Exploring Computer Augmented Communication through an Examination of the Collocated Use of Multiple Mobile Displays

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ABSTRACT

Computer supported collaborative work (CSCW) and specifically the subdomain of Computer Mediated Communication (CMC) has often focused on supporting face–to–face communication over a distance. This communication often has taken place in front of whiteboards [3] and large–scale displays [1], and more recently on the tabletop[4]. However, instead of studying large fixed devices around which groups gather to work, we propose studying collocated groups of users each with their own mobile device as a complement to more traditional computer mediated communication. This paper proposes a new subdomain for CSCW research that broadens the existing focus from fixed displays to multiple mobile personal displays. We term this subdomain Computer Augmented Communication (CAC) since one of the key properties is that the technology augments the communication instead of mediates it due to the collocated nature of the users.

We describe the proposed subdomain through definitions, perspectives, and research directions for further investigations of this emerging subfield. In this paper we enumerate the following contributions. First, we demonstrate how CAC differs from CMC by examining systems that exhibit many of the putative properties of CMC. These systems should not be considered "proper" CMC systems as conversations are not routed through the system. Second, we explore three novel CAC systems that demonstrate different points in the collocated mobile space. Third, we discuss challenges designing for multiple mobile displays in mobile collocated systems. Finally we conclude with challenges for the evaluation of multiple mobile display systems in this emerging subfield.

1. INTRODUCTION

In 2007, for the first time in the history of the mobile phone industry, global mobile phone penetration exceeded 50% . Additionally, there are currently over 3.4 billion active mobile subscriptions worldwide . Additionally, there are over 60 countries worldwide that exceed 100% mobile penetration meaning that the number of mobile subscriptions per person is greater than 1:1 . Effectively that means that in the developed world, particularly in dense urban areas, there is a mobile display in almost every pocket. It is becoming increasingly common to witness social interactions occurring between groups of two or more individuals around some sort of mobile technology be it an MP3 player, a digital camera, a PDA or a mobile phone. And yet, there is a dearth of applications that are developed to support collocated groups of individuals using multiple mobile displays.

In this paper we define the collocated use of mobile devices as a class of systems comprising an area of research that is under–explored and worthy of further investigation. We introduce the notion of Computer Augmented Communication and explore this concept through the deployment of a series of technology probes [2] with multiple groups of individuals. We observed and analyzed the impacts of the probes on both the group and the individual behavior(Section 2). From the analysis of the ethnographic material and the technology probes, we derived a variety of design implications that define some boundary conditions for the novel domain (Section 3). We conclude with a discussion of the challenges inherent in evaluating collocated mobile systems (Section 4).

2. THREE COLLOCATED MOBILE SYSTEMS

In this section we discuss three technology probes that we designed, deployed, and either formally or informally evaluated. The first probe, Mobiphos, is an application that supports the capture and synchronous sharing of photographs between members of a collocated group. The second, Mobile Dance Revolution, is a mobile dancing game in which groups of collocated individuals competed against each other in a mobile version of the arcade game "Dance, Dance, Revolution." The third and final technology probe is a mobile version of poker in which groups of collocated individuals gather around a situated display and employ their own mobile displays to engage in a game of poker with other members of the group and an automated card dealer. Each of these applications focus on different aspects of collocated group use of multiple mobile displays and as such each reveals interesting insights into communication practices and other emergent behaviors exhibited when collocated groups of individuals allow mobile technology to augment their face–to–face conversations.

2.1 Mobiphos Application

Mobiphos is an application designed to run on digital cameras that support the automatic sharing of photographs between members of a collocated group who are engaged in a social activity. Mobiphos allows users to easily take pictures, browse thumbnails of those pictures and share their photos

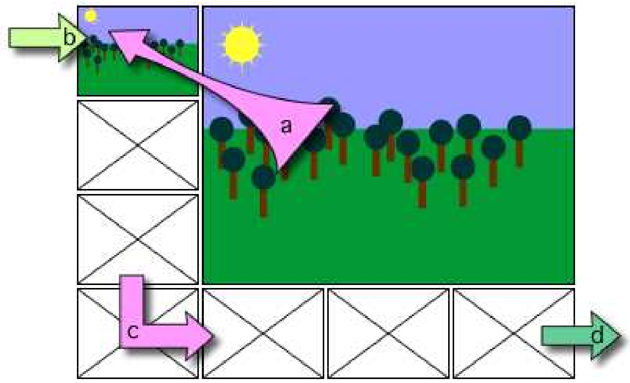

Figure 1: The viewfinder is represented in the top–right of the display. When the user takes an image, the picture from the viewfinder animates into the top–left corner (a). When an image comes from another user, it is also placed in the top–left (b). Either of these events cause the timeline to animate wrapping around the bottom–left corner (c) and the oldest image is moved off screen (d).

