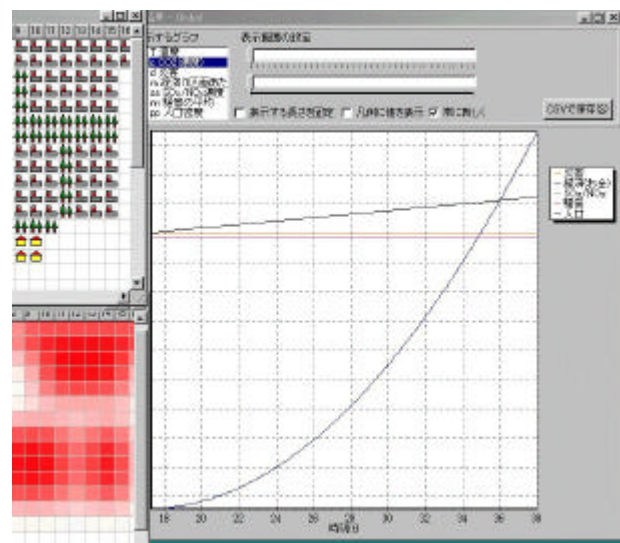


Figure 4. An example image of a simulation result

Interacting with physical objects was a trigger for behaviors and utterances of users. For example, a user of System B frequently pointed to a certain place on the board and another user put a piece there. When the simulation result was improved by this manipulation, they discussed what kind of piece should be added next and where it should be placed. If the simulation result became worse, they changed the manipulation and tried to find another place to put the piece. All the users looked at their manipulation. This

induced their succeeding actions: users stood up, spoke their own ideas, and agreed or disagreed with others' ideas with gestures (Figure 5).

## CONCLUSIONS

In this paper, ePro, a system for supporting group activities by integrating physical and virtual worlds has been described. ePro, used in face-to-face situations, combines a sensor-embedded board that was devised for this project, and a computer simulation. Throughout the experiments and evaluations, this combination proved to be effective for engaging and motivating users in their group activities.

Although ePro is used for supporting group activities on urban planning and environmental problems in this paper, it is also applicable not only to entertainment fields including various board games, but also as an input interface for multiple persons: a new computer interface instead of a keyboard and a mouse. We would like to expand this system to these new application areas.



Figure 4: Users with ePro

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# The Best of Two Worlds: Merging Virtual and Real for Face to Face Collaboration

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## ABSTRACT

In its simplest form, reality is merely information that is presented or acquired. Mixed Reality (MR) is built around the integration of real world physical and computer generated virtual information. We do not use the term *augmented reality* (AR) because we view the merging of both worlds as a symbiosis, with desirable properties from each accentuated and complementing each other, rather than the enhancement of one with the other. Collaborative MR allows multiple participants to simultaneously share a physical space while being surrounded by a virtual space that is registered with the physical. Because the MR world inherits the properties of real and virtual worlds, it is rich with social context, spatial cues, and tangible objects from the real world as well as flexible digital information from the virtual. We believe that Mixed Reality is a medium, largely unexplored, but very well suited for face-to-face collaboration.

## Introduction

We first examine the advantages that real and virtual worlds afford us for face-to-face collaboration. In this way, we are equipped to find a region in the design space where interaction between the two worlds harnesses the full potential of each, creating a world that is greater than the sum of its parts. We discuss some of the issues that arise in this medium as well as some of our experiences building novel interfaces and applications.

## Real World Collaboration:

### Social Context, Spatial Cues, Tangible Objects

In real world face-to-face collaboration, we extensively use a wide spectrum of verbal and non-verbal cues including gestures, body posture, facial expressions, and the use of personal space. This information augments conscious communication by giving us social awareness of other users, making collaboration a rich interaction.

Unlike traditional digital systems, which typically have a small number of output channels, the real world presents a single continuous large display with practically infinite

resolution. In fact, objects as well as the space that contains them convey useful information about the world. Just as we convey and derive a large amount of information from social actions, so too is this the case with the environment.

Another advantage of spatial cues is that they are strongly tied to memory. People are very proficient at using the spatial locality of objects to reference items in memory. Since spatial cues are the same for different users, they allow several people to reference information using the same cue. If everyone who had to read these proposals in the same room with each of them pinned on the wall, you could point to the first paper on the left and would never have to refer to the title "The Best of Two Worlds." In fact, at some point, the paper may be removed and you could continue to point to the empty space and talk about the paper as if it were still there.

The physical world is intrinsically a shared one. Although people each have personalized points of view, there exists a common space and means for discourse. Synchronous sharing and referencing of objects and viewpoints is as simple as handling the same object, passing it back and forth, or pointing and looking at an object. This leads to parallelism for multiple users performing tasks.

Manipulation of physical objects is so well integrated into our daily lives that most people do not think of the real world as possessing an interface. The tangible manipulation of physical objects provides simultaneous use by more than one user, as well as affordances for intuitive use. Consequently, they are able to spend their efforts on the task at hand rather than coordinating activities. Another advantage of physical objects is that they are rapidly re-configurable. One could, for example, tear a corner of a newspaper page and write a phone number and stick it on a board for others to see, use it as a bookmark, or fold it to describe a particular shape.

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### **Virtual World Collaboration: Unbounded, Flexible Information**

Virtual worlds were designed to augment humans and provide them with the capability to manipulate information in ways that are not normally possible in the real world. This includes efficient means to store, retrieve, process, and communicate artifacts as well as symbolic information and methodologies. Unlike the somewhat passive physical objects in the real world, information stored in this world can potentially be active, accessing other information and updating themselves.

Since virtual worlds are completely conceived and created in the mind of the human, it is under her complete control and is not bounded by physical laws. For example, it is not uncommon to scale time, quickly moving forward into the future or undoing actions that happened in the past. In addition, designers may scale space, creating objects that are of different sizes to convey spatial information or to make them easier to manipulate. Also, they can create objects that exist in multiple places at multiple scales or give users different views of the same object. The designer is constrained only by her own imagination in augmenting the collaborators with tools for interaction.

### **Previous work**

Researchers working on Computer Supported Collaborative Work have recognized the advantages that real and virtual worlds afford. However, most work has been largely focused on building tools that leverage on a subset of one or the other for effective communication and collaboration. On a separate front, there has been a significant amount of work done in MR technology [1,9]. This includes the visual tracking and registration techniques, displays, input mechanisms, and interface design. In our work, we attempt to combine principles behind real world face-to-face collaboration with novel technology to create effective MR interfaces for face-to-face collaboration.

A large amount of work has been done in human-computer interaction research to explore different media and interfaces to present information for collaboration. Some common media used are the desktop (or some variation thereof), Virtual Reality (VR), and Tele/Video conferencing [2,4]. Desktop interfaces are a poor medium for complex collaboration because of their small display portals as well as their limited capabilities for interesting spatial input mechanisms. VR interfaces construct synthetic spaces where users can meet and interact. Because users are taken out of the real world to be completely immersed within the virtual environment, they often lose important social cues. Tele/video conferencing, while providing some social cues, is normally projected in 2D and does not give participants the full advantage of spatial context. Also, most systems are not easily scalable to large numbers of participants [3, 5].

