From Awareness to HCI Education: The CHI'2005 Workshop Papers Suite

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Cite as:

Greenberg, S., McEwan, G., Neustaedter, C., Elliot, K. and Tang, A. (2005). **From Awareness to HCI Education: The CHI'2005 Workshop Papers Suite.** Report 2005-772-03, Department of Computer Science, University of Calgary, Calgary, Alberta, Canada T2N 1N4. Compiled as this report in February.

Abstract

These four papers are a suite of articles presented at workshops (listed in the individual citations) held at the ACM CHI 2005 conference, April 2005.

Saul Greenberg. (2005) **HCI Graduate Education in a Traditional Compute Science Department.** ACM CHI 2005 Workshop on Graduate Education in Human-Computer Interaction. Organized by Beaudouin-Lafon, M., Foley, J., Grudin, J., Hudson, S., Hollan, J., Olson, J. and Verplank, B. [see workshop call for papers]	
Gregor McEwan and Saul Greenberg. (2005) **Community Bar: Designing for Awareness and Interaction.** ACM CHI 2005 Workshop on Awareness systems: Known Results, Theory, Concepts and Future Challenges. Organized by Panos Markopoulos, de Ruyter, Boris, and Mackay, Wendy. [see workshop call for papers]	
Carman Neustaedter, Kathryn Elliot and Saul Greenberg. (2005) **Understanding Interpersonal Awareness in the Home.** ACM CHI 2005 Workshop on Awareness systems: Known Results, Theory, Concepts and Future Challenges. Organized by Panos Markopoulos, de Ruyter, Boris, and Mackay, Wendy. [see workshop call for papers]	
Anthony Tang and Saul Greenberg. (2005) **Supporting Awareness in Mixed Presence Groupware.** ACM CHI 2005 Workshop on Awareness systems: Known Results, Theory, Concepts and Future Challenges. Organized by Panos Markopoulos, de Ruyter, Boris, and Mackay, Wendy. [see workshop call for papers]	

HCI Graduate Education in a Traditional Computer Science Department

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ABSTRACT
There are now several serious graduate programs dedicated to the training of professionals in Human Computer Interaction (HCI), and this is attracting considerable attention in the community. Yet HCI professors at most institutions are still limited to do this training within the constraints of a traditional department and program. In this paper, I discuss the issues that I and others encountered while creating an HCI program within a traditional computer science department, and my solutions to them.

Author Keywords
HCI Education. Graduate programs.

INTRODUCTION

Over the last few decades, educators in Human Computer Interaction (HCI) have legitimized this field as a necessary component of the computer science discipline in both undergraduate and graduate programs.

At the undergraduate level, introductory HCI material is now offered at many institutions. These typically appear either as fully-fledged HCI courses at the junior or senior level, or as components in other courses, e.g., within a software engineering course. There are several versions of HCI curricula, a variety of introductory text books, and good introductory lectures available on the World Wide Web. Some institutions even have a second specialized undergraduate course in HCI, or an ‘HCI concentration’ that suggests a slate of related courses to those interested in the area.

At the graduate level, the picture is somewhat mixed. At one extreme, there are still many institutions that have no faculty who specialize in HCI. This is not to say that these institutions intentionally neglect HCI, for the large number of faculty advertisement asking for HCI experience suggests that the bottleneck is acquiring HCI academics. At the other extreme are the few institutions that have created a formal HCI program. These programs solicit students who wish to become HCI professionals, and tend to encourage cross-discipline research and training. Between these two lies the more common situation where an HCI faculty or two craft a program or HCI concentration within the constraints of a traditional graduate computer science degree. By traditional, I mean that the degree program is primarily oriented toward the general discipline (e.g., computer science, psychology) vs. cross disciplinary, has breadth and depth course requirements specific to that discipline, and is thesis-oriented. Specialties within these degrees are usually by research interest of faculty and students rather than through formal program designation.

My interest and experience lies in this middle ground. In this paper, I discuss the HCI program as created within the Computer Science program at the University of Calgary. While the program is successfully training HCI graduates, it is fraught with issues and workarounds that come from trying to fit it into a traditional program. In this paper, I articulate some of these issues, not because they are unique, but so that others in similar circumstances can compare their own issues and workarounds to ours.

THE CALGARY HCI PROGRAM

First, I will briefly describe the HCI program at Calgary at both the undergraduate and graduate level.

Up until a few years ago, I was the only HCI specialist on faculty. A specialist in Information Visualization (who bridges HCI and graphics) joined our faculty a few years ago, while a third HCI person joined this year. Graduate students interested in specializing in HCI or its sub-disciplines (e.g., CSCW, Information Visualization, Context-aware computing) typically work with one of these three professors, all who share a large common laboratory called the Interactions Laboratory. About 20 to 24 graduates inhabit this laboratory.

At the undergraduate level, the department offers several sections of an introductory HCI course at the junior/senior level. While it is an optional course, it is taken by the

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majority of undergraduates. The department also offers an 'advanced' undergraduate HCI course based on the idea of a design studio: students are exposed to several state-of-the-art interface genres (e.g., groupware, tangible interfaces) and are expected to design and implement systems within each genre. The class is restricted to 15 students, who apply for it on a competitive basis. While there are no other undergraduate HCI courses, students can add to their expertise by taking a slate of graphics courses.

At the graduate level, the department offers a fairly traditional MSc and PhD graduate program.

- It is thesis based
- Courses taken are supposed to be a mix of breadth and depth (4 courses for the MSc, and an additional 4 courses for the PhD).
- It favors admission of graduate students with a Computer Science/Engineering background.

There are several graduate course offerings in HCI, but they are not necessarily offered every year. These are described below.

- *CPSC 681. Research Methods in HCI* is an applied survey of evaluation methodologies. It is the most long-standing HCI graduate course in our program, and has been offered in one form or another (sometimes on alternating years) since the very early 1980s.
- *CPSC 781. Advanced Topics in HCI* is a vehicle for teaching a particular advanced HCI topic in depth. The topic may change year by year. Example past topics include CSCW, Tangible User Interfaces, and Heuristic Evaluation.
- *CPSC 683. Information Visualization* covers the theory and development of interactive visual representations of abstract data for the purpose of amplifying cognition. This course was recently introduced due to the arrival of a new faculty member.
- *CPSC 601.XX Special Topics in Computer Science* is a designation for one-off courses (usually a reading course) tailored for a very small group of students with a narrow research focus.

ISSUES AND SOLUTIONS

This section identifies a variety of issues that we continually face in teaching HCI at the graduate level.

Issue 1. Unprepared Incoming Students

Graduate applicants interested in HCI may have no formal training in it. This usually arises because HCI may not have been available at the student's undergraduate institution, or was given as an option that, for one reason or another, did not fit into the student's schedule. The problem is that there is no 'introductory' course on HCI available at the graduate level. Yet students are reluctant to take the undergraduate course because they cannot count it as credit towards their degree. As a result, these students often have to learn the core material on their own.

A related problem is that we often have many graduate students who want some rudimentary training in HCI, even though they do not want to be HCI specialists. This typically arises because these students see HCI as relevant to their research even though it may not be a primary focus. Again, because there is no introductory graduate course in HCI, they either end up taking one of our 'advanced' HCI courses (which may not be appropriate for what they want) or do without.

Solution 1. An Introductory HCI Graduate Course

The obvious solution to this problem is to offer an introductory graduate course in HCI. However, this proved no easy matter. First, there is limited faculty available to teach HCI, and (at least in our department) usually only one graduate course is included in a professor's normal teaching load. This introduces the dilemma that offering an introductory course may mean that the specialist HCI course would not be offered. Second, I originally worked around this problem by offering a one-week (full days) intensive introduction to HCI extra to my load. Over time, this option was dropped simply because it was too hard to schedule and difficult to sustain.

The solution that we are working on now is to get departmental buy-in on the importance of an introductory HCI graduate course, and to have the department guarantee that this course should not compete with other HCI course offerings. We successfully argued the case by noting that a) HCI is important to non-HCI specialists in terms of their breadth training, and b) it is critical to the training of software engineers. Consequently, this course will be offered in the coming years.

