Co-Present Photo Sharing on Mobile Devices

Leonard M. Ah Kun & Gary Marsden
Department of Computer Science
University of Cape Town
Cape Town, South Africa
+27 21 650 2666
[lahkunlgaz]@cs.uct.ac.za

ABSTRACT

The paper reports a mobile application that allows users to share photos with other co-present users by synchronizing the display on multiple mobile devices. Various floor control policies (software locks that determine when someone can control the displays) were implemented. The behaviour of groups of users was studied to determine how people would use this application for sharing photos and how various floor control policies affect this behaviour. Explicit policies was shown to be the best strategy for structured presentations, but when all locks were removed, the users created a new form of social interaction which seemed to be a more compelling use of the technology than the original, intended, application.

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: User Centered Design

General Terms

User Centered Design

Keywords

Digital photography, storytelling, photo sharing, co-present sharing, mobile photography

INTRODUCTION

For digital images captured by cameras or camera-phones, there are many options for sharing the captured images. Single-purpose cameras are used in conjunction with desktop computers to upload images to web sites such as flickr. Camera-phone users can MMS, Bluetooth or even post an image to a mobile-blog to share their images. These are great solutions, provided you are not intending to share images with multiple co-located people. We know from studies such as [10] that co-located simultaneous sharing is a desirable social activity. To achieve this with current cameras or camera-phones one must connect the device to some external display. This is, at best, inconvenient when meeting with friends at a pub or restaurant. We were therefore interested in pursuing an approach whereby any user in a group could broadcast an image onto the screens of other devices that belong to the people in that group. Although we were interested in the technology to achieve this, two main questions drove our research design:

- Would people really be interested in seeing someone else's photos on their device – or is the screen simply too small to be engaging?
- How should the system manage the social interaction – should anyone be allowed to broadcast an image at any time, or does control need to be moderated through some convention such as token passing?

To answer these questions we developed a test-bed system on PDAs and ran three separate groups of user studies.

1. RELATED WORK

"Communication of experience" is the main reason for sharing photos [5]. Chalfen identified photographs to be social artefacts that are used to trigger memories and emotions. Sharing photos is a group activity which brings about the feeling of connectedness between those who the photos are being shared with. Conventional photo sharing where stories are shared with friends and family defined Chalfen's "Kodak Culture". This culture is important as the practices found here seem to be the most enjoyable social interactions when sharing photographs. The main interaction includes storytelling and reminiscing which Frohlich [10] called "photo-talk".

Frohlich and his colleagues studied conventional photo-sharing practices. They established that people organise their photos in albums for social purposes or events [10]. They identified two categories of photo-talk. Storytelling photo-talk occurred in conversations where photos were shown to others who were not there at the time the photos were captured and hence did not share the memory represented by the photos. In situations where more than one person who shares the memory represented in the photo is present, this storytelling often becomes a collaborative project. Reminiscing photo-talk occurred in conversations when sharing photos exclusively with members of the original "capture group".

Crabtree et al. conducted an ethnographic study on 22 families in the UK to investigate collaborative use of paper-based photos in the home environment [7]. It was observed that photographs do not only act as conversational resources for the holder of the photographs, but are also conversational resources for the other participants as well. The participants may ask questions upon viewing a certain photograph of the holder and raise conversational topics that may result in the telling of a story. This behaviour was also observed by Frohlich who found that

not all stories relate to the photographs at hand. It is thus noted that having a flexible group view of photographs is important where the collaborative use of photographs is concerned. Crabtree's findings echoed Frohlich's findings that sharing photos exclusively with members of the original 'capture group' resulted in reminiscing talk. It was rare to find members of the original capture group to re-tell stories that they have experienced together.

With the development of digital cameras, the cost of taking photographs was no longer a constraining issue. Portability of photos was drastically improved and various new methods and possibilities of sharing photos have been developed. The traditional way of sharing digital photographs was via the PC screen. Users typically did not organise their digital photographs as the PC screen was not seen as a convenient device for synchronously reviewing and sharing those photos with others [10]. Online photo-sharing websites allow users to post photos and comments online to share with remote friends and family. It was found that sharing photographs this way was not as enjoyable as conventional photo sharing. Vronay [20] and his colleagues tried to determine why sharing photos this way was not as compelling as sharing photos face-to-face. They found that sharing photos online with text annotation does not convey the emotion and storytelling as sharing photos face-to-face.