### **Mixing Reality for Collaboration**

In Mixed Reality, we combine the social, spatial, and tangible properties of the real world with the flexible, accessible, replicable information created in the virtual. The usual “window into the world” and “immersive” metaphors imply a seam between two separate realities and are, in our opinion, confining. In MR collaboration, we give the user a multi-sensory experience, permitting them to use the real world as their interface. With this interface, we provide intuitive control to have information when, where, and however users want it. Users can thus concentrate on the tasks at hand without attending to technology’s needs.

In creating collaborative MR environments, we encounter new and interesting research questions that do not exist in each of the independent worlds. The main issue in such worlds is the seamless integration of real and virtual, along with the relation of one to the other (semantic, spatial, or otherwise). There are many different ways of linking and manipulating co-located real and virtual objects and it is not immediately apparent how to best create a single coherent interface.

Even though collaborators have different viewpoints in the real world, they see and can refer to the same objects. In the virtual, it is sometimes desirable for different people to see different interpretations of the same information, or even different information in the same space. For example the electrical engineers might like to see the electrical wiring diagrams in a building, while the civil engineers would prefer the structural diagrams, and so on. An important issue to consider is the fact that because we are grounded in the real world, collaborators must be able to use spatial references, such as pointing to a particular object, just as they would in the real world. In MR worlds, the issue of consistency within and among users is an important one. Users must have some awareness of what other users are seeing as well as the abilities that they have. They should also be able to easily control what other users see and know of them.

Building on the philosophy that we can and should combine different media to exploit the advantages of each, we extend our work to integrate different interfaces to expand the design space and facilitate heterogeneous collaboration across media. Researchers have designed and implemented a myriad of different interfaces, each supporting special functionality and being useful for different tasks. In our increasingly complex world, specialization will continue, and effective work will require new combinations of skills drawn from collaborative teams of specialists. Each individual has diverse requirements and preferences for the presentation and manipulation of information. This manifests itself in the evolution of different devices, interfaces, and media. Each individual must be allowed to employ existing tools and media in the col-

laboration process, not only to present their own ideas, but also to view and edit those of others. We explore combining MR with such media as traditional desktops and VR, as well as with users not augmented with any technology.

### Our Mixed Reality Research

The fundamental elements in augmented and mixed reality systems are techniques for tracking user position and/or viewpoint direction within physical environment, methods for registering virtual objects in physical environments, and rendering and presenting them to the user via augmented reality display devices, e.g. head-mounted displays and large-screen projection screens.

Our work makes heavy use of computer vision techniques for tracking and registering virtual objects [6,7]. We mark physical objects with simple square fiducial patterns with unique identifying symbols. The video output from either static or mobile video camera is captured and image processing techniques are applied to identify square markers and symbols in the middle of markers. Because we are tracking square markers of known size, the relative camera position and orientation can be found in real time. Once this is known, the virtual camera can be placed at the same position so that 3D virtual objects appear to be exactly attached to markers (inset in Figure 1). The technique, optimized for speed, allows for fast and reliable tracking (~30 fps latest Intel Pentium-based computers).

At least two display configurations can be used in our mixed reality environments to support face-to-face collaboration, each with its own advantages and disadvantages: head-mounted displays (HMDs) and wall-sized projection screens. The choice between these approaches leads to very different interaction styles and interface designs. In the case of HMDs, users are presented with a traditional mixed reality display. Their view of the real world is augmented with virtual objects so that they can see other participants and virtual images (Figure 1). The major shortcoming of HMDs is that they are obtrusive: the users have to wear devices. In the large-screen configuration, the users can interact with each other without need to wear any display devices (Figure 2). However, in this case only a portion of the workspace can be augmented with virtual objects and users cannot maintain natural communication with other participants without interrupting their interaction with virtual and physical objects. An interesting approach would be combination of two, which would allow both instrumented and non-instrumented users to interact in the same mixed reality environment. The choice of the approach is defined by application requirements and one such particular application is described in the following section.



Figure 1: Users interacting with HMDs. The projection screen in the background allows other users to watch and interact.

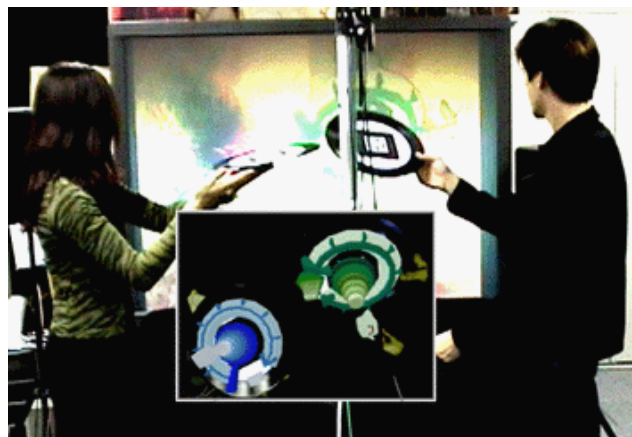


Figure 2: Users collaboratively playing music in Augmented Groove [8].

### Application: Collaborative Design of Aircraft Instrument Panels

We explicitly consider implications of collaboration in real and virtual worlds, but also think about the applications in which such augmented collaboration is required and beneficial. We have explored such areas as collaborative engineering design, music, education, and leisure. We present one of our ongoing projects in the area of engineering design. In this project, we explore how MR interfaces can be used to support rapid collaborative prototyping in an industrial design application. Although our techniques are broadly applicable, our specific application area is the design of aircraft instrument panels, a joint research initiative carried out with support from DASA/EADS Airbus.

In our interface, we allow designers, engineers, human factors specialists, and aircraft pilots to quickly layout and rearrange a set of virtual aircraft instruments on a board simulating an airplane cockpit. The participants are able to easily and quickly evaluate the layout, rearrange instruments as necessary, add new instruments or remove those that are not needed. The design activity is inherently

collaborative and involves team-based problem solving. It requires that the interface facilitates discussion and joint evaluation, allows use both of existing physical plans, schemes, documents and tools, but also of digital data.

The ability to simultaneously access and manipulate physical objects and digital data by several participants is a key requirement for the application. Furthermore, the interface should provide intuitive and easy techniques for traditional ‘house-keeping’ activities, e.g. removing virtual panels from the board, copying, deleting them, saving modifications, etc. The system that we have designed meets these goals by providing a tangible collaborative mixed reality interface, in which users arrange virtual instruments on a whiteboard by manipulating small marked cards that have images of virtual instruments attached to them (Figures 3,4).