within a collocated group of people in real–time. When a person takes a photograph using Mobiphos, that picture is automatically shared with every member of the collocated group. At the same time, she is able to view a constantly updating stream of picture thumbnails scrolling across her screen as they are being captured and shared with her by her fellow group members. This interaction is accomplished through a group–wide wireless network that Mobiphos uses to provide real–time photo sharing capabilities. From the user's perspective, all of the photographs captured by the group form a common repository of images whereby each member of the collocated group has access to all of the photos.

Due to the real–time sharing nature of Mobiphos, there are several interaction challenges that must be overcome. These challenges include supporting simultaneous individual and group functions, group awareness of individual actions, and the sharing of photos with knowledge of the user's participation. Traditional digital cameras use the LCD screen for multiple purposes. During image capture it serves as a digital viewfinder displaying the image that a user is about to capture. The LCD can also be used to browse images and thumbnails of photographs already captured. In Mobiphos, we needed to combine these two modes into one to allow the user to simultaneously take new photos using the digital viewfinder as well as review the photos being shared.

Our design uses the top–right, $\frac{3}{4}$ of the screen as the viewfinder while the remaining area of the display to the left and bottom of the viewfinder shows thumbnails in a timeline (Figure1). The timeline positions the most recent picture in the top–left corner with the rest of the thumbnails oriented in an L–shape around the viewfinder from newest to oldest. This design allows the user both to take new pictures and view older photographs at the same time. When a new photograph is captured by the user, or a photo comes from another camera running Mobiphos, the thumbnails on the left move down as the thumbnails along the bottom move to the right. Photos are viewed as an array of thumbnails and new photos receive an overlay, drawn like a picture frame, with a color specific to the user who captured the photo. If new pictures come from another user, a thumbnail slides in from off screen to the top–left position to signify that it was not a picture taken by the user holding the camera.

In an effort to support group awareness of individual actions, we designed a preview interface that made it easy for a participant to observe at a glance the focus of every other group members screen. Whenever a user selects a photo to view at a larger size, all other Mobiphos devices are alerted of this focusing. The other devices will then see a colored dot appear in the top–right corner of their screen, where the color is used to indicate which user is performing the focusing action. If the another user wants to know the photo of interest, they can tap on the dot in the top–right corner. This will slide in a window which shows the focus of all users in the group. To view the same photo as another user they can tap on that photo. This will both dismiss the window and scale up the photo chosen. The user can also simply dismiss the window without choosing any photo.

2.2 Mobile Dance Revolution

Mobile Dance Revolution, MDR, is a mobile phone version of the popular arcade game "Dance, Dance Revolution." Dance, Dance, Revolution (DDR) is a stand alone machine that has no manual input as a user interacts with the game by stomping her feet on a gamepad built into the machine . The gamepad consists of four arrows, each arrow points in one of the four cardinal directions (North, South, East, West or Up, Down, Left, Right). On the screen there are four target arrows (each arrow correlates to one of the four arrows on the gamepad). As music plays, arrows move from the bottom of the screen to the top of the screen in time to the music. As an arrow passes through one of the target arrows at the top of the screen, the user is expected to step on the corresponding arrow on the gamepad. The more accurate the timing of the users stepping on the gamepad, the more points the user receives.

For MDR, we've removed the gamepad and large display and replaced it with a mobile phone that the user holds in her hand and a pair of three-access bluetooth accelerometers. The user straps the accelerometers to each ankle and connects the phone to the accelerometer. The user can now perform an action equivalent to stepping on a gamepad arrow by kicking a leg either forwards, backwards, or sideways. As such, the user is now mobile and can play the game anywhere anytime.

Like the stationary version of DDR, users can play alone or against others. The stationary version of the game physically situates two DDR games next to each other and connects them such that players can compete simultaneously in real time. For MDR, a similar interaction occurs: two or more players agree to compete against each other, join a shared game which presents a 5-second count-down to each player and then synchronizes the start of the game. This synchronization occurs over a wifi network. Unlike the stationary version however, MDR allows players to not only play side-by-side but also face-to-face or even across the room from each other. MDR enables collocated groups of two or more players to compete in a mobile game leveraging their physical movement as input to the game.

