Understanding and Improving Flow in Digital Photo Ecosystems

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ABSTRACT

Families use a range of devices and locations to capture, manage, and share digital photos as part of their digital photo ecosystem. The act of moving media between devices and locations is not always simple though and can easily become time consuming. We conducted interviews and design sessions in order to better understand the movement of media in digital photo ecosystems and investigate ways to improve it. Our results show that users must manage multiple entry points into their ecosystem, avoid segmentation in their collections, and explicitly select and move photos between desired devices and locations. Through design sessions, we present and evaluate design ideas to overcome these challenges that utilize multipurpose devices, always-accessible photo collections, and sharing from any device. These show how automation can be combined with recommendation and user interaction to improve flow within digital photo ecosystems.

KEYWORDS: Digital photos, capture, sharing, display, ecosystems.

INDEX TERMS: H.5.2 Information Interfaces and Presentation: User Interfaces–User Centered Design; Prototyping; H.5.3 Group and Organization Interfaces: Collaborative computing

1 INTRODUCTION

Digital cameras are commonplace in most families' homes. With them, families capture an abundance of photos of outings, vacations, family members, and friends [12,20]. They also capture seemingly mundane everyday things that happen or they come across [12,17,18,27]. Images are then stored, displayed, or shared with others where families utilize a range of technologies including personal computers, digital frames, printers, printing kiosks, etc [9,13,21]. Families also use non-technologies such as photo frames, albums, shoeboxes, and various surfaces in their homes (walls, shelves, etc.) [13,18,21,25]. We call this collection of devices, items, and locations the *digital photo ecosystem*.

One of the main tasks that families must do within their digital photo ecosystem is move or transfer photos between the locations and items that they use. We refer to this as *ecosystem flow*. Yet managing flow is not always simple. For example, many people have difficulties transferring images from their digital camera to a computer. They may also not know how to share images with remote family or friends or may simply not have enough time to do so, especially when events are frequent and pictures are continually being captured [12,13]. Previous research has looked at various aspects of ecosystem flow through ethnography and design. This includes a multitude of studies on photo capture, management, editing, display, and sharing.

Our goal was to build on the previous research by further understanding the nuances of ecosystem flow and investigating ways to improve it. Improving flow meant understanding how to simplify movement, reduce the amount of time needed to move media, and allow the flow of media to better match the routines and needs of families. Our research took a two stage approach.

First, we conducted contextual interviews with 22 middle-class families (Section 2). Our results outline family routines for moving digital photos between various devices, displays, and locations (Section 3). They also highlight the challenges that arise as a result of these routines and possible design opportunities to address them involving: automation, anytime/anywhere sharing, and an always-accessible digital photo collection. However, what our interview results do not do is illustrate the specific ways that these design ideas should be incorporated into photo ecosystem devices. For this we turn to the second part of our methodology.

Second, we wanted to evaluate the design ideas coming from our interviews and explore their nuances. Yet we did not want to incur the cost of designing an entire next-generation digital photo ecosystem built around these ideas and evaluate it for its pitfalls. Such a task is by no means trivial especially when considering the varying number of technologies used and potential platform and connectivity issues that come with it. As an alternative, low-cost approach, we conducted design sessions with the same families and utilized sketching [6] and Wizard of Oz techniques [15] (Section 4). We probed the first ten families about the design ideas by having them discuss and build photo devices made out of Styrofoam blocks that acted as physical representations for their ideas. Next, we iteratively built a series of interactive prototypes using the same Styrofoam blocks and probed our remaining twelve families using them (Section 5). Our results highlight the ways in which multipurpose devices, ubiquitous collections, and ubiquitous sharing offer potential for improving ecosystem flow.

2 CONTEXTUAL INTERVIEW METHODOLOGY

We first conducted interviews with family members in order to understand the flow within their current digital photo ecosystem and gain initial design ideas for addressing any challenges.

2.1 Participants

Our interview participants comprised of one family member from each of 22 different families. We recruited participants who felt they were the family's *primary photo organizer* (18 people) and also those who did not (4 people). The photo organizers are the individuals who likely know the most about the family's photo routine, while the others provide the point of view of other family members. In the case of four families, multiple family members participated because of their interest in the topic. This provided us with an additional four participants who were not the families' primary photo organizer. Thus, in total, we had 26 people participate in the study. Naturally, we would have gained more insight by interviewing all members of each family; however, this would have increased the complexity of finding participant families and scheduling them. We feel we have achieved a balance though by including those who are the family's primary photo organizer (18 people) and also those who are not (8 people).

Participants also varied in terms of gender (15 females, 9 males) and age, again providing us with a range of perspectives. Each of the following age ranges had at least four participants: college-aged (under 25 years), young-middle aged (26-35), middle-aged

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(36-50), and pre-retired/retired (over 50). Our families also varied based on composition: nine had at least one child under the age of ten, four had at least one teenager, six were empty-nesters (with children who had moved away), and three had no children. Participants had various occupations and all families had at least one digital camera. Overall, our participants were highly representative of "Kodak Culture" photography [7,20] as opposed to users heavily focused on online communities (e.g., Snaprs [20]).