Issue 2. Students from Other Disciplines

HCI attracts students from other disciplines. Since HCI is fundamentally a cross-discipline area, we should include these students into our program. Not only would they receive training, but they would add richness and alternate perspectives as they work side by side with the computer science HCI students. Yet our program runs within Computer Science. As our department grows in size (170 grad students), admission rules are becoming inflexible, where they increasingly favor admission of computer scientists over those from other non-technical disciplines. While there is a means to admit these students, this comes at the cost of either an onerous course load or by somehow creating a cross-department multi-disciplinary degree. Thus while both HCI and other faculty favour multi-discipline students, the bottom line argument is that we are still granting Computer Science degrees. As a consequence, the hurdles are just too high.

Solution 2. Cross-Discipline Courses & Collaborations.

The obvious solution would be to create a new degree designation (say, MSc in HCI), i.e., a new program or concentration that touted itself as a cross discipline program. Yet this proved impractical. First, the resources simply were not there to create and maintain such a program, as it would require new faculty and new program design. Second, it is very difficult to get the University of Calgary to designate new degrees, for these demand government approval.

While we were stuck with admitting into the program only those students with a technical background (excepting exceptional cases where we do try to craft some kind of special cross discipline program), we did not want to lose the richness of cross-discipline collaboration. What we do instead is encourage students to apply to their home discipline (Psychology, Industrial Design, Communications, Educational Technology), and then to take courses from us. That is, while our program could not be cross-discipline, we designed our HCI graduate courses so they can be taken by non-computer scientists. This works well in practice. In CPSC 681, for example, we typically get students from Psychology intermixing with computer scientists within the course and on joint projects. In CPSC 683 Information Visualization, we have had students from Communications, and from a nearby Arts college work on joint projects, many of which were exhibited in at a museum.

A major benefit of including students from other disciplines into these courses is that course projects often turned into first class research projects that went beyond the scope of the class. Students started working together, regardless of the discipline. Because of their abilities, I often hired some of these 'outside' students as research assistants. They identified themselves as members of our laboratory, and enriched our culture of HCI education.

Issue 3. Breadth versus Depth

Our program expects students to take courses that exhibit both breadth and depth in Computer Science. While a recommendation at the MSc level, it is codified at the PhD level into a certain number of courses from predefined areas (e.g., theory, systems, applications). This can leave HCI students at a disadvantage. For example, other specializations in Computer Science expect a minimal level of 'core' compulsory training coming out of the undergraduate degree, e.g., those interested in graduate work in theory would likely have quite a few theory courses under their belt, usually a combination of several compulsory courses and a few optional courses. Yet, as mentioned in Issue 1, HCI students are often lucky if they have a single HCI course before admission. Thus they require a good number of HCI courses to bring them up to the level expected of an HCI professional. This means they can easily fall awry of the breadth requirement, or they cannot take or count some of these desired courses as part of their load.

Solution 3. Designing Flexibility into the Breadth.

Our solution was to add flexibility to the definition of breadth as required by our graduate program, especially at the PhD level. I was recently made Graduate Director of Computer Science, and as part of this I was asked to redesign the depth/breadth requirement of our PhD program. This did not mean I could relax it; in fact, my mandate was to make it stricter than it was in order to stay aligned with requirements of other Universities. The original proposal (handed over from a previous year) was a fairly standard requirement that students must take two courses within each area of theory, systems and applications.

The solution was to add flexibility to the breadth requirement. First, a fourth area 'External to Computer Science' was added to supplement the three core Computer Science areas. This meant that students could take courses related to HCI from other disciplines (e.g., Psychology Human Factors, Industrial Design) and have them count towards their breadth. Second, we added a caveat that would let students deviate from these hard rules if it could be shown that this was in their best interests: "However, in particular cases, course programs for PhD students can deviate from the above by designing and justifying an alternative breadth/depth program that satisfies the supervisor, the supervisory committee, and the graduate committee." I should add that these solutions also solved concerns raised by other faculty members who needed a greater depth component than that allowed by the original program description.

Issue 4. Course Availability

As mentioned above, several courses are offered in HCI on an irregular basis. This is proving problematic, for incoming students needing core HCI expertise (such as evaluation methods) may not be able to take it until the second year of the program. This is simply too late. Again, students in this situation are expected to pick it up on their own, or to have other students mentor them.

Solution 4. A Graduate HCI Concentration

Our solution, which has not yet been implemented, is to design an HCI concentration for the graduate program. A concentration is a semi-formal program. While students can enroll in a concentration, it is really little more than a recommended set of courses. The trick is to get these courses approved by the department, and to have the department guarantee (as much as possible) that a certain slate of courses would be offered every year.

In our particular situation, we would like to guarantee the following two course offerings every year: Advanced Introduction to HCI, Research Methods in HCI. Each year, we would also guarantee a course offering of at least one 'specialist' HCI course, in the form of the Advanced Topics in HCI e.g., Computer Supported Cooperative Work, Information Visualization, Context-Aware Computing. Interspersed would be the reading courses, given on a discretionary basis. This means that an incoming student would be able to take two or three HCI courses in the first year.

Another option that we encourage is for students to look for HCI-related courses outside the Computer Science Program (See Solution 4). We have found several good courses, e.g., a Sketching and a Qualitative Evaluation course in Industrial Design, a Human Error and an Industrial Ergonomics course in Psychology, and several others. The challenge is to get our students admitted into these courses without the necessary pre-requisites. We do this in several ways. First, the HCI faculty talks to these course professors about the relations between HCI and their course material. Second, we invite students of those professors to join our courses. Third, we seed the process with an 'exemplar student' to prove that Computer Science students can not only do well in those courses, but that they can also add valuable insights to the class discussions and projects.

When the concentration is in place, we expect it to be a mix of recommended courses both inside and outside of Computer Science. Ideally, we would like other faculties to create their own concentrations that include our courses. By doing so, we will have created a grass-roots interdisciplinary program, which will provide another solution to Issue 2.

OTHER CONCERNS

There are several other concerns arising from graduate education of HCI students within Computer Science. I list them here in no particular order, and just raise them as possible discussion points.

HCI as a technical field. As computer scientists, our students can contribute much to the technical aspects of interface design. Yet, in practice, our HCI courses tend to concentrate on HCI material gleaned from other disciplines, as these will be the areas that students will be least familiar with. While we demand students do technical aspects of HCI as part of their research, we really should provide them with a technical course. This could include (say) algorithms for advanced input techniques, interface toolkit design, interface architectures, interface aspects of distributed systems, and so on.

Toolkits for rapid prototyping. One of the best ways students learn is by doing, where they rapidly prototype and modify novel interface designs. Yet most commercial systems offer tools for only 'mundane' GUI design. To solve this, our laboratory has a toolkit culture, where students package interface methods with a well defined API so that other students can build atop of them. In practice, this has been tremendously successful.

HCI teaching modules. There is, as yet, no single recipe for teaching HCI that will fit all faculty and/or students. One solution is to recognize these by creating HCI modules on specific topics, where modules can be combined in different ways to create courses. I have done this over the many years I have been teaching HCI. My material has been made available over the web and has been used by countless others (www.cpsc.ucalgary.ca/~saul/hci_topics). Others have also attempted this (e.g., Shneiderman collects topics and relates it to his book). The current effort by Georgia Tech to create a more universal repository in its HCC Education Digital Library should help significantly in this regard by creating an HCI Commons that does not reflect an individual perspective or that is not tied to a commercial venture.

HCI teaching resources. A great many resources exist that can considerably assist in the teaching of HCI. As a community, we should collect and disseminate these resources. The teaching modules mentioned above is one example. Tested and well documented interface toolkits for innovative interface design is another example, e.g., as done by ourselves (SDGToolkit, Groupkit, Grouplab DiamondTouch Toolkit, the Collabrary, Phidgets) and Ben Bederson (his Piccolo toolkit. Yet another example would be videos of interfaces. While many are previously published, they are very hard to acquire in practice. The Open Video project is one example of a university attempting to collect and disseminate this type of material.

CONCLUSIONS

As HCI matures, we as a community are anticipating specialized HCI graduate programs for training highly qualified HCI personnel. While a handful of programs now exist that do this, we should not forget that the vast majority of universities are only just hiring a single HCI faculty member to teach HCI within a traditional program, and that most students are still coming through these traditional graduate programs. Consequently, I believe it is important for the educational HCI community to exchange issues, tradeoffs and workarounds that HCI faculty in these traditional programs have developed over time. While programs with established HCI faculty already know how to do this, the many new faculty members that are being hired may use this information to fast-track a workable HCI program within their traditional department.