2.3 Mobile Poker

Mobile Poker is another mobile collocated game which has users situated around a combination of their own handheld display as well as a situated display. However, unlike MDR and Mobiphos, the application is situated around a stationary display. Mobile Poker (Mo'Poker) is a mobile version of the popular card game Texas Hold'em. In Texas Hold'em there is a dealer who distributes cards and multiple players. Texas Hold'em is a community based card game where the dealer displays five cards to the community and distributes two cards to each player. A player uses the two cards in her hand plus the five community cards to create the best possible poker hand. The game can be a highly social game as players often pay attention to the other players in an effort to detect if competitors are bluffing.

The blending of personal displays and a shared display allows us to give users an experience very similar to a traditional poker game. A top down view of the table is shown on the large screen. This view appears as an octagon with a robotic dealer which sits in the middle of the table. Each player's mobile phone shows their area of the octagon. This area is identical to what is shown on the large screen with the exception of showing the details of the player's hole cards. All actions of the game are performed from the player's individual devices. Any action in which the user engages that does not give away private details, such as betting, folding or raising, is shown on the large display. The animations that happen when performing these actions are shown on all devices. Large bets will not only appear as a pile of chips on the main screen but will also appear on the edges of the players sitting next to the better. This allows a player who is attending to their local display to have some connection to the rest of the table.

As in traditional poker, physical position is important. To this end, the game shows the position of people at the virtual poker table on the large screen and players are encouraged to sit around the large display to mimic the virtual seat map.

3. IMPLICATIONS FOR DESIGN

Our three collocated mobile systems are the result of many rounds of iterative design. The collocated nature of the users affected the design in many ways resulting in all systems taking into account the group size, a shared context, face–to–face communication, data visualization and built–in flexibility to allow for shifting contexts.

When designing Mobiphos for example, we explored different ways of leveraging participant conversations. The final version of Mobiphos used colored frames around photos to signify ownership. The color of the frame corresponded to a similarly colored label on the mobile phone. This indication of ownership enabled the participants to arrive at a simple verbal description of the photograph facilitating a simple method of discerning which picture was being discussed. It was not uncommon to observe a user take a photograph and state that it was "a good one". At that point the other users would look down at their own displays and wait for a photo with a frame of the correct color to appear. Using self–praise to draw interest to a recently captured photograph was a common practice employed by participants when they were interested in enticing others to look at a particular participants recently captured photograph.

With Mobiphos, each user has their own copy of the photo and a screen to view it on while with existing devices sharing is accomplished by having all of the users huddled over a single camera screen. In complementary situations the users would be involved in a discussion and would take photos that helped them make their point thereby augmenting the conversation. Another effect of the external conversation was that, due to its speed, it was important to maintain sync of photos on all of the cameras. Delays in receiving photos could cause a breakdown in a conversation or prevent a conversation from ever happening.

MDR and Mo'Poker make use of external conversation to remove interface elements necessary in non–collocated versions. However, with these applications the external conversations allows us to remove interface elements that non–collocated versions of the games would require. For example, Mo'Poker does not include a messaging system like many networked poker applications. With a collocated game we are able to focus on the game design and allow the external conversation to handle the fluid nature of face–to–face conversation that is so common to a turn based game such as poker. With MDR, the score or level of the other players was not communicated on the device. It was easily obtained by simply asking or watching the other player's performance.

The number of users in a group was a factor in the design of Mobiphos. The use of color frames scaled well for 3–4 users but may not have scaled to say groups of ten or more users. This would begin to push on the ability of the participants to distinguish colors and remember the mapping between color and user. Scaling the group size also impacts the issue of maintaining timeline synchronization across devices. The automatic sharing of photos meant that every capture not only had the standard overhead of saving to disk and inserting the photo into the timeline but also involved sending every photo to all of the other participants. This in addition to many users capturing photos at various times and the combination of all users photos into a single timeline occasionally led to mismatches between user timelines. These differences were overcome by using the colored frames and verbal descriptions instead of absolute position in the timeline to point out a specific photo and ground the conversation.

With MDR real–time synchronization of the music across devices was important for helping the users maintain a shared context. If the music was offset on one device, it had the potential to confuse all players and make them dance off–beat.

Mo'Poker is an example of how making group information easily accessible is important to the goals of the user. In a traditional game of poker all of the public information is gathered by looking at the table and talking amongst players. Because of the small amount of screen real–estate on the handheld device we used a central large display to show the overall state of the table. This view onto the game showed information such as: Who is still in the hand? How much have they bet/raised? and How much do they have left? The design used in Mo'Poker allowed us to maintain a visualization of group state on one device thereby making the network design easier.

