The EDGE of Face-to-Face Collaborative Technology

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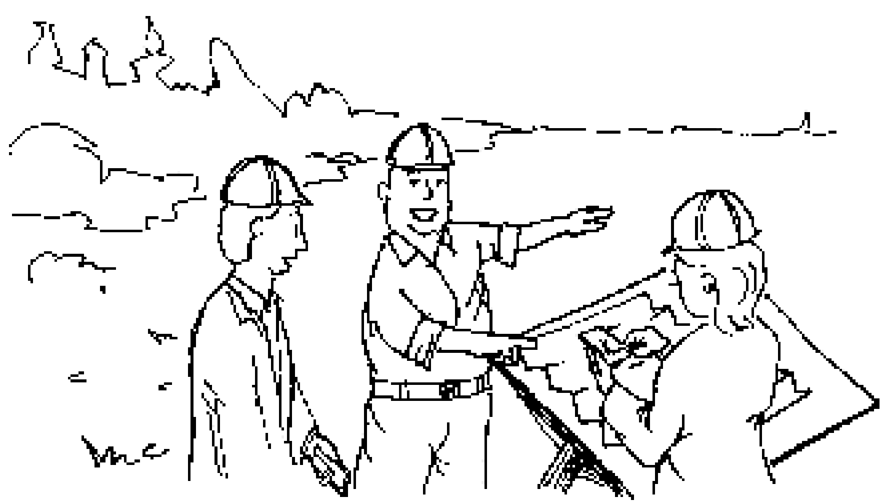
Introduction

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

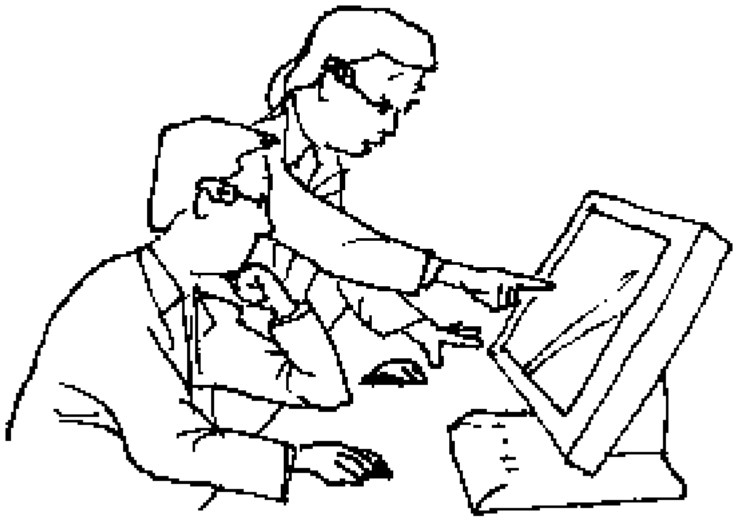
Limitations of handheld computers for collaboration include their small screen and limited viewing angle. This makes it difficult for multiple people to collaborate around a shared display. An initial solution was investigated using low-fidelity prototypes, which used multiple handhelds to create a tiled 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-Loo 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

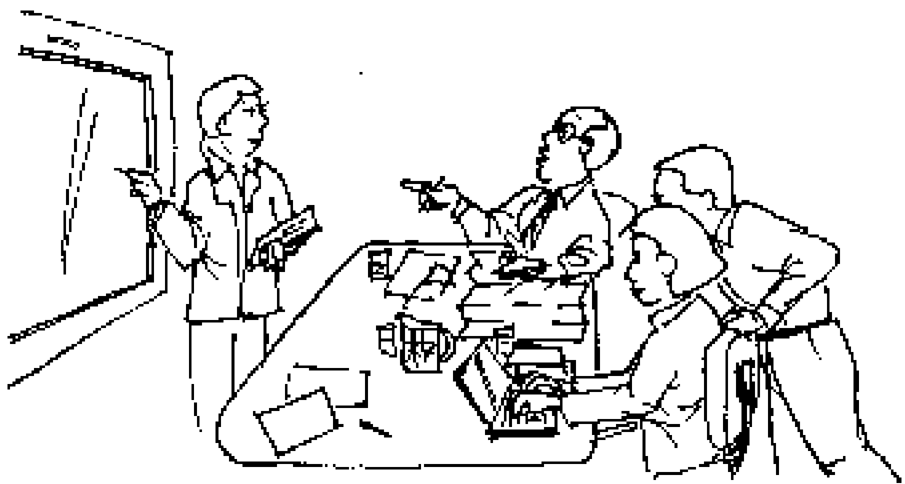
We have already made significant research contributions in synchronous shared environments, especially in the area of Single Display Groupware (SDG). SDG systems provide support for small groups collaborating around a shared screen by offering simultaneous, multi-user input [8]. We have performed extensive 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.

References

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