ACKNOWLEDGMENTS

When I was a graduate student, David Hill was a profound influence on me - I attended his HCI course in 1980, and he sent me to the very first CHI conference. Later, I was fortunate to be hired at an institution with a long record of HCI education stemming back to the 1970s. Calgary was always supportive of HCI; I never had to 'fight' for it. Over time, I have learned and built upon the work of my colleagues; HCI is a wonderful field where professionals encourage sharing. Finally, I am grateful to Sheelagh Carpendale, who brought her insights as both an artist and computer scientist faculty member to our training of HCI students.

Community Bar: Designing for Awareness and Interaction

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ABSTRACT
The Community Bar is a groupware tool supporting informal awareness and casual interaction for small communities of intimate collaborators. Its conceptual design is primarily based on a comprehensive sociological theory called the Locales Framework, with extra details supplied by other theoretical model of awareness. It is also influenced by the Microsoft SideShow system: it displays basic awareness information in a space-conservative sidebar, and reveals progressively more information through a series of transient large tooltips and pop-up windows.

Author Keywords
CSCW, informal awareness, casual interaction.

ACM Classification Keywords
H.5.3 [Information Interfaces and Presentation (e.g. HCI)]: Group and Organization Interfaces---Computer-supported cooperative work.

INTRODUCTION

Kraut et al [4] showed that physical proximity is a major factor in stimulating collaboration between communities of intimate collaborators. They discovered that a large portion of the collaborators' time was spent in unplanned, casual interactions with others. These casual interactions served to keep individuals informed about each other in social and professional contexts and make the transition to tightly-coupled collaboration easier. Whittaker et al [9] found that these type of interactions are (1) unplanned, brief, and frequent, (2) amongst small groups of people familiar with one another, (3) useful for artefact-centric work and reinforcing social bonds, and (4) severely affected by physical separation. Kraut et al [4] also found that these casual interactions were based upon the members of the group having an informal awareness of each other, such as knowledge about presence, activity, and availability. Having this knowledge allows people to engage in light-weight casual interactions at appropriate times and in an appropriate manner.

Informal awareness and casual interaction tools are intended to help overcome the problems that physical separation causes for collaboration. These tools, designed around the above characteristics collocated interactions, provide mechanisms for maintaining informal awareness information and engaging in casual interactions between distributed group members.

Yet these tools are shallow caricatures in terms of how they support the social practices of the individuals and the groups that use them. Some tools (such as Instant Messengers) treat one's social communities as a disparate set of buddy lists, where they favour isolated chats between two people. Other tools (such as chat groups) have rigid notions of how groups are defined and how one becomes members of it. From a theoretical perspective, communities are far richer than that. Our own work is motivated by the Locales Framework [2], one of the few comprehensive theoretical group work and interaction frameworks in the computer science field, as well as the Focus and Nimbus model [5]. By combining these theories with the sidebar metaphor introduced in Microsoft's Sideshow [1] and media items of the Notification Collage [6], we are developing an awareness and casual interaction tool called the Community Bar.

We begin with a summary of both the Locales Framework and the Focus and Nimbus model. Next are specific design principles derived from these theories. Finally, we describe the design of the Community Bar tool and how it relates to these principles.

THEORETICAL BACKGROUND

The Locales Framework is one of the few comprehensive sociological theories of group work in the field of computer science [2]. Because it is specified in a descriptive manner and at a very high level, we add details to its mutuality (awareness) aspect by referring to Rodden's Focus and Nimbus model of awareness [5].

The Locales Framework – A Brief Overview

The *social world* - a group of people with a common purpose - is the fundamental concept used in the Locales framework. The common purpose may be formally defined, such as a company with a business model and mission statement, or informal, such as a group of friends that meet for lunch. The framework is divided into five aspects that describe how social worlds behave, as described below.

McEwan, Gregor and Greenberg, S. (2005) Community Bar: Designing for Awareness and Interaction. ACM CHI Workshop on Awareness systems: Known Results, Theory, Concepts and Future Challenges Organized by Panos Markopoulos, de Ruyter, Boris, and Mackay, Wendy. April.

Locale Foundations. A *locale* is the site and means that a social world uses in its pursuit of the shared purpose. Sites are places that the social world uses, and means are the objects within those places. An example of a locale is a meeting room, where the site is the room itself and the means include whiteboards, pens, individual notebooks, chairs, tables, etc. inside the room. Another example would be a shared network file system, where the site is virtual space and the means include the "soft" electronic documents stored in the file system.

Civic Structure. No social world operates in isolation. Members are involved in multiple worlds at once. Social worlds exist within broader organisational structures, and sometimes smaller sub-worlds are contained within the social world. An analysis of Civic Structure describes the relevant outside influences on a social world.

Individual Views. As an individual engages in work, he/she is rarely involved in a single task to the exclusion of all others [2]. They will engage in multiple different tasks, across separate social worlds, simultaneously. There are two important aspects to be considered; a *view* on one social world, and an individual's *viewset* across multiple social worlds. A view is how an individual sees a single social world (the people and the locales), and it is dependent on the level of engagement with the centre of that world. A viewset incorporates the individual's views of all the social worlds with which they are engaged. People personalise their viewset, arranging the multiple tasks according to their current focus. They personalise their view onto a task; arranging the tools and artefacts for that task according to their current level of engagement.

Interaction Trajectory. Interaction Trajectories describe the highly dynamic nature of social worlds. Social worlds engage in actions towards their goals as well as the possible changes to any of the properties of the social world; members, goals, locales, structure, etc. Social worlds have phases (e.g. setup, full operation, finalising), and there are routines and rhythms [8]. They have pasts, presents, and futures. Awareness of past actions and outcomes, present situations, and visions for the future are important for creating plans and strategies.

Mutuality. Awareness of people, spaces and resources is vital for collaboration within the social world [2]. Fitzpatrick teases apart the definition of mutuality into provision and reception of awareness information. Members of the social world make information about themselves and their activities available to others. Others then perceive the information and become aware. The separation is important as not all provided information is always perceived. Awareness is an interaction between the provision of information by a person or object and another's reception of that information. The focus and nimbus model of awareness [5], described next, investigates this idea in more detail.

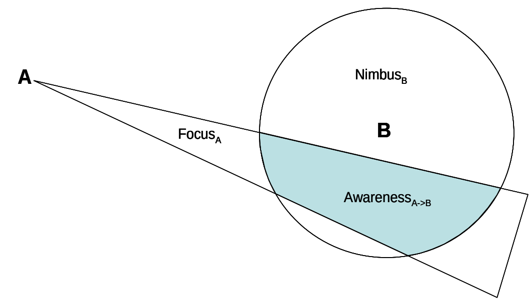

Figure 1: Focus and Nimbus combine to form awareness

Focus and Nimbus Model of Awareness

Rodden's [5] focus and nimbus model explicitly breaks down awareness into an interaction between the observer and the observed. Each person or artefact in the environment provides some perceivable information about itself, called *nimbus* in the model. Conversely, each person in the environment has capabilities to perceive this information. The way in which they direct this perceiving capability is called *focus*. The awareness that $person_A$ has of $object_B$ is a function of the overlap of the focus of $person_A$ with the nimbus of $object_B$ (see Figure 1).

The value of the model to the current discussion is that: (1) awareness is defined by both the observer and the observed; and (2) awareness can be conceived as a continuous function rather than binary.

DESIGN PRINCIPLES

The design principles outlined below are mostly restatements of the major points discussed in the theory above. Principles 1 to 3 are derived from the introductory discussion of informal awareness and casual interaction. Principles 4 to 7 are from Greenberg et al [3]'s transformation of the Locales Framework into heuristic evaluation principles for groupware. Principles 8 and 9 are from the focus and nimbus model of awareness.