With the increasing popularity of mobile phones and advancements in camera technology, industry began integrating digital cameras with mobile phones. Consumers can now take digital photos at any moment they desire and send these images to their friends almost instantaneously. Research was conducted to determine the behaviours of photo sharing with these new devices. It was found that photos were not sent very often. This was due to the expense, complexity and poor image quality [13]. It was also established that mobile phones were being used as personal flip books and that most photos were shared with co-present people on the mobile phones screen.

Attempts at photoblogging from cameraphones were also pursued [6][15][16][17]. Photoblogging systems provide a way to publish mobile pictures on the web and allow visitors to comment on published pictures. These services supported ambient virtual co-presence which gives users a sense of closeness by knowing what their social network of friends or family are doing; however, this method of photo-sharing does not support photo-talk.

Current digital co-present solutions included the tabletop interfaces [1][18][19] and Balabanović's Storytrack [2]. Tabletop interfaces are great for sharing digital photos, but lack the portability.

Balabanović's StoryTrack is a prototype that enables digital photos to be used in a manner similar to print photos for sharing personal stories was developed [2]. This was achieved with a mobile device that could be passed around to view digital photographs. Balabanović stated that to share photos in a natural setting, a portable device is required and should be large enough to show photos at a size similar to regular prints. From their user experiment, the researchers found two different styles of storytelling. Photo-driven: this is where a subject explains every photo in turn, the story prompted by the existing sequence of pictures. Story-driven: the subject has a particular story in mind, then gathers the appropriate photos and recounts the story. The conclusion of this paper is that this device demonstrates that digital photos can be used to support some of the same kinds of story sharing that people enjoy with print photos. It is important, then, that any system be evaluated for both Story-driven and Photo-driven style applications.

Research from Frohlich [10], Kindberg [13] and Vronay [20] all suggest that sharing photographs face-to-face is the most common and enjoyable method of photo sharing. It would seem that to achieve compelling photo-sharing, supporting co-present face-to-face sharing should be the foundation of the design for our prototype.

It seemed clear that the next generation of photo sharing application should allow users to share photos in an ad-hoc way without involving external pieces of technology such as computers or monitors or group displays. As most people carry a device capable of displaying digital images (in the form of a camera-phone) it seemed sensible to develop an application that could broadcast an image amongst co-present handsets. WYSIWIS (What-You-See-Is-What-I-See) is the most common form of application sharing for collaboration, where all participants can see the same shared view of the application and interact with it. Our application should therefore act as a type of mobile WYSIWIS application. WYSIWIS applications are naturally synchronous and sequential which we believe supports the very nature of photo-sharing. Assuming that this can be achieved technically, the problem remains of broadcasting images in such a way as to support the type of social interaction that users experience with print photographs.

Greenberg [11] discusses the responsibilities of view sharing software that must be considered during its design and evaluation. These responsibilities include maintaining consistent shared views, managing floor controls between participants wishing to interact with the system and allowing participants to gesture and annotate around shared views. From [4], [9] and [12] it seems that social protocols have been observed to be effective in small groups of about two to three people, or groups where people are familiar with each other. More advanced floor control policies are suggested when the groups become larger. Boyd [3] described floor control as the problem of managing interaction among users of an application. We are interested in the interaction that occurs when using our prototype, and thus will focus on floor control policies.

Floor control policies are divided into two categories. Explicit policies require participants to deliberately request and release control. Implicit policies automatically requests control for participants, triggered when a participant generates input events. Crowley et al. [8] described four variants composed of a combination of explicit/implicit requests with explicit/implicit grants.

Finally, Koskinen et al. describe a study in which several groups of users were given digital cameras and mobile phones capable of sending images over a wireless network [14]. Their aim was to determine how real people sent mobile images. They state that browsing photographs is a group activity, which brings about a feeling of connectedness among the participants. They found that there is a lot of interest in technology when people can use it to entertain people. In the design of our experiments, we wanted to see if we could also discover this notion of 'entertainment' through image sharing.