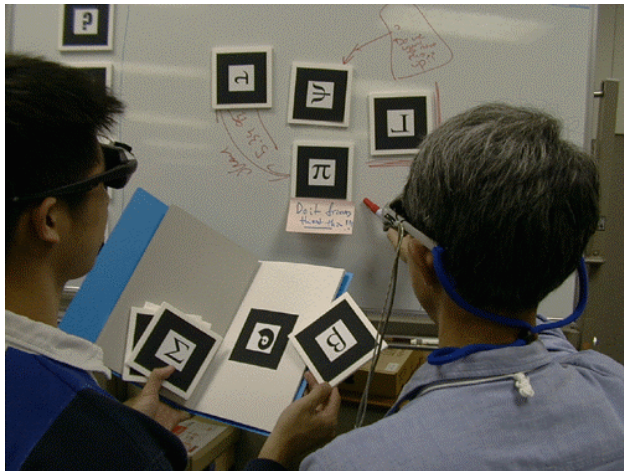


Figure 3: Users arranging instruments on the dashboard using physical markers.

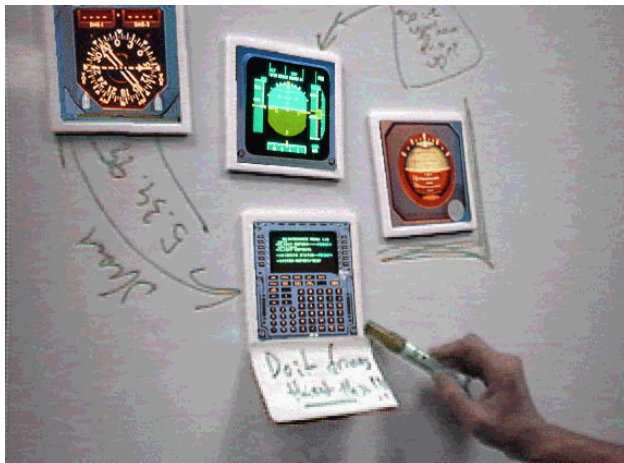


Figure 4: One user's view of the real world augmented with virtual instruments.

The cards work as physical placeholders for virtual objects. The designer can assign any virtual instrument by copying it from the ‘mixed reality catalog’ of instruments: a real book with virtual models of the instruments overlaid on each page, an approach that was first introduced in the Magic Book system [1]. Users can copy the desired instrument onto the placeholder cards by placing them beside the book, i.e. docking the card to the book. The object moves from the page onto the card and becomes associated with that card. Each card is equipped with a magnet and can be placed on a whiteboard, built to resemble and represent an actual aircraft dashboard. To layout the instruments, several participants can rearrange cards on the board, physically manipulating virtual instruments, passing them to each other, adding new instruments and removing them from the board if needed.

Besides physical placeholders we have designed command widgets that allow the user to perform simple operations on cards, such as copying and deleting objects. To invoke the operation the user docks the appropriate widget and card to each other: for example docking a copy card with any instrument card would copy the instrument to the copy card or vice versa depending on whether the instrument card were empty or not.

Our early experiences have indicated a number of advantages to this approach. First, manipulation of physical objects to control virtual objects is quick and intuitive both for individuals and for groups of users. Second, participants are provided with immediate and rich feedback including visual, tactile, proprioceptive, as well as variety of social cues about other participants, leading to intuitive, effective and enjoyable interaction. Designers can also get a ‘real feel’ for the instrument panel, which is important in industrial design. Finally, the provision for select Windows, Icons, Menus, Pointing (WIMP) commands also allows designers to apply existing knowledge from familiar desktop interfaces to the mixed reality workspace. We are working to extend this system to allow users working within other media (such as on a desktop or in VR) to collaborate with the MR designers.

## Conclusion

Examining the affordances of the real and virtual worlds in face-to-face collaboration, we can begin to construct a mixed space that seamlessly merges advantages of both. We described one of several ongoing projects in this area as an example of the utility of the MR medium. We believe that work in this area will stimulate further thought on issues of collaboration and provide us with the insight necessary to construct effective collaborative environments.



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Desney is currently an intern at the Media Integration and Communications Research Lab at the Advanced Telecommunications Research (ATR) Institute International in Kyoto, Japan. Here, he is working not only on developing new vision-based interaction techniques for mixed reality (MR), but also on integrating a system utilizing VR, MR and standard desktop interfaces for collaborative design of airplane instrument panels (a joint effort with the HIT-lab at the University of Washington and DaimlerChrysler). He has consulted for Walt Disney Imagineering, designing and user testing several VR attractions now at the DisneyQuest Interactive Theme Parks in Orlando and Chicago. It is this work that first got him interested in the collaboration across multiple media. He has also recently interned with the Adaptive Systems and Interaction group at Microsoft Research, building 3D navigation techniques for use with novel projection displays.

See also <http://www.cs.cmu.edu/~desney/resume.htm>

# Architecture of BEACH: The Software Infrastructure for Roomware Environments

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## ABSTRACT

Shared environments beyond the desktop supporting face-to-face collaboration put new requirements on software: Users interact with multiple devices, and collaborate using different kinds of devices. The configuration of the devices is changing frequently due to the demands of new work practices in organizations which will be characterized by a high degree of dynamics, flexibility, and mobility. These are examples of requirements that have an impact on the architecture of the software infrastructure of these environments.

BEACH, the software part of i-LAND (the ubiquitous computing environment at GMD-IPSI), uses an architecture designed to meet these requirements. It provides the functionality for synchronous cooperation and interaction with roomware components, i.e. room elements with integrated information technology.

This paper discusses the software requirements for a roomware environment, and presents the architecture of BEACH. It closes with an overview of the current implementation and future work.

## Keywords

Roomware, synchronous groupware, team-computer interaction, multiple-user interaction devices, multiple-device interaction, integrated collaboration environment, i-LAND, COAST, BEACH

## INTRODUCTION

To support face-to-face team work situations, the access to digital information must be integrated with the working environment. i-LAND, an interactive landscape for creativity and innovation, supports team work by providing a collaboration environment that combines the interaction with digital information with the physical, architectural part of the environment [16]. So called roomware components, i.e. room elements with integrated information technology, offer teams appropriate possibilities for the interaction with digital in-

formation in meeting and collaboration situations [17]. Figure 1 gives an overview over the roomware and hardware infrastructure of i-LAND.

BEACH, the Basic Environment for Active Collaboration with Hypermedia, provides the software infrastructure for i-LAND. It offers a user interface adapted to the needs of roomware components, which require new forms of human-computer and team-computer interaction. The roomware components must be connected to allow synchronous collaboration with shared documents distributed over multiple roomware components.