1. **Awareness information should be always visible at the periphery.** Awareness information needs to be constant and dynamic to maintain knowledge of the surrounding environment. However, it should not interfere with focus on other tasks.
2. **Allow lightweight transitions from awareness to interaction.** A primary benefit of having informal, peripheral awareness is as a basis for casual interaction. As casual interactions have to be lightweight, unplanned, and frequent, any tool that supports them must also reflect these properties.
3. **Provide rich information sources.** Awareness can be based on many different cues. The more information that is presented, the better people are able to interpret awareness information.
4. **Provide centres (locales).** The Locales Framework tells us that people work in multiple contexts simultaneously, switching between them. These multiple centres or

locales should be reflected in the design of informal awareness and interaction tools.

5. **Provide a way to organise and relate locales to one another (civic structures).** Locales relate to each other in different ways. A representation of an individual's locales needs to allow the relationships between the locales to be expressed.
6. **Allow individual views.** Each person interacts with a set of locales in different ways. The interface should allow the user to structure their view of the tasks according to their personal preference.
7. **Allow people to manage and stay aware of their evolving interactions over time.** Awareness and casual interaction information is especially time sensitive and must be kept up to date. This point also refers to being aware of the past, present, and future of interactions.
8. **Provide methods for controlling focus.** As a user's interest in their locales changes over time, they need to be able to adjust their focus onto the people and artefacts in those locales.
9. **Provide methods for controlling nimbus.** In much the same was as a person changes their focus with their interest, their nimbi should be able to change as well. People need to be able to adjust how they appear to fit the context in which they are interacting.

COMMUNITY BAR

Community Bar is an informal awareness and interaction tool that is based on the design principles described above. The practical aspects of the design are heavily inspired by Microsoft Sideshow's [1] sidebar and "quick drill-down into information" designs, and also by the media-items in the Notification Collage [6].

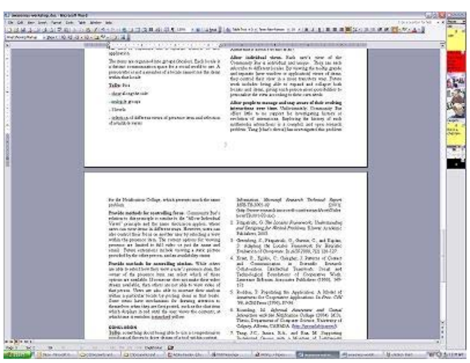

Figure 2: Community Bar peripherally visible by its constant location at the side of the user's screen (see right side).

As in the Sideshow application, the basic profile of Community Bar is a space-conservative bar on the side of the screen (Figure 2, right side). The bar displays small items, and like Sideshow, the items support quick drill-down into information. Placing the mouse over an item displays a "tooltip grande" [1] (Figure 3) which can then be expanded into a separate window or new application. Items are also organised into groups (locales), where each locale is a distinct communication space for a social world to use. A person who is not a member of a locale cannot see the items within that locale.

Details of Community Bar are further elaborated below with respect to the design guidelines described previously.

Awareness information should be always peripherally visible. Community Bar is displayed as a thin bar on the side of the workspace (Figure 2). The bar reserves the space on the screen and can never be covered. The bar's awareness information is always visible but only taking a small amount of space on the screen so that it doesn't interfere with the user's main task. Awareness is provided within the user's peripheral vision of their workspace.

Allow lightweight transitions from awareness to interaction. When the user moves their mouse over the awareness elements on the bar, they display a "tooltip grande" (see [1]). The tooltip grande view, as well as showing more information detail than the smaller item in the bar, provides methods of interaction (Figure 3 shows an example). When appropriate, the tooltip grande can be expanded further into a separate window view or by launching a new application. For example, the video item progressively expands to one with higher resolution and a faster frame rate. Similarly, a Postit item expands to one that is larger font and editable. The web page item shows a small thumbnail in the bar, a larger thumbnail as well as comments from the poster in the tooltip grande, and launches the page in a web browser when explored further.

Provide rich information sources. In the current version, users can optionally display full video feeds of themselves, send text messages, post sign-up lists for events, and post web links. We encourage other media items, and even supply an API for programmers to create these new items. Planned items include: file transfer, currently playing music display, picture slide show, and availability (online, away, busy, etc.).

Provide centres (locales). Community Bar supports concurrent display of multiple locales (see Figure 3). The locales are listed vertically in the bar. All the items within a locale are shown under its heading. Each person will see only the items from locales in which they are subscribed.

Provide a way to organise and relate locales to one another (civic structures). The current prototype does not implement any way for the user to structure their locales, except to show or hide them on the bar. Future work includes investigating what kind of relationships are useful in an informal awareness and casual interaction tool, and what types of visualisation and interaction are most useful.

Allow individual views. Each user's view of the Community Bar is individual and unique. They can each subscribe to different locales. They control their own view of particular items by selectively raising the transient tooltip grande or the full window. Future work includes being able to expand and collapse both locales and items, giving each

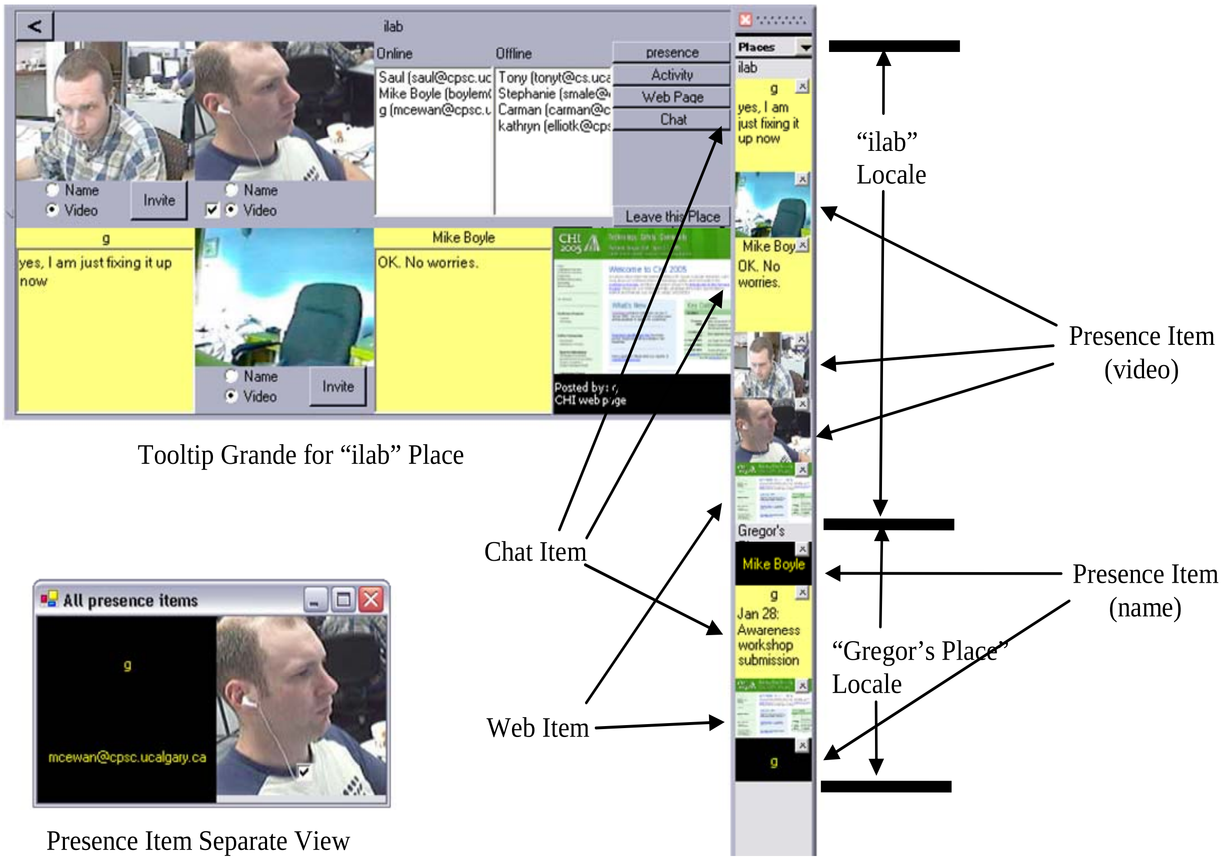

Figure 3: Community Bar. The "ilab" place Tooltip Grande displays the Tooltip Grande view for all of the items in that place.

person more possibilities to personalise the view according to their own needs.