2. Prototype System

2.1 Implementation

Using a PDA to act as a cellular handset surrogate, the prototype developed was developed for HP iPAQs using the .net compact framework 2.0. The interface was based on that of a standard photo viewing application for Windows Mobile. The method of communication between devices was through IP multicasting using the built-in WiFi – WiFi multicasting was the only way to ensure interactive response times.

Using WiFi multicasting, multiple PDAs listening on the same multicast IP can synchronise with the show. A messaging system was developed to decode the multicast packets being sent and manage the co-present interacting devices. Devices can connect and disconnect from the show at anytime.

When a device connects, a message is broadcasted to determine if there is any current host on the multicast IP chosen. If no host responds, the device declares itself as the host. If a host is found, the device is sent the current show data to synchronise with the show. The host of the show can select which floor control policy to use.

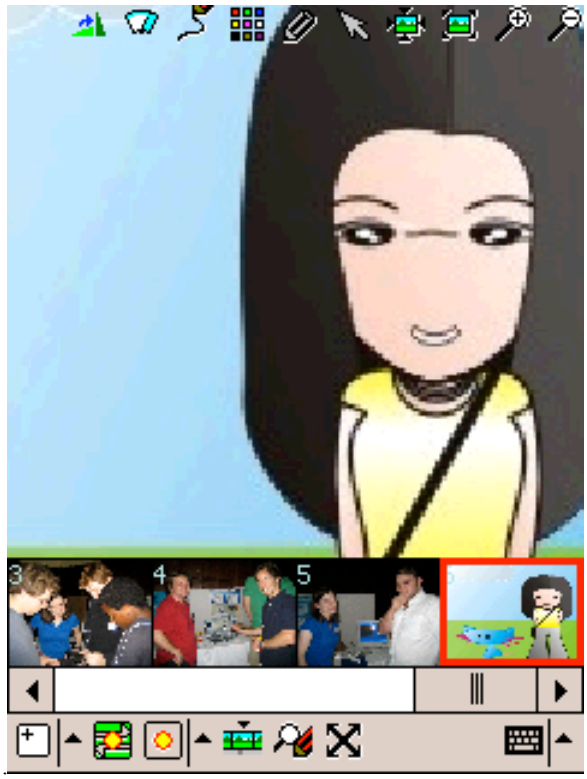
The broadcasting of the photographs with no error correction was initially implemented. Photographs were sent to the other devices in a reasonable amount of time. Since no error correction was implemented, occasionally photographs would end up corrupted on the receiving device. For this reason, in our experiment the photographs were preloaded onto the devices and only coordination information was broadcast. It should be noted that the WiFi speeds on the handsets available to us was particularly slow and transmission of full images should be possible with current hardware that has a more robust WiFi implementation.

Figure 1: Illustration of how devices communicate.

The application supported the following functionality:

- Panning: Panning is achieved by dragging the main image display with the stylus.
- Zooming: Zooming is achieved by pressing the zoom in/out icons.
- Rotation: Rotation achieved by pressing the rotate icon.
- Drawing: Drawing is achieved by activating the drawing feature by pressing the drawing icon. The line thickness and colour of the drawing can be chosen.
- Pointer: The pointer can be used to point at objects on the screen. The pointer is moved by activating the pointer and clicking/dragging anywhere on the main display.
- Thumbnail browser: The thumbnail browser is used to browse the photos in the current photo directory.
- Navigation thumbnail: A thumbnail of the image is shown in the corner of the display which displays when the screen is tapped and hides when nothing is pressed for three seconds. This thumbnail shows the user the portion of the photo that the user is viewing in the main display. The image can be panned using this thumbnail by pointing the stylus on the thumbnail to the position of the photo you desire to view.
- Synchronise: An option to connect/disconnect from the show was achieved by selecting the "connect/disconnect" option from the menu. When connected, the application will either join a show or host a show if no current show detected.