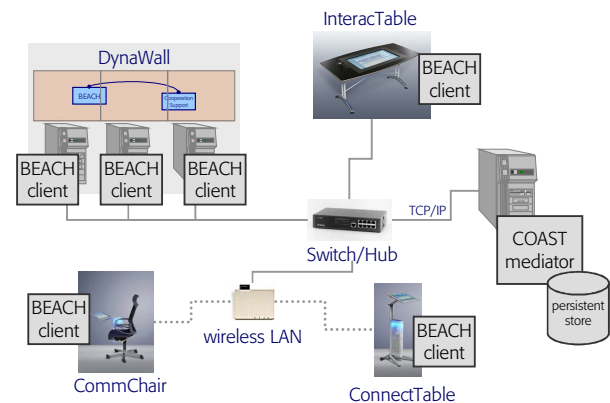


Figure 1. Roomware component setting of i-LAND

In this paper, the requirements for the software infrastructure of a roomware environment are discussed. Based on these requirements, the architecture of BEACH has been designed, which is presented next. The paper closes with an overview of the current implementation and future work

## REQUIREMENTS FOR THE SOFTWARE INFRASTRUCTURE

The software infrastructure of a roomware environment has further requirements compared to software running on distributed standard PCs. This section will explain the requirements related to collaboration with roomware components.

A roomware environment offers a variety of possible work settings. A subgroup sitting in CommChairs (see fig. 1, [8]) can work within a common workspace, whereas two users at a DynaWall [4] could work both

on the same documents or independently. Beside the general ability to work on shared documents, the software has to cope with additional aspects:

1. one user working with multiple devices
2. roomware components consisting of multiple embedded computers
3. dynamic reconfiguration of roomware components
4. integration of the physical environment
5. collaboration between different kinds of roomware components
6. roomware components to be used by multiple users at the same time
7. different orientation and shape of displays
8. support for common tasks

#### **Requirement 1: Multiple Device Interaction**

In an environment like i-LAND (or others following the ideas of ubiquitous computing [21], e.g. iRoom [2]) a user usually has access to more than one computer. Within a meeting, a user might leave the CommChair and walk up to the DynaWall to give a presentation. Here, the software must be able to detect and quickly change the assignment of the current user at these roomware components to give the user access to private information, for instance the prepared material for the presentation.

The continuation of the previous scenario brings up a different case of multiple device interaction: The user giving the presentation might have access to another roomware component in parallel to the DynaWall. To view her private annotations in addition to her slides, she uses e.g. an electronic lectern. Here, she uses several devices simultaneously with the same information displayed on both devices — but within a different context which influences the resulting view (different size, different level of details, private annotations).

Other examples where a PDA-like device is used concurrently with a digital whiteboard, a table, or PC are given in literature [2, 5, 9, 11, 12]. The PDA is used to have access to additional information or functionality without wasting space on the display. In these cases, both devices show different information and offer a different functionality.

#### **Requirement 2: Composite Roomware Components**

Some roomware components (currently only the DynaWall, see fig. 2) actually consist of several segments, each with a separate machine. Due to limitations of the available hardware (each Smart Board can only recognize a single pen position at a time) this setting allows each segment to receive pen input simultaneously. To give the user the impression of a homogeneous interaction area, the segments must therefore be coupled via software.



*Figure 2: The DynaWall made up from three segments coupled via software*

#### **Requirement 3: Dynamic Configuration**

During a meeting it happens often that several independent problems are identified which have to be solved. In such situations a team usually splits up into a set of subgroups, each trying to solve one problem. After a defined amount of time the team forms a plenary again and all solutions are presented. This scenario shows that different kinds of collaboration modes must be supported within i-LAND. The dynamics of a meeting must therefore be reflected in the design of the software, which should be flexible enough to give a team the necessary freedom to work efficiently.

#### **Requirement 4: Integration in the Environment**

Another important aspect arises from the integration within the environment. As the physical configuration of a meeting room strongly depends on the current work mode of a team, changes made to “real” objects can be used to trigger actions of the software. There are cases where a state change of the software is essential to maintain the consistency of the “real” and the “virtual” part of the world: The ConnecTable is a small interactive table which can be assembled quickly from independent segments to yield a larger homogeneous interactive area if desired (fig. 3). This is useful to support flexible splitting into and re-joining of subgroups. Here, the software must be capable of *dynamic changes* to the size and format of the currently available interaction area, and it is necessary to reflect these possibilities in the conceptual design of the user interface.



*Figure 3: Two connected ConnecTables*

#### Requirement 5: Collaboration with Different Devices

Different roomware components are equipped with a broad range of displays of different sizes and with different orientations. For differently sized devices different scaling factors must be used, taking into account whether the user needs an overview over the whole document, or whether just a part of the document is being edited.

This becomes even more complicated in the case of multiple users working together. In this situation, standard methods of shared editing can not be used, e.g. WYSIWIS would require that all collaborating users have coupled workspaces of exactly the same size. Instead, the software must allow even tightly coupled components to use different view properties, but ensure that the users get a representation that fits to the current working mode. A user in a CommChair working on a shared workspace together with a user at a DynaWall (fig. 4) will need both an overview representation of the whole workspace content and a second, zoomed view to work with. In case, the CommChair is located directly in front of the DynaWall such that the user can see the overview there, the overview representation displayed at the CommChair can be shrunk much more, as it is only needed for navigation.

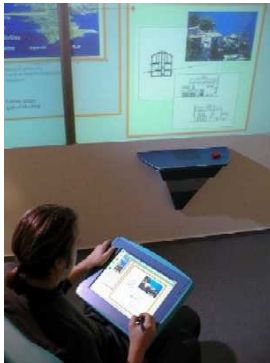


Figure 4: Remote annotating documents on the DynaWall while sitting in a CommChair

#### Requirement 6: Multiple User Devices

Some roomware components like a DynaWall or an InteracTable offer another challenge for the software: Several persons can use one roomware component together and interact simultaneously with a single device. This is often called Single Display Groupware [1, 9, 15]. Software running on this device must therefore be able to receive events from several input-streams, to recognize input from different users, and to track several concurrent event sequences (like the drawing of a stroke) [6].

#### Requirement 7: Adapted Visualization

Another problem arises at an InteracTable [16]: The orientation of the output does not necessarily has a common top-bottom/left-right for all users working at an InteracTable, as different users can look at the surface from different positions. At a traditional paper-based table, the users would simply rotate a page around to show it to someone else. At the InteracTable the same is possible. But in addition, the user should be

able to keep a view on this object oriented toward him so that they both can look at the object with the preferred orientation.

#### Requirement 8: Special Support for Common Tasks

An interview study we carried out states that creative teams have several recurring tasks [20]. As a consequence, the software should offer dedicated help for a selected set of such tasks, which should be extensible to meet future needs [7]. Important examples are creative sessions, presentations, meeting moderation, and project / task management.

#### ARCHITECTURE OF BEACH

With respect to the requirements described in the previous section, BEACH has a layered architecture that is built on top of a core model (COAST & BEACHcore in fig. 5). A layer with common models defines the basic interfaces for documents, user interface, tools, and interaction styles. On top of these models, a set of generic components is defined, that provides the basic functionality necessary in most teamwork and meeting situations. This includes for example standard data types like text, graphics, and informal handwritten input (scribbles), as well as private and public workspaces for generic collaboration support.