Allow people to manage and stay aware of their evolving interactions over time. Community Bar does not yet allow support for people to investigate their history or evolution of interactions. Exploring the history of such multimedia interactions is a complex and open research problem, although we started investigating this in the Notification Collage predecessor to the CB [7].

Provide methods for controlling focus. Community Bar's relation to this principle is similar to the “Allow Individual Views” principle and the same discussion applies. In essence, each media type offers several different nimbuses (the sidebar, the tooltip grande, and the popup window), and people can control their focus by viewing these items in different ways. We are also working on different ways for people to control their focus on a media item by changing its representation. For example, the video item has the option of switching from the full video representation to just the name and email; other planned representations include availability status and a static picture of the person.

Provide methods for controlling nimbus. While others are able to select how they view a user's presence item, the owner of the presence item can select which of those options are available. If someone does not make their video stream available, then others are not able to view video of that person. Users are also able to increase their nimbus within a particular locale by posting items in that locale. Some items also include mechanisms for drawing attention to themselves when they are first posted, such as the chat item which displays in red until the user views the contents, at which time it switches to standard yellow.

CONCLUSION

Community Bar is an informal awareness and casual interaction system that has been designed from a comprehensive sociological theory. The theory has been used to make sure that the tool not only directly supports its function of awareness and interaction, but also integrates into the overall work practices of the user.

ACKNOWLEDGMENTS

We would like to thank Michael Boyle and Stephanie Smale for their valuable feedback on early drafts of this paper. This work has been partially funded by NSERC.

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Understanding Interpersonal Awareness in the Home

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ABSTRACT
As the development of home technologies continues to increase so does the need to understand and design technologies to support and enhance the everyday lives of home inhabitants. The focus of this paper is on one facet of home life that technology can be designed to support, namely *interpersonal awareness*. Specifically, we outline the beginnings of a conceptual framework for interpersonal awareness where we describe the types of people for whom this awareness is desired, the low-level details of maintaining this awareness, and the maintenance problems faced by home inhabitants in gathering this awareness. Our goal is to provide designers and practitioners with a unified and detailed understanding of interpersonal awareness that can guide the design of groupware applications to enhance the domestic routines of home inhabitants.

Author Keywords
Interpersonal awareness, ubiquitous groupware, home technologies, contextual locations

INTRODUCTION

Communication technology has been identified as a prime area for technology design in the home [1,4]. However, we cannot simply migrate ideas from the office environment into the home. Instead, technologists must have a rich understanding of the domestic routines of home inhabitants in order to design technologies that are useful, usable, and socially appropriate for the home.

The particular aspect of home communication that we are interested in is *interpersonal awareness*: a naturally gained understanding of the social relations of one's personal contacts. This awareness is vital for the micro-coordination of households. For example, parents often need to be aware of their children's extra-curricular schedules to coordinate rides. This awareness even extends beyond immediate household members, involving other personal contacts such as friends and the extended family. For example, friends may want to know about another's schedule to plan a night out or families may be concerned about the well-being of an elderly parent who lives elsewhere.

Neustaedter, C., Elliot, K. and Greenberg, S. (2005) Understanding Interpersonal Awareness in the Home. ACM CHI Workshop on Awareness systems: Known Results, Theory, Concepts and Future Challenges CM CHI Workshop on Awareness systems: Known Results, Theory, Concepts and Future Challenges. Organized by Panos Markopoulos, de Ruyter, Boris, and Mackay, Wendy. April.

Interpersonal awareness is largely predicated on one's existing interpersonal relationships. We are less interested in how these relationships are formed and maintained however; this is described in detail in the disciplines of sociology and social psychology (e.g., 5,10). Our interest instead lays in understanding the low level details of maintaining interpersonal awareness, how this awareness is manifested in the home, and how we can design technology to support it.

Our initial work has been the development of a conceptual framework for interpersonal awareness based on the results of contextual interviews. In this paper, we focus on discussing an early version of our framework, rather than describing the empirical basis behind it (found in 2,9). While others have done research on awareness in the home, be it through studies of domestic culture or technology design for point solutions (e.g., 1,3,8,11), our goal is to move beyond this work and provide a detailed and unified understanding of interpersonal awareness that can be used by designers and practitioners to guide the design of groupware applications for the home.

First, we describe the interpersonal relationships on which awareness is predicated and the specific awareness information that is desired by home inhabitants. Next, we outline the low level details involved in acquiring and maintaining this interpersonal awareness. Finally, we discuss the limitations and problems people face when maintaining interpersonal awareness and the role technology can play in supporting these limitations.

FOUNDATIONS OF INTERPERSONAL AWARENESS

In this section, we describe the social groupings for interpersonal awareness and the specific awareness information people desire to know.

Social Groupings for Interpersonal Awareness

Through our empirical studies [2,9], we have found that people desire interpersonal awareness for three groups of social contacts:

home inhabitants: the people with whom one lives, e.g., family members and/or roommates;

intimate socials: the people with whom one does *not* live but still maintains a close personal relationship, e.g., significant others not living together, close friends; and,

extended socials: the people with whom one does *not* live where the relationship is more casual, e.g., friends, extended family members or relatives.

While these social groups may appear simplistic, sociologists have found similar groupings for social relationships [5,6,7]. However, we caution that these groups are best viewed as broad clusters defining a spectrum of relationships *vs* strictly bounded groups. In general, we have found that the more intimate a person is with another, the stronger the need is to share and maintain interpersonal awareness. This *intimacy* is defined as a primary human need characterized by a mutual feeling of familiarity, closeness, or love between two people [10].

Home Inhabitants. Most individuals share a large degree of intimacy with their home inhabitants, e.g., significant others, immediate family members, roommates. This is because household members often have very intertwined lives, especially in the case of families. Households must micro-coordinate their day-to-day plans [6] and it is often necessary for household members to schedule their activities and events based on the activities of their cohabitants. This makes interpersonal awareness vital for one's home inhabitants.

Intimate Socials. People also maintain a high need for interpersonal awareness of intimate socials, yet the necessity for this awareness is generally not as high as for home inhabitants. Intimate socials do not live together and there is usually little need for the micro-coordination of activities. Despite this, there still exists a strong need to maintain interpersonal awareness, mostly because these individuals share a great detail of information about their lives; they share a fairly high level of intimacy. This need is often simply for the mere desire to know how an intimate social's life is progressing, be it in terms of social or work-related activities.

Extended Socials. People typically have a lesser need for interpersonal awareness of their extended socials. Here, the need is much more discretionary because the awareness gathered about extended socials is primarily used as personal knowledge; people simply like to know about the lives of their extended contacts.

We now describe how the level of need for interpersonal awareness affects the types of awareness information that is shared and desired by individuals.

Interpersonal Awareness Information

The maintenance of interpersonal awareness is centred on knowing specific items of information about one's social contacts, depending on the individual and his or her context. In general, a strong need for interpersonal awareness equates to the desire to know very specific low-level details about one's social contacts; a more discretionary need for interpersonal awareness equates to the desire to know only high-level awareness information.

Home Inhabitants. People typically require low-level, day-to-day details of current and upcoming plans of their co-habitants, be it about social activities or work. This often involves knowing where people are, when they will be home, and when they are free to partake in shared activities. They are also interested in knowing specific details about outcome of activities that have already happened.

Intimate Socials. People typically require low to mid-level awareness details of their intimate socials. Rather than day-to-day detail of social activities, people desire to have a general understanding of an intimate social's upcoming events (over the next few days or weeks), the outcome of past activities, and knowledge about one's health and personal relationships. Others report similar findings for awareness information of intimate socials (e.g., 8,11).

Extended Socials. People generally only desire to know high-level awareness details of their extended socials. This includes knowing usually only about past activities or events but at a much higher level of detail where only major life events or changes are shared, e.g., health issues, changing jobs, getting married, having children.

While this awareness seems to be about fairly mundane things—schedules, activities and outcomes, locations, events, person's state—they are not divorced from sociality. Rather people use this low-level information to infer what is going on in other people's lives to build the bonds that tie the two together, and to motivate conversations and involvements about various life activities.