The final interface can be seen in Figure 2 below



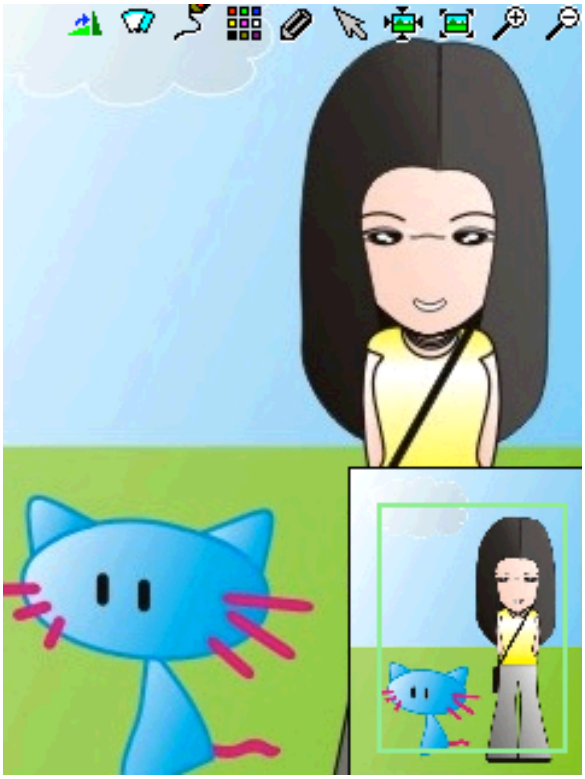


Figure 2: Software in action – the top image shows the options for image selection, whilst the second one shows a panning interface in full screen mode.

2.2 Floor Control Policies

The floor control policies are the software locks implemented that determine which user and when such a user can control the show. We chose to implement three different policies to determine which best fits the requirements for photo-sharing. An implicit floor control policy, explicit floor control policy, and a "free-for-all" mode to determine whether social protocols can be effective in this highly social interaction.

- Host-Token: With this policy, the user that possesses the host-token has full control over the shared display. The user that initially possesses the host token is the first user to join the show. This token can be requested by other users by pressing the "request host" button. The host will then receive a message to notify him/her that a user is requesting the host token. The host can then either release/deny the host token. This is an explicit floor control policy and reflects Crowley's explicit request, explicit grant variant.

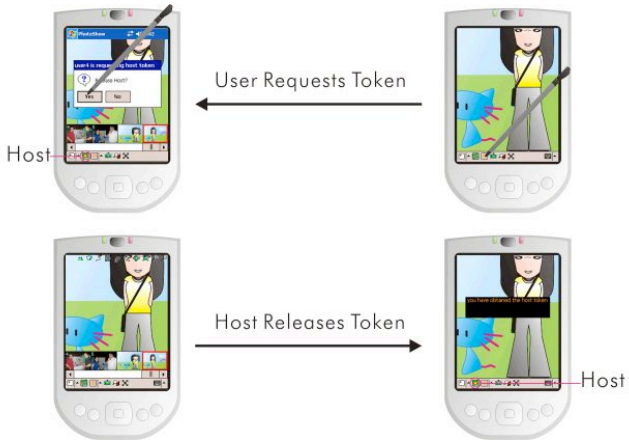


Figure 3: When a user requests the host token, the current host is prompted to release/deny the request.

- Three-Second: With this policy, initially a user is given control of the display once he/she performs a control action. A control action is any action that would manipulate the display (i.e. pan, zoom, rotate, draw, etc). This user will retain control for three seconds after his/her last control action provided the last control action is performed within three seconds after his/her previous control action. If no control action is performed for three-seconds, another user can take control of the display by performing a control action. Users can identify when they are blocked from taking control by a notification icon that is displayed in the corner of the screen. When this red circle is displayed, it means that the user is blocked from performing any control action. When no circle is displayed, it means that he/she is free to manipulate the display. This is an implicit floor control policy and reflects Crowley's implicit request, implicity grant variant. Three seconds was chosen as, in an initial pilot, this was the maximum length of time users could look at an image before becoming bored.