Based on the models and the generic components, modules for specific support can be added, which define tailored functionality for distinct tasks.

The following sections will explain these layers.

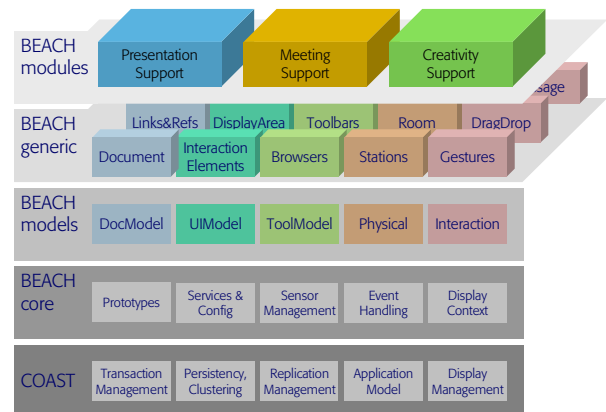


Figure 5. Layers of the architecture of BEACH

#### Replication and Synchronization

In order to provide computer support for synchronous collaboration a platform for the distribution of objects is needed (requirements 1, 2, 5, 6). As underlying technology for BEACH the COAST framework [13, 14] had been chosen, which was developed at GMD-IPSI.<sup>1</sup> The former version of this framework has been used in the DOLPHIN system [18].

In addition to the local object space containing all non-distributed objects, COAST defines a *shared object space* for objects that can be accessed by multiple

<sup>1</sup> COAST is now available as open source from <http://www.opencoast.org>.

computers. These objects are persistent and stored by a COAST server.

### Specialized Infrastructure

The aim of the core layer of BEACH is to provide functionality that will make the development of the higher levels easier. Here, we will focus on the multi-user event handling and on the view transformations.

#### Multi-user Event Handling

For multiple user devices (req. 6) it is necessary to provide an interface to hardware that is capable of handling multiple users at the same time. Multiple device drivers can send events, tagged with an identification of the originator, to BEACH. As an alternative to the standard mouse button up or down events, these can also be events like pen up, pen moved, or pen down.

To support an adapted user-interface for roomware components equipped with a pen, the events generated by the device drivers can first be assembled to higher level events. As it is very intuitive to draw strokes with a pen instead of just clicking on a document, pen events can be combined to strokes. For these stroke gesture events can be generated depending on the shape drawn with the pen (like tap, line, circle [3]).

As different kinds of events need different strategies for dispatching, the event can choose an appropriate dispatching strategy. For example, key pressed events are received by the controller having the keyboard focus, button down or pen down events are dispatched to all views at this position, and mouse moved events are directly discarded — as they only have an effect after a button (or pen) down.

To track several concurrent event sequences, the concept of “trackers” has been extended. A tracker is an object receiving events directly, without using the view hierarchy for dispatching. BEACH is capable of handling several trackers at the same time by keeping a mapping of input device IDs to the different trackers, which will get all events from this device.

#### View Transformations

As views should be displayable in different orientations and sizes (req. 7), depending on the current context, BEACHcore replaces the standard “graphics context” (which handles the drawing) by an adapted version that supports transformations. A transformation is an object that responds to messages for transforming points and graphic primitives like images. These transformations are applied by wrapper objects which are inserted into the view hierarchy and which “wrap” the view to be transformed without needing to change it.

For performance reasons, a view can have access to the transformation responsible for itself. This enables the view to transform and cache objects for which the transformation is too slow when it is applied on every redraw. This is especially important for images which are scaled or rotated, and can also speedup the drawing of long scribbles (i.e. polylines).

### Basic Models

The model layer of BEACH consists mainly of interfaces and abstract classes that define the abstractions of the components BEACH can handle. This is separated from the generic elements to ensure extensibility, flexibility, reusability, and interoperability of modules and components.

The *document model* defines the base classes and functionality of all objects that can be part of a document.

The *user-interface model* is needed, as BEACH also defines an alternative user-interface concept suitable for roomware components.

A *tool* is component that provides additional functionality to the documents. Prominent examples are toolbars or browsers. Document browsers have a special role in providing the connection between the user-interface and the document, offering also possibilities to navigate in the document. In addition, the tool controls the possible work modes like the degree of coupling.

The *physical model* is the representation of the parts of the “real” world relevant to BEACH. For example, the term “station” refers to the computers running a BEACH client.

To be able to support different styles of interaction, the *interaction model* specifies how different interaction styles can be defined.

### Generic Collaboration Support

Using the BEACHmodels, a set of generic components is defined, which is useful in all kinds of meetings and other cooperative work situations. In contrast to the elements defined by the lower layers, these components are visible to the user.

The basis for *documents* created with BEACH is a hypermedia data model. The instances of data model classes are always part of the shared object space, as this gives several users the possibility to access these objects simultaneously. The generic document elements include workspaces (the equivalent of a page), hand-written input (scribbles), texts, and images.

The main elements of the *user-interface* of BEACH are segments and overlays [10]: The complete interaction area of a roomware component can be divided into “segments”, which defines the space available for a tool, e.g. a document browser. In addition, “overlays” can be positioned freely and are used similar to the windows of most popular operating systems. They also contain a tool, but they would normally be used for toolbars and other smaller tools that have to be at hand all the time.

Some *tools* have already been mentioned: The document browser and toolbars. These are currently the only tools provided by the BEACHgeneric layer.

The most important part of the representation of the *physical environment*, is the configuration of roomware components. To be able to combine several stations to a composite roomware component (req. 2, 4), the current setting is available as shared objects, as shown in

figure 6. A roomware component consists of one to several stations. Each station has a display. The displays of all stations belonging to a roomware component are combined to a display area, which represents the complete interaction area of the roomware component, e.g. the complete area of a DynaWall.

If displays are added to or removed from the display area, the views showing it will adjust immediately the available size of the area (req. 3).

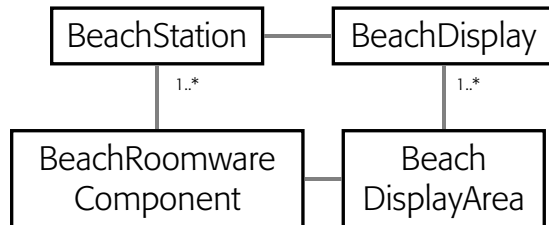


Figure 6: Relationships between roomware components, stations, displays, and display areas

For the *interaction* with roomware components, there are currently two interaction techniques available besides mouse and keyboard: Gestures written with a pen, and support for drag and drop.

To generate the gesture events mentioned above, each stroke that is drawn is sent to a gesture recognizer to check whether it is similar to one of the set of supported gesture shapes. In this case, a gesture event is generated and dispatched. In contrast to mouse events, which refer to a specific point, a gesture event is associated with a stroke — which could cross the bounds of multiple view objects. Therefore, a dispatcher for gesture events is provided that is capable of selecting the right view's controller.