MAINTAINING INTERPERSONAL AWARENESS

Interpersonal awareness information is typically gathered using one or more of the following techniques:

face-to-face interaction: when people are co-located with their social contacts they naturally converse and share awareness information;

mediated interaction: when separated by distance, people use handwritten notes and messages or technology such as the telephone, email, or instant messenger to maintain awareness; or,

visual cues from domestic artifacts: by observing the presence, absence, or status of artifacts in the home, awareness information is often naturally understood without direct interaction.

We now discuss each of these in turn, outlining their use by the three social groups of interpersonal awareness.

Face-to-Face Interaction

Face-to-face interactions between co-located social contacts reveal a large amount of awareness information. People prefer this type of interaction for gathering awareness because, naturally, they like talking directly to their family and friends [3,11]. This type of interaction also benefits people because it provides the complete context of a situation, e.g., people are able to see the gestures and body language that are associated with verbal conversation [6].

Home Inhabitants. Face-to-face interaction for gathering awareness is most prominently used by home inhabitants. This is for the simple reason that they are often co-located because they live together. Family members usually need synchronous communication at some point for the micro-coordination of daily life [6]. Significant others have even been found to streamline their conversations to develop short-hand interactions involving brief instructions or interaction episodes, which are generally only understood by family members [6].

Intimate Socials. People also use face-to-face interaction to gather awareness information about their intimate socials, yet because they do not live with them, these interactions are less frequent and other means for gathering awareness are needed. Face-to-face interactions with intimate socials typically occur during social outings or shared activities.

Extended Socials. Maintaining an awareness of extended socials does not often involve direct face-to-face interaction. These individuals are seen on a much less frequent basis, typically only during infrequent social outings or visits and, as such, there are few opportunities for face-to-face interaction.

Mediated Interaction

Modern society is moving to an increased number of indirect relationships [6]; thus, it is not surprising that we see mediated interaction as one of the primary means for gathering awareness information. Mediated interaction is necessary for awareness maintenance when social contacts are separated by distance. Here, typically technologies such as the telephone, email, or instant messenger are used to share awareness information. One of the biggest limitations of mediated interaction is in the lack of context presented. People are unable to see the many social cues that are found in face-to-face interactions, e.g., gestures and body language. For this reason, people prefer mediated interactions that are as close to face-to-face interaction as possible [3].

Home Inhabitants. Mediated interaction is necessary for situations where co-habitants are not home at the same time, e.g., someone has gone to work. Often home inhabitants leave notes or messages around the house for their cohabitants to see [1,2], which can contain information about where someone went or when they are returning. Home inhabitants maintain a general sense of the routines of their cohabitants and will place these notes in locations that they know a particular person will frequent or see [2].

When using technology for mediated interaction, people typically favor using telephones and cell phones to maintain awareness of their home inhabitants. However, they may also rely on email and instant messaging systems like MSN Messenger or Yahoo! Messenger. Technically-inclined people were even found to use instant messaging from within the home to gather an awareness of other co-located home inhabitants.

Intimate and Extended Socials. The need for using mediated interaction to gather awareness increases for intimate socials and even more so for extended socials. These groups tend to be separated by distance more frequently than home inhabitants with fewer opportunities for face-to-face interaction. Again, technologies including the telephone, cell phone, email, and instant messenger are used to maintain awareness for these groups. Intimate socials tend to live in closer proximity, e.g., the same city, than extended socials and thus the telephone is often favored. While people prefer to hear the voice of one's extended socials, email is typically the favored technology for this group because it is asynchronous and less expensive than long distance phone calls.

Visual Cues from Domestic Artifacts

The third way in which people can maintain interpersonal awareness is through visual cues from domestic artifacts. Here the *presence*, *absence*, or *status* of domestic artifacts can provide rich awareness information about home inhabitants. Households are displays; people leave imprints of their lives and activities throughout the home [3]. People are typically only able to use this information to garner a sense of awareness for their home inhabitants.

We found that home inhabitants generally know where their cohabitants leave their personal items and the *presence* or *absence* of particular domestic artifacts from these locations can provide awareness information. For example, seeing your spouse's keys missing from the key hook where she usually leaves them may indicate that she has taken the car and left for work. Conversely, if you arrived home after work and saw your daughter's vehicle parked out front of the house, you would know that she is currently at home and perhaps will be around for supper.

The *status* of domestic artifacts also offers rich visual information that can be used to gain an awareness of one's cohabitants [2,11]. For example, the status of a light, being either on or off can indicate the presence and location of household members [11]. A shopping list on the fridge that contains many items may indicate that a home inhabitant is planning to go to the grocery store soon.

PROBLEMS IN THE MAINTENANCE OF AWARENESS

We found that three main limitations or problems exist for people in terms of gathering interpersonal awareness: *time separation*, *distance separation*, and *time limitations*. We describe these problems in turn and then discuss the role technology can play in enhancing everyday routines to reduce the effects of these limitations.

Time Separation

The first issue, time separation, is particularly problematic for maintaining an awareness of home inhabitants. Despite the fact that home inhabitants reside in the same dwelling, they are not necessarily always home at the same time. Because of this time separation, they are not able to rely on the typical face-to-face interaction episodes that can provide much needed awareness information. As a result, they are forced to seek out and provide awareness information while relying on mediated interaction such as leaving notes or the use of technology including phones, email, or instant messenger.

Distance Separation

The second problem, distance separation, is particularly troublesome for intimate socials and even extended socials. As social contacts become separated by distance, it is more difficult to gather awareness information because they must actively seek it out. That is, they are often forced to use mediated interaction techniques. This distance does not need to be large for it to be a problem. People even find it difficult to maintain an awareness of their social contacts that are in the same city.

Studies of domestic culture have articulated specific cases of problems with distance separation. Tollmar and Persson [11] found that families find it difficult to gain a sense of awareness of children who have recently moved out. Mynatt et al [8] describe the difficulties adult children have in gathering an awareness of their aging parents because they do not reside in the same location.

Time Limitations

The third problem, time limitations, is particularly related to intimate and extended socials. People desire to maintain an awareness of more people than they can actually achieve given a limited number of hours in the day. Often people even find it difficult to maintain an awareness of more than just their cohabitants. This problem arises because awareness maintenance is time consuming for intimate and extended socials. Awareness most typically must be acquired through mediated interaction techniques. These require that an individual spend the time to, say, phone or email a social contact.

The Role of Awareness Technology

The three problems that people find when maintaining interpersonal awareness all stem from the same basic premise: in almost all cases, interpersonal awareness must be gathered through direct conversational interaction techniques, e.g., face-to-face conversations, the telephone, email. The problem is that direct conversational interaction techniques require time and people are unable to quickly and easily gather awareness information using them. When people become separated by distance or time, technology must be used to provide awareness, yet most of the technologies used are not specifically designed to support awareness. Rather, they are designed to support interaction.

This suggests the need for lightweight technologies designed with the specific purpose of helping people maintain interpersonal awareness of their social contacts. However, we do not advocate doing away with direct conversational techniques altogether. Instead, we feel that technology designed specifically for supporting interpersonal awareness can augment the existing mechanisms people already employ.

CONCLUSION

This paper presents a first version of an empirically-based conceptual framework for interpersonal awareness. Specifically, our contribution lays in the identification of the people for whom interpersonal awareness is desired, the types of awareness information maintained, an understanding of the current techniques people use to maintain this awareness, and a discussion of the problems people face in awareness maintenance. This initial understanding of interpersonal awareness provides designers and practitioners with a requirements analysis for the design of interpersonal awareness groupware.

While we have described our work in the context of the home, many of the ideas we present also relate to other work on awareness, e.g., awareness for co-located or distributed collaboration. We feel that it is vital for those studying the many forms of awareness to be able to discuss and share their experiences to further awareness research.

Acknowledgements. We thank NSERC and TRLabs for funding. Special thanks to Tony Tang for his ideas.

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Supporting Awareness in Mixed Presence Groupware

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ABSTRACT
Mixed presence groupware (MPG) is software that connects *both* collocated and distributed collaborators together in a shared visual workspace. Our early study of this new genre is that people focus their collaborative energy on collocated partners at the expense of remote partners, which imbalances collaboration. We call this problem *presence disparity,* caused by the imbalance of awareness exuded by virtual embodiments versus actual people. VideoArms is an embodiment technique that mitigates presence disparity by enhancing awareness of remote collaborators in a mixed presence workspace. We describe how VideoArms works, and the design principles behind its construction.