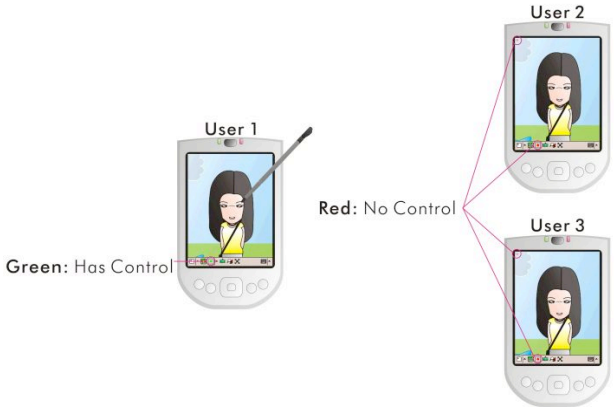


Figure 4: Three-second notification of control.

- Ad-hoc: With this "free-for-all" mode any user can control the display at any time. The motivation for implementing this mode was to determine if users can co-ordinate control socially without any software locks. It is anticipated that a social protocol would emerge to organise any chaotic behaviour that is expected.

Figure 5: Simultaneous interaction with ad-hoc "free-for-all" mode.

3. EXPERIMENT DESIGN

The objectives for this experiment were:

- To determine what social behaviors this application will produce/encourage (e.g. the photo-driven, story-driven and entertainment behaviors described by previous researchers)
- To determine whether/how various floor control policies affect the social experience

To achieve the objectives, it was decided that a naturalistic observation would be conducted. The test subjects consisted of three groups of four friends. We engineered three of the friends in each group to have shared some experience together where they had captured a reasonable amount of digital photos. The fourth friend would not have shared the same experience and had not seen the photos before. The groups were asked to bring about 60 photos of the experience that the three friends have shared. For this experiment, the group was to talk about their photographs with each other.

The use of friends within a group allowed us to investigate the effect of the system as realistically as possible. The idea behind keeping one friend out of an experience was to engender a desire for the rest of the group to share their experiences with their friend using the medium of the PDA system. We chose only one friend to be excluded to maximize the number of photos that were available for sharing. From our reading of the literature, this group experience should lead to collaboration in story-telling.

Prior to the experiment, a tutorial was conducted to show the users how to interact with the application. They were also been given some time to explore the application on their own.

For the experiment, each user was presented with their own Pocket PC. The photos were preloaded on their devices. The users were told that they would be given about 15 minutes to talk about their photos using each floor control policy. The experimenter would notify them when the floor control policy was to change. For each group, the floor control policies were tested in different orders as to eliminate any learning effects or fatigue effects for a specific policy.

After the experiment, a group discussion was held to ask the users various questions on how they felt about the application and the various floor control policies.

3.1 Observations

One group was used as a pilot and the other groups were used in the observations. Each group used the floor control policies in different orders. The groups consisted of various combinations of males and females. Users were observed using video cameras and human observers in the room, as in Figure 6 below.

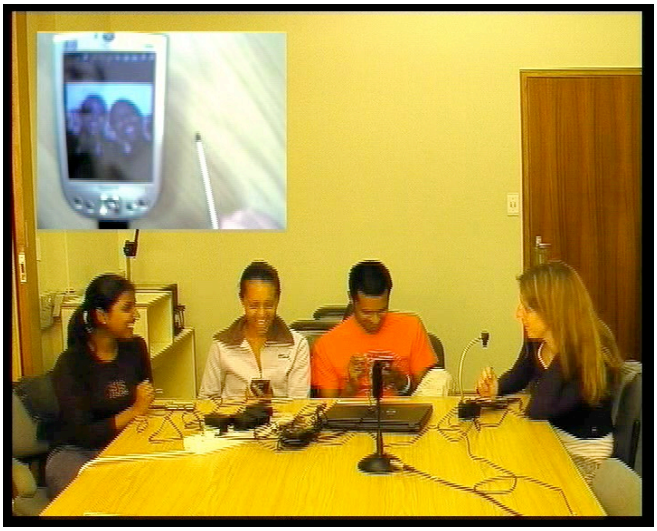


Figure 6. Four friends using the system with the image from one of the PDAs inset in the top left.

All groups tested where composed university students, all of which were computer literate and owned camera-phones. The first group consisted of four females aged between 22 to 23. Three of them shared a day outing together. The second group consisted of two males and a female that went rock climbing together. A male friend was used as the extra friend. The age of this group ranged from 23 to 26. The third group consisted of four males, three of which attended a party together. Their ages ranged between 19 to 20.