#### Tailored Support for Tasks

The generic elements that are available in BEACH are useful in many different situations. For some tasks it is of help, if specific support is given (req. 8). Therefore, the architecture of BEACH has a module layer, which allows modules to add further elements with tailored functionality and to extend existing components. This way, modules can support creativity sessions, cooperative presentations, or meeting moderation.

By providing hooks to add new tools and services, modules can be plugged into BEACH without having to adapt code of the lower layers.

#### CURRENT STATE AND FIRST EXPERIENCES

BEACH is implemented using VisualWorks Smalltalk. Our first experiences with the current version of BEACH are quite promising. We used the prototype at the German computer fair CeBIT in March 1999 to give interactive presentations using a DynaWall and a CommChair. Since May 2000 there is an installation of i-LAND at the German Occupational Safety and Health Exhibition open to the public. For our own work in the AMBIENTE team, we used BEACH to collect ideas and draw design sketches on the DynaWall with some team members sitting in CommChairs or having brought their laptops and others standing directly at the DynaWall. Nevertheless, to be usable in the everyday

work, BEACH needs a better interfacing to existing applications.

The implementation of cooperative applications on top of the COAST framework was very successful, as a lot of error-prone tasks, like the conflict detection and handling caused by concurrent actions, or the updating of multiple distributed views are carried out automatically by the framework.

#### OPEN ISSUES AND FUTURE WORK

For the further development of BEACH it is helpful, to get feedback of the usability of BEACH in different — especially non-research — contexts. For the evaluation we will therefore make pilot installations of i-LAND and BEACH together with industry cooperation partners.

The latest information about the activities of AMBIENTE, BEACH, and i-LAND can be found at <http://www.darmstadt.gmd.de/ambiente/>, and <http://.../ambiente/activities/beach.html>.

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## **SHARED FACILITATED ENVIRONMENTS**

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### **Abstract**

Many collaborative technologies provide little or no guidance to participants in terms of the roles and processes that help guide collective intelligence. We believe that decades of scientific research on group processes as well as various traditional processes can be supported in shared facilitated environments so that groups can be more productive at various tasks.

### **Author's Background and Motivation.**

John Thomas is currently Manager, Knowledge Socialization at IBM's T. J. Watson Research Center. The efforts of his team currently focus on developing new tools, techniques, and representations to support on-line groups. John received a Ph.D. in psychology from the University of Michigan in 1971 and managed a research project in the psychology of aging for two and a half years at Harvard Medical School before joining IBM Research. He spent 13 years doing research in various areas of human computer interaction including query languages, natural language processing, design problem solving, audio systems, and speech synthesis. In 1986, he began the Artificial Intelligence Laboratory at NYNEX Science and Technology. The laboratory did work in expert systems, machine vision, human computer interaction, intelligent tutoring systems, robotics, speech recognition and advanced tools for software design. John was active in the formation of ACM's Special Interest Group in Computer Human Interaction and has served in various capacities including general co-chair of the CHI conference in 1991. John has taught at a variety of institutions of higher education including courses in cognitive psychology, problem solving and creativity, statistics, the psychology of aging, and human factors in information systems. He is also a licensed psychologist in New York State and has over 130 publications and invited presentations in computer science and psychology. Both as a group therapist and a manager, John has considerable experience facilitating various kinds of meetings. His research and practice have, in various ways, focused on trying to enhance collective human wisdom. He sees the workshop as an opportunity to share ideas on using technology to help achieve this goal.



## Research Description

### 1. Importance of Collaboration: Practical and Scientific.

From a practical and economic perspective, we are clearly living in an increasingly interconnected world. In reflection of this trend, the field of human-computer interaction has shifted focus from supporting the productivity of individual workers to teams and even corporate intranets and extranets (Thomas, In Press).

From a scientific perspective, we often tend to learn the most about the object of study during transitions and adaptations. Thus, a learning test is generally more diagnostic of brain function than a test of stored knowledge; a glucose tolerance test tells us more than a resting blood sugar level; a stress test tells us more about the heart than does resting heart rate. Similarly, this century's rapid transitions should allow us to understand more about collective human behavior than ever before possible.

At the same time, we still face enormous planetary problems potentially including but not limited to global fouling of the ecosphere, inequity in economic opportunity, increased chances for catastrophic disease, and international terrorism. Such planetary problems arose with current approaches and limitations to collaboration and probably will only be solved via breakthroughs in collaboration.

For many generations, human beings evolved natural language as a method for collaboration among small groups of people who generally shared context, goals, experience and culture. Given such a high degree of overlap in background context, sequential human speech served fairly well, e.g., the telling of stories for sharing experiences (Thomas, 1999). However, unaided speech is not well-suited to large-scale collaborations among people; particularly, not when the people involved may have vastly different sets of assumptions, cultural backgrounds, goals, contexts, experiences and even different native languages. We have not yet invented an entirely effective replacement of natural language for large, diverse groups though storytelling can be useful in bridging some gaps among groups when incorporated into the appropriate process (Van Der Heijden, 1996; Beyer & Holtzblatt, 1998; Bodker, 1999). Can we extend such techniques even further to facilitate communication among larger, more diverse groups?

In addition, people (and most other animals) evolved to be sensitive to sudden changes in sound, illumination and other sensory input. In the "natural" environment of 1,000,000 or 10,000 years ago, such perceptual biases were conducive to survival. Today, these same perceptual and attentional predispositions guide our current actions; e.g., observers are held rapt by high-speed chase scenes in movies and television though such scenes have little if any actual survival value in the observers real lives. By contrast, many of today's real problems such as overpopulation and global warming are too slow, too small, or too large to be perceptually salient (Ornstein & Ehrlich, 1989). We know that by changing representations, we can make isomorphic problems very easy or very difficult according to how much such representations resonate with human perceptual capacities (Ahlberg, Williamson, and Shneiderman, 1993; Carroll, Thomas, and Malhotra, 1980; Tufte, 1997). Are there ways of presenting important but non-obvious problems in a way that helps bring to bear people's natural perceptual capabilities to bear?

## 2. New technological possibilities.

Recent advances in computing power, interface technologies, bandwidth, storage, and social engineering provide a field of possibilities from which novel solutions to large scale collaboration may be designed, tested, and improved. For instance, large-scale displays now offer the possibility of reminding and focusing people on the goals and context that are shared. This could potentially help people avoid diving into distracting and divisive subproblems (Thomas, 1980).

In the “real world” effective on-line collaborations both at a distance (e.g, Finholt & Olson, 1997) and face-to-face (Fischer, 1997), are already being facilitated by technology. We believe further advances can be made by incorporating creativity aids, suggestions for processes (Thomas, 1989), and by providing tools for alternative representations (Thomas & Carroll, 1979).

Advances in speech recognition, combined with natural language processing and data mining raise the possibility of large scale real time collaborations with large groups. Speech recognition can turn raw speech into text. Even without perfect accuracy, statistical techniques can help the automatic formation of “affinity groups” that share various interests, values, or goals.