Author Keywords
Mixed presence groupware, awareness, consequential communication, embodiments, gestures.

ACM Classification Keywords
H.5.3.b. Collaborative computing; H.5.3.c. Computer-supported cooperative work.

INTRODUCTION
Prior groupware research has focused on distributed groupware and collocated groupware independently of one another. Yet the proliferation of large digital displays, which naturally support collocated collaboration, make it increasingly important to examine how groupware can support *groups* of distributed collaborators. Consider the following scenario.

You lead a team of designers based in Seattle, and have scheduled a joint brainstorming session with another group in your New York office. This is possible because your company has special meeting rooms in each city location, connected by audio and containing linked electronic whiteboards. This software allows one or more members of either team to simultaneously draw ideas on the wall using styli, where colleagues in either location see those drawings as they are being created in real time.

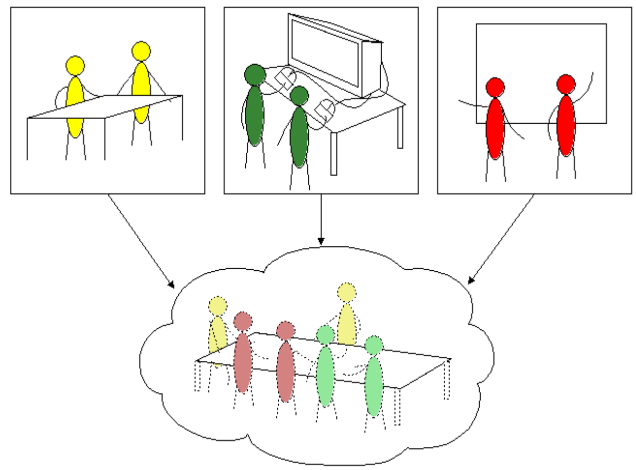

Figure 1. Three teams working in MPG over three connected displays (top), stylized as a virtual table (bottom).

Our research focus is to understand and design the collaborative software described in this scenario, which we call *mixed presence groupware* (MPG). MPG is software that connects *both* collocated and distributed collaborators together in a shared visual workspace. As well, MPG usually represents collaborators as entities within the workspace by some type of *embodiment*—virtual presentations of their bodies. In practice, we have built MPG systems by connecting several distributed displays, each with multiple input devices, thereby connecting both collocated and distributed collaborators. Figure 1 shows a stylized example MPG system where three groups of collocated collaborators (top) work together in a shared virtual space (bottom).

Yet MPG presents a unique problem called *presence disparity*, where collaborators focus their energies on collocated collaborators at the expense of their distributed counterparts [6]. While individuals can maintain a very rich awareness of physically collocated collaborators, presence disparity arises because it is difficult for them to gain an equivalently rich awareness of remote participants via their embodiments. This is because most groupware systems reduce this virtual presentation of the embodiment to telepointers—usually a custom mouse cursor—which

Tang, Anthony and Greenberg, Saul (2005) Supporting Awareness in Mixed Presence Groupware. ACM CHI Workshop on Awareness systems: Known Results, Theory, Concepts and Future Challenges. Organized by Panos Markopoulos, de Ruyter, Boris, and Mackay, Wendy. April.

This workshop submission is a dramatically reduced form of a longer paper.

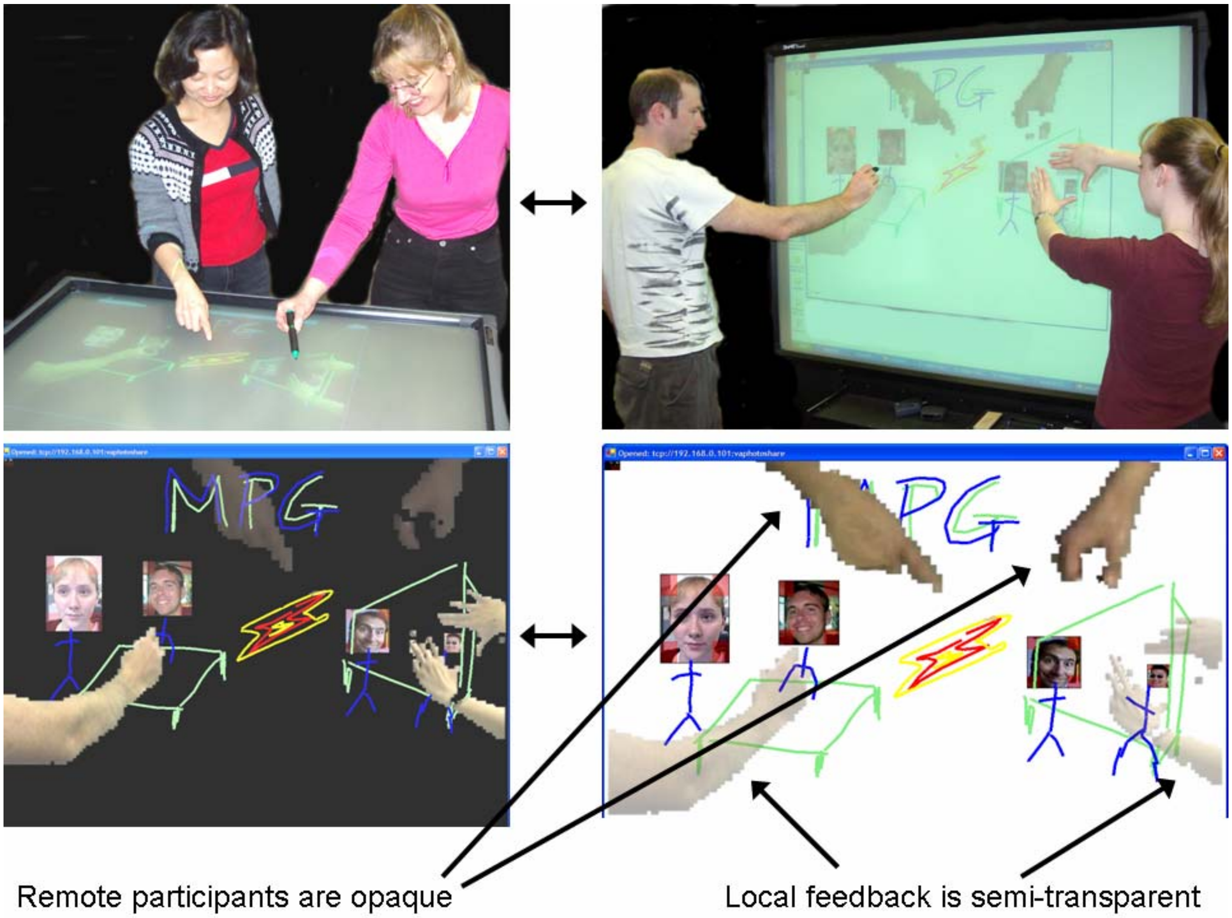

Figure 2. VideoArms in action showing two groups of two people working over two connected MPG displays (top) and a screenshot of what each side sees (bottom). Local and remote VideoArms are in all scenes, but local feedback is more transparent.

clearly cannot compete against the physical body of a collocated collaborator. Thus, presence disparity unbalances the collaborator's subjective experience because even dyadic collaborative dynamics will vary in terms of how one senses presence, engagement and involvement of collocated *vs.* remote partners.

This imbalance between how one is able to maintain an awareness of collocated *vs.* remote collaborators has a negative impact on conversational dynamics. Since MPG collaborators cannot communicate (verbally and non-verbally) as effectively with remote collaborators as they can with those who are collocated, remote collaborators are less likely to be attracted into informal discussions of work objects, and are therefore less likely to perform the task as effectively as collocated counterparts.

In this paper, we discuss the design of VideoArms, an embodiment technique that aims to mitigate the problem of presence disparity in MPG. VideoArms digitally captures people's arms as they work over large work surfaces, and displays them as digital overlays on remote displays. In doing so, VideoArms provides a rich means for collaborators to maintain workspace awareness [2] of remote participants in MPG systems.