The most important design issue that we encountered was the way in which users would appropriate the existing technology and make it work for them. In the case of Mobiphos, when a user zoomed in on a photo we made sure everyone else in the group knew which photo was chosen. This was meant to allow user's to select a photo taken in the past and easily get the others into the same context so that a discussion may arise. In practice, we found that users took many photos that were only relevant in the context that they were taken and rarely discussed older photos. Because photos taken in the present were discussed more often and those same photos were visible in the front of the timeline we found that users just had conversations describing the photo to maintain context. This it turned out was easier for users than zooming in and then having the other users change modes to access the photo.

With MDR the users were could choose to play in a cooperative or competitive mode within the game. This choice allowed the users to decide what they wanted their final scores to mean. With Mo'Poker the game enforced proper turn taking but did not require users to sit in any specific order around the large display. However, users would easily reorient themselves given the information on the screen. The large screen also shows whose turn it is to make a move. This little bit of information allows the game to not worry about such things as putting a timeout on a player's decision time. The other player's can use this knowledge to get the current player to hurry up through conversation which is typical in a traditional poker game. We refrained from implementing game features that could easily be implemented through conversation.

We have found that being mindful of the external conversation, considering scaling issues when deciding on design variables and staying flexible in design so user's can appropriate the application for their own needs is important when designing mobile collocated applications.

4. IMPLICATIONS FOR EVALUATION

Evaluating the collocated use of multiple devices is a non–trivial endeavor. Capturing participant behavior in context with regard to the state of the system the environment, and other users in the field, it is certainly one of the more daunting tasks though it is only one of many challenges to be overcome if a research team hopes to understand the impact of their technology on participants. Other challenges that need to be negotiated include study design (specifically how to appropriately balance qualitative with quantitative data capture and analysis), scale of the system (number of users and number of researchers needed to appropriately evaluate the system), and how to successfully handle technical troubleshooting in the field.

One common approach for capturing participant behavior is to record all speech during an evaluation and then to analyze the conversations post–hoc. As the collocated systems described above are all CAC systems instead of CMC systems, none of the voice communication is channeled through the mobile system. If conversations are to be logged, recording devices need to be worn by the participants or carried by the evaluators in the field. Though this method of data collection sheds some light on activity in the field, understanding the context in which a particular utterance occurs is essential if a research team hopes to fully comprehend a technology's impact. In the field observation also makes it possible to spot non–verbal cues in the conversation such as body posture or other gestures. Certainly, using a video crew to capture activity in the field is an option but it is expensive and requires a significant time investment to train the crew to insure that they capture the necessary interactions. In the field observations not be as plentiful as data collected by a video crew but they will be richer since the researcher also experienced the context and noted contextual factors that the camera might have missed.

When evaluating these systems, our team opted to place researchers in the field accompanying each group of participants. Two researchers took field notes about participants' use of the technology during the experiment, noting, for example, conversations and observable behavior associated with technology use. Having two researchers taking field notes for each group was essential when, for example in the Mobiphos system, participants wandered away from the group to briefly explore different vantage points. Additionally, group members often divided up to hold multiple conversations while walking from site to site and it would have been impossible to capture these conversations in their context without the having multiple researchers in the field.

To ensure that technical challenges were addressed in the field and not allowed to hinder the experience, we employed an additional researcher to manage technical troubleshooting for each evaluation. On the occasions where participants encountered technical issues with the system, the researcher was available to address any potential trouble ensuring a smooth experience.

5. CONCLUSION

We have proposed a new CSCW subfield called Computer Augmented Communication (CAC). A unique point in describing this subfield is that all users are collocated and have their own personal mobile device as their view into the activities of the group. By building and evaluating these three systems we have started to see the effects of collocation on group use of multiple mobile displays. With regards to design, it is important for it to be easy to incorporate the existing face–to–face communication, to make design decisions that scale with the expected size of the group and to keep interfaces simple so that different usage patterns can be appropriated as the user's context changes. For evaluating collocated multi–display systems, we have found that a combination of pre– and post–experiment semi–structured interviews, automated usage logs, and in–the–field observation provides a good combination of quantitative and qualitative results. Further exploration of CAC systems will lead to a deeper understanding of design/evaluation principles necessary to create a proper user experience for mobile collocated users.

6. REFERENCES

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