Advances in the sophistication and complexity of simulation models, combined with high resolution displays offer the possibility that some of the subtle, slow-scale problems mentioned above such as global warming might be translated into visual forms and representations that make the severity of the problems, and possible paths to solution more salient.

In the past, conversations were transient. There was no “objective” evidence of their content. It often happens, e.g., in a group meeting that the first person to raise a new idea is not recognized. Instead, the second or third person to mention the idea is often credited with it, quite possibly because the first mention is unassimilable by the current mental model of the listeners but causes a change in mental models so that a subsequent mention is comprehensible. Regardless of whether this particular speculation is correct, the more general point is that computerized records of group meetings and larger scale collaborations allow the possibility of feeding back to the participants various visualizations of behavior back to the group. In conjunction with metrics of effectiveness, such feedback mechanisms may allow groups, over time, to become much more effective in their interactions.

## 3. The traditions of meetings facilitation processes and procedures.

In earlier work, we showed that the introduction of problem solving aids to break set increased performance and creativity (Thomas, Lyon, and Miller, 1977) and that instructions to take on multiple viewpoints increased problems found in heuristic evaluation of a software design (Desurvire and Thomas, 1993). Unknown at the time to the authors, the use of multiple viewpoints has been quite consciously used by the Iroquois (and other cultures) for thousands of years (Underwood, 1994). Other writers on creativity have suggested similar methods (See, e.g., Stein, 1977; DeBono, 1985).

There are other examples of feasible techniques that might be facilitated and guided with software. For example, Bohm Dialogue (Bohm, 1996) has been used successfully in a number of real-world corporate settings (Isaacs & Smith, 1994; Isaacs, 1996) to help large groups of people understand the systems aspects of their organization. In Bohm Dialogue, participants are encouraged to balance inquiry and advocacy, to separate their ego from their contributions, to listen and reflect on what others say before speaking, to collectively build knowledge “at the center” (of the group). The current state of the art of speech recognition and speaker identification is such that automatic checks and aids to such a process could be usefully trialed.

In other cases, software might help groups implement superior processes such as negotiating from needs rather than positions (Fisher & Ury, 1991). To illustrate the difference, a story is told of two siblings who each wanted an orange. They argued and argued, but ultimately split the orange in two as the fairest compromise. This is negotiating from “position”; each sibling had the position that they wanted the entire orange. What they did not discover, because they did not reveal their actual needs was that one sibling wanted the entire orange to eat and the other sibling wanted the entire peel for use in a cake. The point is that had they worked together to solve both needs they could have reached a more optimal solution. We could certainly imagine using various techniques to remind negotiators about some of the Fisher and Ury techniques for understanding and meeting needs. However, it also seems quite feasible that additional tools based on computational linguistics could help monitor the degree to which participants in an environment were sticking to fixed positions. It is an open research question how information from such a monitor should be fed back to the group. E.g., one could imagine a social proxy (Erickson and Kellogg, 2000) in which only group levels of some behavior were shown, individual levels anonymized, or individual levels associated with people.

#### 4. Work of the knowledge socialization group.

In the knowledge socialization group at Watson, our work has consisted of several interlaced threads. In one thread of work, we have been conceptualizing, designing, and building tools to support the creation, capture, organization, understanding, and utilization of stories as a method for groups to build and share knowledge. In the “Value Miner”, e.g., natural language processing methods are used to find values as expressed in text. This could be applied to conversations, documents, and websites as well as stories. The Value Miner finds value-related words and phrases and tries to categorize these. In a related, “Point Of View” tool, the value similarities and differences of various participants are shown.

We are also working on story visualizations aimed at helping individuals and groups create, understand, and find stories relevant to a situation at hand. In addition to visualizations, there are guidelines and measures based on known heuristics of story writing that can be incorporated into groupware (McKee, 1997; Frey, 1994).

In another thread of work, we are building tools that incorporate process guidelines to facilitate various kinds of meetings including synectics (a structured kind of brainstorming), Bohm Dialogue, the K-J bottom-up affinity method, idea evaluation, and Writers Workshops. Writers Workshops is a traditional feedback technique for creative writers but has been adopted by

communities working on pattern languages. In a Writers Workshop, the writer (or proposer of a pattern) circulates the work ahead of time to a group of people. In a face to face meeting, the writer then reads a portion out loud to the group. At this point, the author becomes a “fly on the wall.” They turn their back, listen, and take notes but do not defend or explain during the ensuing discussion. Instead, a member of the group summarizes the essence of the work. Then, the group says what they like about the work in terms of form and then in terms of content. Then, members of the group may offer suggestions for improving the form and then the content. Finally, the author is praised and invited back in. Then, someone is supposed to tell an irrelevant story (in order to break set and reassert group solidarity). Such a process has proven to be an efficient and effective way for an author to get feedback and we are looking at various ways to facilitate such a process in face to face meetings.

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### **Justification**

I believe that my multiple backgrounds in organizational learning, knowledge management, and clinical psychology as well as human-computer interaction may bring a different perspective to bear on the issues in supporting face-to-face collaborations. The topic of the workshop is something I've been thinking about for several decades and now technology has finally reached the point of making some of these ideas feasible.

# Using Translucent Interface Components to Lessen Interference Effects in Single Display Groupware

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## Abstract

Single Display Groupware (SDG) is a class of applications that supports multiple simultaneous users interacting in the same room on a single shared display through multiple input devices. Because users share the same display, they have the same view of the working area. *Interference* occurs when one user raises some interface component—pop-up menus, dialog boxes, secondary windows—that hides or obscures the view of the underlying work surface for other users. This is not only distracting, but may also impede people from continuing their work. In this paper, we describe our in-progress research on using translucent interface components in single display groupware as a way of lessening interference effects. In particular, we are comparing how translucent vs. traditional opaque menus affect levels of interference when users are playing a simple SDG “connecting the dots” game.

## Research Description

Single Display Groupware (SDG) is a class of CSCW applications that deals with several co-located people viewing and interacting with the same output display. While all use the same computer, each person has their own input device that they can use simultaneously with others.

There are several technical issues in developing SDG applications. Most arise from the poor support in operating systems and programming languages when developing applications for multiple users and multiple input devices. In particular, most operating systems provide direct support for only one user, using a single pointing device and keyboard, to interact with it at a time. Similarly, programming languages provide interface components (or widgets) designed for single users. For example, widgets such as menus, dialog boxes, and toolboxes do not discriminate, recognize and appropriately respond to simultaneously input from several users and their input devices. Consequently, developing even simple (but effective) SDG applications is difficult.