With each of the groups, a user started by taking control of the display and storytelling their photos to the fourth friend that was not part of the experience. While the user conducted the storytelling, others in the group attempted to explore if/how they could contribute.

3.1.1 Host-Token

With this policy, the storytelling of photos and control of the display was very organised. Users seemed to enjoy having full control over the display, storytelling their photos without worrying about being interrupted. Some interesting behaviour was observed when passing the token. Users tended to pass the token verbally/socially. When the host was notified that a user was requesting the host token, he or she would ask who requested the host and usually deny the request. If the host was verbally asked for the host token, the host was usually more likely to release the host token. Some users wanted to release the host token before another requested it, since he/she did not want to control the display any longer. However this was not possible as method of passing the host token was not implemented this way. With one of the groups, another problem was observed with the host token policy. One user constantly tried to obtain the host token by constantly requesting it. The host did not want to release the host, which meant he had to constantly deny the

request. This seemed to irritate the host, which eventually led to him releasing the host to the requester.

3.1.2 Three-Second

Storytelling persisted using this policy; however the user telling the story and the user controlling the display were occasionally two different people. This was due to the automatic release of control three seconds after the last control action of a temporary host. Users that wanted to control the display seemed to start getting frustrated as they were always being denied the control. Users would wait for the notification when control was released and try to manipulate the show, only to realize someone else obtained control before them. This led to the users asking whoever was in control to manipulate the display. When a user wanted to take full control over the show, he/she would ask the current host for control. The host would then pronounce that he/she has stopped manipulating the display and that the requester can take control. When verbally asking for control, other users in the group did not try to grab control.

3.1.3 Ad-hoc

Using this mode, the users tended to stop storytelling about their photos and instead everyone started to try and manipulate the display as much as possible. This was generally in the form of drawing on the screen, typically trying to tease a co-present friend that was in the photo. The friend being teased would then try to find a photo of the others, or draw on the other co-present users captured in the photo as a response. Since there was no software lock to determine who had control over the display, all users could simultaneously manipulate the display. This seemed very chaotic. However, within this chaos, all the users seemed to be enjoying this form of interaction the most.

3.2 Group Discussions

The majority of the subjects typically did all their photo activities (viewing and sharing) using a PC. This included viewing photos with their friends via the PC screen and sharing photos on the internet (online photo albums, blogs, e-mail). The interface of the application was found to be easy to use – they mentioned that the icons used to manipulate the display seemed familiar and thus intuitive. All the users enjoyed the shared display aspect of the application and agreed that they would use this type of application in real world situation.

Almost all the users preferred the host-token policy as with this policy users have the most control of the display. They disliked the three second policy as they did not know who was in control, and they could not always obtain control when they desired. They mentioned that with the ad-hoc mode, things were too chaotic. Even though the host-token policy was preferred, all users agreed that a choice of floor control policies would be best as the other policies could be useful for other situations.

The users were asked how this method of sharing photos compares with sharing printed photos. Most users did not print photos very often. If they did, they typically only print the more meaningful photos. Using this application, they could also share the photos that they would not normally print. The only criticism mentioned of using this method is that the resolution and quality of the photo displayed is not as clear as a printed photo. The size of the display is also not as large as a typical printed photo. However, these factors did not seem to detract overly from the users' enjoyment.

4. Discussion

4.1 Host-token

From the post-experiment discussions, users stated that they preferred the host-token policy. The reason being that control was explicit and removed any ambiguity (i.e. they have full control over the display). From our observations, story-telling and conversations were very controlled and happened in a civilized manner. There was little confusion on determining who was in control during the interactions. The only minor problem noticed with this policy is that users wanted to give up the host token before another user requested it first. This could not be achieved as the host token can only be released when it is requested. Our model requires that someone be in control and that the same someone must give up control. To allow voluntary token abandonment would mean that there is no one in control, allowing ambiguity to creep back in.