VIDEOARMS: A VIDEO-BASED MPG EMBODIMENT

VideoArms is a video-based embodiment technique for MPG systems that digitally captures collaborators' arms as they work over the workspace using a video camera, and redraws the arms at the remote location. Figure 2 illustrates a sample session of VideoArms. The top images show two connected groups of collaborators. Each group works over a large touch-sensitive surface—the left is a front-projected touch-sensitive horizontal DViT, while the right is a rear-projected vertical SmartBoard. Each surface displays the same custom MPG application that lets people sketch and manipulate images, while displaying video embodiments.

Figure 2 (bottom) also illustrates what users can *see* when using the VideoArms embodiment in this MPG application. First, collocated collaborators can see their own arms as local feedback, rendered semi-transparently, providing feedback of what others can see while minimizing interference. For example, the bottom right image of Figure 2 shows three semi-transparent arms as local feedback for the two collaborators working on the wall display (Figure 2, top-right).

Second, each group sees the solid arms of the remote participants in reasonable 2½-dimensional fidelity (while the images are not truly 3-dimensional, the system captures and reproduces color-based depth-cues). For example, the bottom right image of Figure 2 shows two opaque hands which present the arms of the remote participants working on the table display (Figure 2, top-left) to the two people working on the wall display (Figure 2, top-right).

Third, the remote drawings of arms preserve the physical body positioning relative to the workspace. Both physical and video arms are synchronized to work with the underlying groupware application, where gestures and actions all appear in the correct location[1]. For example, because the people at the table display (Figure 2, top-left) are positioned at the rear of the table, their arms appear on the vertical display as coming from the top (Figure 2, right).

Figure 2 also reveals communicative aspects of the embodiment. In this MPG setting, all participants can simultaneously gesture to the full, expressive extent of arms and hands. The system neither dictates nor implies any sort of turn-taking mechanism, and captures workspace and conversational gestures extremely richly. Furthermore, users are not tethered to any particular place in the workspace: using touch and pens to interact with the groupware application, users are free to physically move around the workspace as they see fit. For example, we can see the use of rich gestures in the top right image of Figure 2 when the woman uses her hands to indicate the intended size of an object. At the same time, the woman on the left of the table (Figure 2, top-left) points to a particular object.

Design Principles

The VideoArms metaphor captures and presents the workspace from a bird's eye view of the workspace. It builds upon the "through the glass" metaphor of previous analog video systems [3,7,8], although unlike them it uses a set of completely digital capture, transmission and display algorithms. Just as in real life, the video arms serve as the primary indicators of a collocated collaborator's presence (Figure 3). To mitigate presence disparity for remote collaborators, VideoArms was designed to support four principles.

1. To *provide feedback* of what others can see as *feedthrough*, a person's embodiment should be visible not only to one's distant collaborators, but also to oneself and one's collocated collaborators.

2. To *support consequential communication* for both collocated and distributed participants, people should interact through direct input mechanisms, where the remote embodiment is presented at sufficient fidelity to allow collaborators to easily interpret all current actions as well as the actions leading up to them.

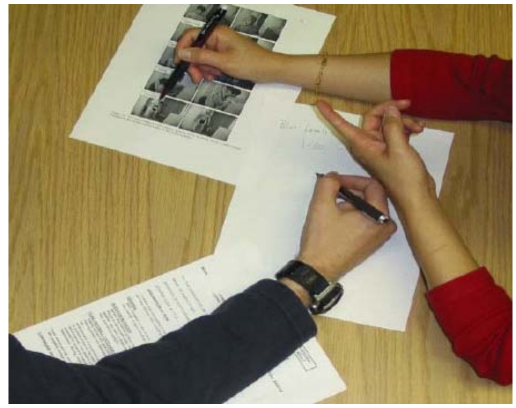

Figure 3. A bird's eye view of a physical workspace.

3. To *support bodily gestures*, remote embodiments should capture and display the fine-grained movements and postures of collaborators. Being able to see these gestures means people can disambiguate and interpret speech and actions.

4. To *support bodily actions as they relate to the workspace context*, remote embodiments should be positioned within the workspace to minimize information loss that would otherwise occur.

We perceive our own actions and the consequences of our actions on objects as *feedback*, and we constantly readjust and modify our actions as our perceptions inform us of changes to the environment, or changes about our bodily position [5]. Threading a needle when blindfolded is difficult because without our ability to perceive our own bodies as physical objects in the world, we cannot smoothly interact with it. Thus, the first design principle suggests that a person's embodiment should be visible not only to one's distant collaborators, but also to oneself and one's collocated collaborators.

Our bodies are the key source of information comprising *consequential communication*: awareness information unintentionally generated as a consequence of an individual's activities in the workspace, and how it is perceived and interpreted by an observer [5]. A person's activity in the workspace naturally generates rich and timely information that is often relevant to collaboration. For instance, how a worker is positioned in the workspace and the kinds of tools or artefacts being held or used tells others about that individual's current and immediate future work activities (e.g., the arm poised to write in Figure 3). Therefore, the second design principle addresses the need to support consequential communication by using direct input mechanisms and through high fidelity MPG embodiments.

While consequential communications comprises unintentional body actions, *gestures* are intentional bodily movements and postures used for communicative purpose [1]. Gestures play an important role in facilitating

[1] VideoArms digitally reproduces a video-captured image of the workspace. In principle, it can therefore support an infinite number of non-overlapping arms. While our goal was to develop a true MPG application with VideoArms, technical limitations imposed by the input devices (the actual SMARTBoards) meant that our final system only supported two simultaneous touches on one display; the other display could only support a single touch.

collaboration by providing participants with a means to express their thoughts and ideas both spatially and kinetically, reinforcing what is being done in the workspace and what is being said (e.g., the pointing arm in Figure 3). For this reason, the third design principle speaks about the necessity for embodiments to capture and display the body gestures of collaborators.

Because consequential communication and gestures occur in the workspace, removing such actions from their context also removes much of their interpretation. For instance, the statement, "Put this object here," is meaningful in the context of Figure 2 and 3, but is unintelligible outside of the context of the workspace. This leads to our fourth design implication, which stresses that embodiments should be placed within the context of the workspace.

From a collaborative standpoint, the VideoArms prototype theoretically provides a rich means for individuals to maintain an awareness of both remote and collocated collaborators. First, local participants know what remote people see because their own embodiments are shown as semi-transparent feedback. Secondly, because the body is used as an input device on the touch sensitive surface, VideoArms supports consequential communication: other collaborators can easily predict, understand and interpret another's actions in the workspace as one reaches towards artefacts and begins actions. Rich gestures (coupled with conversation and artifact manipulation) are also supported well because the remote arms are displayed in rich 2½ dimensional fidelity and a reasonable framerate (~12 fps). Finally, task-related gestures are easily interpreted because they are placed in the context of the workspace. In addition, collocated participants can use and interpret natural body language of as they collaborate.

Implementation

VideoArms uses inexpensive web cameras positioned approximately two meters in front of the display to capture video images of collaborators. The software extracts the arms (and other bare-skinned body parts) of collaborators as they work directly over the displayed groupware application. It then transmits these digital images to the remote workstation, where they are further processed to appear as an overlay atop the digital workspace. To provide local feedback, VideoArms overlays a local person's video on the work surface.

CONCLUSION

The design of VideoArms was motivated by the desire to mitigate presence disparity in MPG systems, a problem which is caused by the differential ability to maintain workspace awareness of remote collaborators compared to collocated collaborators. In this work, we have identified four design factors for MPG embodiments, which are instantiated concretely in VideoArms. Although not reported here, we have just completed a preliminary study that demonstrated that VideoArms supports rich gestures and consequential communication across the link, thereby reducing presence disparity.

VideoArms is not a total solution. For example, eye contact and body positioning, which have been found to be important to collaboration [3], are not supported at all. Yet VideoArms is a reasonable first-step as it provides a richer awareness of the workspace by presenting the parts of the body that appear within it.

VideoArms is a working proof of concept, and as such there is still room to improve its interface as well as the underlying groupware system. These need to be fixed, at which point we will undertake a more thorough empirical evaluation to validate VideoArm's effectiveness as an MPG embodiment. At this point, however, we believe that we have forwarded MPG research into a space where we can begin to understand embodiment design and the tradeoffs between different types of embodiment types within MPG collaboration.

ACKNOWLEDGMENTS

We thank Carman Neustaedter for his help in this research and in earlier drafts of this work, and members of the Interactions Lab for their continued support.

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