Our research concentrates on designing interface components for SDG. One of our concerns is analyzing interface components in terms of the level of *interference* they may cause to SDG users. Interference occurs when an interface component appears over the working area in a place that obstructs or impedes someone's view of the underlying surface. Users can unintentionally interfere with other users' work e.g., by moving their cursor close to or on the top of another's work and then raising a pop-up menu or opening a secondary window that is positioned over another's work area. We believe interference is an important usability issue because of the characteristics of SDG: users share the same display and whatever appears on it, they share tools on the display (and these tools compete for space with the underlying worksurface), and screen real estate is tight,

We believe that *translucent interface components* may help minimize interference among users. First, these components are semi-transparent: all participants not only see what is on the component, but can also see through it to the area underneath. Second, the component responds only to its owners input; all other participant's actions are directed to the correct objects underneath it on the work surface.

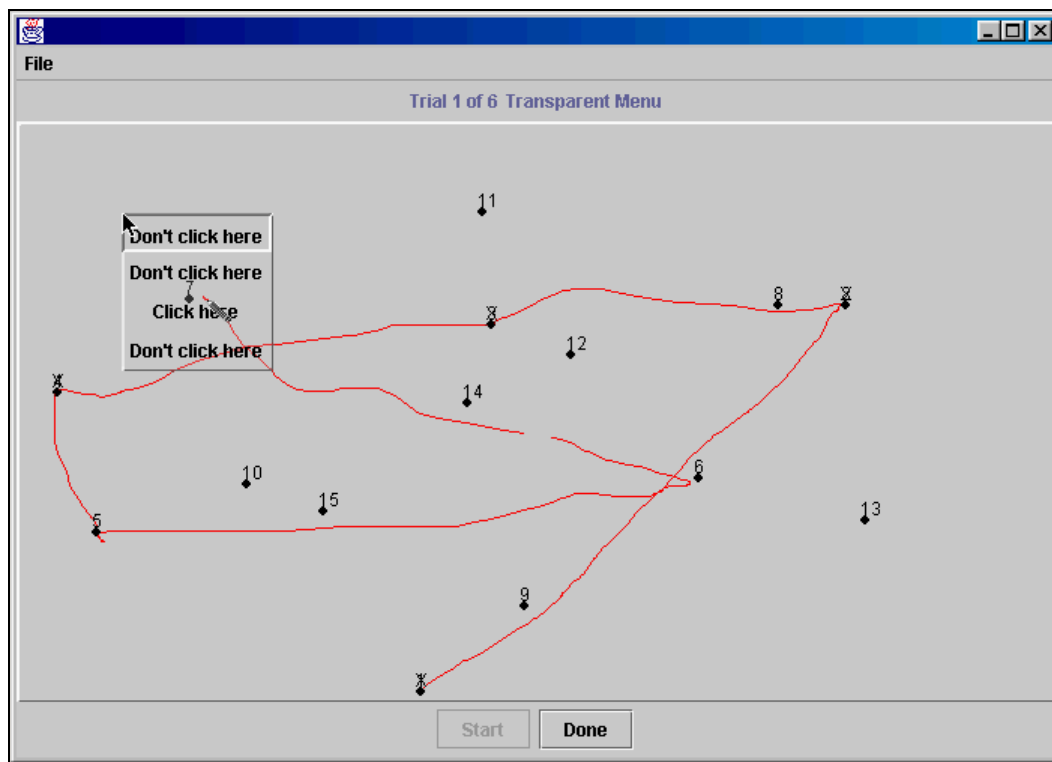


Figure 1 – “Connecting the Dots” with translucent menus



Figure 2 - “Connecting the Dots” with opaque menus

To test this idea, we are comparing and analyzing the use of translucent pop-up menus (Figure 1) to that of opaque menus (Figure 2) in an SDG setting. Our study (which is now in progress) will look at the level of interference that translucent and opaque popup menus can cause to users in an SDG situation. We use a simple “connect the dots” SDG application that allows two users to interact at the same time (Figure 1). With this study we want to measure how the opaque and translucent menus raised by one person affects the performance of the other person who is connecting the dots: this will be measured by recording the task completion time. We will also collect their impressions of the usefulness of translucent menus in this setting.

Specifically, we will generate ‘worst case’ levels of interference by having one person try to slow down or impede the other person’s work. Each person has a specific role: the *player* is the person connecting the dots, and the *interferer* is the person popping up the menu. The interferer is directed to try and pop up their menu over the area where the player is connecting the dots. Each game consists on fifteen numbered dots, which the player has to connect in numeric order by drawing a line to the next dot and then clicking on that dot. Near misses are noted, but the player is allowed to keep on going. The interferer’s job is to try and raise their menu in a way that hinders the person from reaching and clicking on the next numbered dot. An example game is illustrated in Figure 1. There are three types of trials in the test: a *solo trial*, in which only one user plays (i.e. connects the dots without any interference); an *opaque menu trial*, in which both play and the menus are opaque; and a *translucent menu trial*, in which both play and the menus are translucent. Each pair of users will play several trials in a specific order, randomly defined by the system.



Figure 1 shows a snapshot of the “connecting the dots” application using translucent menus with two users playing. The player is identified by a cursor that has a shape of a pencil while the interferer has a black arrow cursor. The interferer popped up a menu when the player was selecting number 7. It is a translucent menu, so it is possible to see through it (the lines previously drawn, the number 7). We also see that the player has clicked dots 1 through 4 (marked with an X), but missed dots numbers 5 and 6 since they are not marked. Figure 2 shows a similar situation with opaque menus: while the two cursors are visible, the area underneath the menu is not i.e., the drawn lines and numbered dots are occluded.

The tests are now in progress, and preliminary results will be presented at the workshop. Our initial data suggests that translucent menus do lessen interference effects in SDG, and that subjects prefer them to opaque menus. If translucent menus prove successful, we will apply this technique to other interface components.

### **Authors' Background**

Ana Zanella is a Ph.D. student in the Department of Computer Science at the University of Calgary. She has a B.Sc. in Computer Science from Pontificia Universidade Catolica do RS, Brazil, and a M.Sc. in Computer Science from Pontificia Universidade Catolica do RS, Brazil. Ana's current research interests include CSCW, Co-located Groupware, Single Display Groupware, widgets for Single Display Groupware, Multiple Input Devices.

Saul Greenberg, a Professor in the Department of Computer Science at the University of Calgary, is an active researcher in Human Computer Interaction and Groupware. He is the author and co-editor of several books, including "The Computer User as Toolsmith" (Cambridge University Press, 1993), "Computer Supported Cooperative Work and Groupware" (Academic Press, 1992), "Groupware for Real Time Drawing" (McGraw Hill, Europe), and "Readings in Human Computer Interaction: Towards the Year 2000" (Morgan-Kaufman, 1995). He has served on many academic reviews committees, and is on the editorial board of the "International Journal of Human Computer Studies" and "Computer Supported Cooperative Work".

### **Justification for Participation**

Our research, although in its initial phase, shows potential in terms of new ideas for the design of widgets for SDG applications. Our goal in participating in the workshop is to meet other researchers interested on SDG design issues, to hear about their work, and to share with others the research we are doing.