With this policy, a combination of story-driven and photo-driven behaviours were observed. The users' photo set was typically in a chronological order in the thumbnail browser. The user initially in control would start by displaying the first photo in the thumbnail browser. They would then start describing the photo being displayed on the screen (photo-driven). The next photo in the browser would then be selected and the photo described again. While describing a photo, a specific story would come to mind of the user. The user would then find the specific photos in the thumbnail browser to display to enhance the story-telling (story-driven). The photos following that photo were usually related and were displayed to continue with the story.

From the observations and discussions, it is clear that this is the preferred policy for story-telling behaviour.

4.2 Three-second

The main problem found with the three-second policy is that users could not obtain control when they wanted to. The user currently in control was also unidentifiable unless users resorted to asking the whole group "who's in control?". The interesting behaviour observed with this policy is that a new social protocol seemed to emerge to deal with the ambiguities. Due to the confusion (i.e. not knowing who is in control and not knowing when they will be able to obtain control), users started to pass control socially by verbally asking for control and verbally telling someone that they will be releasing control. In effect, the users were re-creating the explicit host-token policy described above. For this application, it would seem that implicity policies (at least, the way in which we implemented it) is inappropriate.

Using this policy, story-telling persisted; however, the story-teller was occasionally interrupted while telling the story, allowing another user would grab control of the show.

4.3 Ad-hoc

The "free-for-all" mode was implemented to determine whether users could co-ordinate themselves socially without implementing any software locks. When using this "free-for-all" mode, the result was always chaotic as all users tried to simultaneously manipulate the display. This typically included multiple users drawing on the display. Since users could draw on the display simultaneously, it was not known who drew what on the display. In one of the groups, a user requested that each user use a different colour so that they would know who drew a particular drawing. No signs of a social protocol emerging were

observed. Storytelling was practically abandoned. However, due to the all users interacting simultaneously, and no one having to wait for control, the users seemed to have the most fun using this mode. This would echo the findings of Koskinen et al. [11] who discovered that sharing photos can be an entertaining experience.

4.4 Experimental Method

All researchers who wish to evaluate completely new forms of system face a problem in that they have little indication of how users will react to the system. If you do not know how someone will react, it is hard to ensure that the reaction will be measured correctly. For our evaluations, the approach of using friends and excluding one friend from the experience seemed to work out well. We generated a lot of discussion in the groups and, by having many people with material they wished to share, we generated mild conflict with users wishing to explain something more clearly than the person who currently had the floor. Even though the users were in an unnatural environment and knew that they were being observed, after using the application for a while, they seemed to become more comfortable in sharing and talking about their photos. Throughout the testing, none of the users seemed to get tired/bored from using the application.

5. Conclusion

From these observations, there seems to be two methods of interacting with photos.

Sharing and storytelling of photos is promoted by strict floor control policies. Not only does this ensure better behaviour from the audience, but it allows the presenter to focus on the story, knowing that their presentation will not be hi-jacked. From the observations we took of the groups, the host-token policy supported both story-led and photo-led interaction.

Teasing friends and the 'entertainment' aspects are promoted by the ad-hoc/"free-for-all" mode. With the other two policies, users were willing to accommodate the policies and work with them directly (host-token) or adapt them to their needs (three-second). This was emphatically not the case with the ad-hoc mode. No attempt at structure could be maintained and the session deteriorated (or improved, depending on your view) into a form of game.

Therefore, one can conclude that applications of this nature which need to support story telling should have some form of software locking built in – our experiments would indicate that host-token is the most appropriate. However, the exact form of the policy is not so important as we observed that users were more likely to pass control when verbally asked for it.

One aspect which we did not investigate was allowing users to select which policy they wished to use. Would groups realize that someone wanted to tell a story and voluntarily switch to some locking policy; or would groups always default to an ad-hoc interaction?

Also, by limiting our group size to four participants, we created groups in which it was possible to augment the locking policies with verbal interaction. Furthermore, the ad-hoc mode is sustainable because there are only four people messing with the screens. However, were that number to grow, the ad-hoc interaction may become so chaotic as to make it impossible to derive any entertainment value from the interaction. It is our goal to re-run these experiments to investigate these factors.

6. ACKNOWLEDGMENTS

The handsets for this development work were provided by a donation from HP and bridges.org. This work was funded by South Africa's National Research Federation as well as Telkom and Siemens South Africa through their 'Centres of Excellence' initiative.

7. REFERENCES

[1] Apted, T., Kay, J., Quigley, A., Tabletop Sharing of Digital Photographs for the Elderly, Conference on Human Factors in Computing Systems, Proceedings of the SIGCHI conference on Human Factors in computing systems

[2] Balabanović, M., Chu, L. and Wolff, G.J. Storytelling with Digital Photographs, Proceedings of CHI 2000. pp. 564-571. 2000.

[3] Boyd, J. Floor Control Policies in Multi-User Applications, Conference on Human Factors in Computing Systems, INTERACT '93 and CHI '93 conference companion on Human factors in computer Systems, pp. 107-108

[4] Brinck, T., Gomez, L.M. A Collaborative Medium for the Support of Conversational Props, Computer Supported Cooperative Work, Proceedings of the 1992 ACM conference on Computer-Supported Cooperative Work. pp. 171-178

[5] Chalfen, Richard (1987): Snapshot Versions of Life. Bowling Green, Ohio: Bowling Green State University. Popular Press.

[6] Counts, S. and Fellheimer, E. Supporting Social Presence through Lightweight Photo Sharing On and Off the Desktop. Proceedings CHI 2004, Vienna, Austria. 2004.

[7] Crabtree, A. Rodden, T. Mariani, J (2004) Collaborating around collections: informing the continued development of photoware. Proceedings of the 2004 ACM Conference on Computer Supported Cooperative Work, pp. 396-405

[8] Crowley, T., Milazzo, P., Baker, E., Forsdick, H., and Tomlinson, R.. 1990. MMConf: An infractructure for building shared multimedia applications. In Proceedings of the ACM Conference on Computer-Supported Cooperative Work (CSCW '90, Los Angeles, CA, Oct. 7-10), F. Halasz, Ed. ACM Press, New York, NY, 329-342.

[9] Deering, S.E., Cheriton, D.R. Multicast Routing in Datagram Internetworks and Extended LANs, Symposium Proceedings in Commpunications Architectures and Protocols, 1988, pp. 55-64

[10] Frohlich, D., Kuchinsky, A., Pering, C., Don, A. and Ariss, S. Requirements for Photoware. Proceedings CSCW 2002, New Orleans, USA. Pp. 166-175. 2002.

[11] Greenberg, S. Sharing Views and Interactions with Singer-User Applications, Proceedings of the ACM SIGOIS and IEEE TC-OA conference on Office Information Systems, pp. 227-237, 1990

[12] Greenberg, S., Marwood, D. Real Time Groupware as a Distributed System: Concurrency Control and its Effect on the Interface, Computer Supported Cooperative Work, Proceedings of the 1994 ACM Conference on Computer Supported Cooperative Work, oo.207-217

[13] Kindberg, T., Spasojevic, M., Fleck1, R. and Sellen, A. How and Why People Use Camera Phones. Technical Report. Consumer Applications and Systems Laboratory, HP Laboratories Bristol, 2004.

[14] Koskinen, I., Kurvinen, E. and Lehtonen, T.. Mobile Image. IT Press. 2002.

[15] Pictavision http://www.pictavision.com

[16] Salovaara, A., Jacucci, G., Oulasvirta, A., Saari, T., Kanerva, P., Kurvinen, E., & Tiitta, S. (2006). Collective creation and sense-making of mobile media. Proceedings of CHI 2006, ACM Press, New York, pp. 1211-1220

[17] Sarvas, R., Oulasvirta, A. and Jacucci. G. Building Social Discourse Around Mobile Photos – A Systemic Perspective MobileHCI 2005, Salzburg, pp.31-38. 2005.

[18] Shen, C., Lesh, N., Vernier, F., Personal Digital Historian: Story Sharing Around the Table, Interactions, Volume 10, Issue 2, Winds of Change, pp. 15-22

[19] Vernier, F. Lesh, N.B., Shen, C, Visualization Techniques for Circular Tabletop Interfaces, ACM Advanced Visual Interfaces (AVI), May 2002

[20] Vronay, D. Farnham, S. Davis, J. PhotoStory: Preserving Emotion in Digital Photo Sharing, Virtual Worlds Group, Microsoft Research