2.2 Method and Analysis

We conducted semi-structured *in situ* interviews with our participants and asked them to describe: the technologies and non-technologies that they used as a part of their digital photo ecosystem, the way in which they moved media through their ecosystem, and any challenges that they faced in doing so. Participants also gave us a tour of their home to show us the various locations in which media was acted on, resided in, or was displayed. We also probed families about video usage but found that most families rarely used videos to capture memories (at least currently); thus, we do not present results on video use, though it warrants further exploration (especially considering the recent proliferation of online video sharing sites such as YouTube).

We recorded audio and handwritten notes for all interviews and video for prototype sessions. This generated over 100 pages of written data which we analyzed using an open coding method [23] along with affinity diagramming [14]. We returned to our audio/video recordings only when needed to clarify observations.

3 FLOW IN CURRENT DIGITAL PHOTO ECOSYSTEMS

In this section, we describe our interview findings and also recast the related literature in a manner that helps us better understand ecosystem flow. Thus, most of the findings described here are our own observations derived from our interviews. In places where we have validated research or recast findings, references are provided.

3.1 Family Member Roles

Family members take on different roles within their digital photo ecosystems. These roles are really the underpinning of a family's routine as it lays the framework for family members to understand who is responsible for what tasks and act on these responsibilities.

3.1.1 Capturing Photos

One family member is often designated as the family's *primary capturer*. All family members typically understand that this person is in charge of taking pictures. As a result, this person will be the one bringing the family's main digital camera with them for outings or on vacation. They are also more apt to know the location of the family's primary camera within the home when it is not being used. A family's primary capturer has the most knowledge of what photos have been captured and subsequently will have a great deal of knowledge of what photos are available for sharing with others. In 14 of our 22 families, the role of primary capturer belonged to an adult woman (e.g., Mom, wife, single parent); in five cases it was the role of the adult male (e.g., Dad, husband); in two families it was the role of an adult child; and, in one case the role was shared between both parents. In many cases, mothers were the primary capturer because they wanted to capture memories of their children growing up. Fathers who were the primary capturer did so typically because of an affinity for technology.

Of course, sometimes other family members capture pictures aside from the primary capturer. This is especially the case for teenagers and adults in the family. In this case, family members may share the family's main digital camera, akin to the way that families also share other home technologies [4]. As a result of being shared, the camera is often kept in a publicly accessible location such as a counter shelf or office desk. Family members may also have their own digital camera or a mobile phone with a built-in camera [17]. Sixteen families had at least one secondary capture device; five used additional digital cameras, and eleven used mobile phones. The implication of these findings, as it relates to ecosystem flow, is that *photos will enter a family's photo ecosystem from multiple devices and by several family members*. This means that multiple entry points will need to be included and managed as a part of a family's organization routine.

3.1.2 Organizing Photos

The responsibility of organizing the family's digital photos is taken on by a family's *primary organizer*. This means that she or he will: move photos from the main digital camera to the computer (regardless of whether s/he captured them), print photos for albums or displays (but not necessarily place them in these locations), share pictures with others, and back photos up on other forms of media. The primary organizer needs to have the technical expertise to move photos between devices and the time to actually do so. We saw some families whose primary organizer was not particularly "tech-savvy." In these cases, a more technically-competent family member would show the primary organizer how to setup and organize the family's photos and then help them on an as-needed basis. As a result of their activities, the primary organizer also has a great deal of knowledge of what photos are available within the family's collection. They may also be the only family member who knows what photos are being shared with whom. In 15 of 22 families, the role of primary organizer was fulfilled by the primary capturer (12 females, 3 males). In five families the role was fulfilled by the primary capturer plus another family member (6 females, 4 males). In two cases, the role was taken on by the other adult parent (when compared to the capturer) (1 female, 1 male). Other studies have also described this role and shown that it is dominated by women [16,21].

As mentioned, pictures are also captured on devices other than the family's main digital camera by other family members. In most cases, the primary capturer is not responsible for moving the media from theses device to a family's collection. This becomes the responsibility of individual family members. Family members may certainly ask the primary organizer to do this though.

3.1.3 Displaying Photos

A third role exists in terms of putting pictures on display throughout the home. Taylor et al. [26] refer to this as "curatorial control." In all families from our study, the role of *display manager* was taken on by the female head of the household (the gender role has not been previously shown). The display manager may or may not be the same person as the primary capturer or photo manager. If she is not, then coordination may arise where the display manager works with other family members to find pictures in order to print them. We saw many families where the display manager role was taken quite seriously—other family members knew not to put photos on display. For example, one mother told us that only she was allowed to touch the photo frames and if anyone changed anything, she would change it back.

3.1.4 Discussion

Previous research has highlighted the role of the primary organizer [16,21] and display manager [26]; we build on this with further details along with acknowledgement of the role of primary capturer. All three roles were taken on by one person in only 9 of our 22 families. In five of these cases this was because there was only one adult parent in the family. Thus, we can see that the nature of responsibilities within a family's photo ecosystem is most often distributed amongst two or more people. This is

especially the case when there are multiple adults in the home. As a result of this distribution, family members must coordinate to fulfill their roles and share knowledge of the family's collection.

The implication of these findings is twofold. First, in any design situation we need to think about *how the design will affect family roles* and whether or not tension will be created. Family members can become quite attached to their responsibilities: They may enjoy their activities or like the feeling of ownership over them. Second, designs should work to support family coordination and help family members *bridge a lack of shared knowledge*. This could make it easier for some family members to know what photos are available for them to use or share, or what photos family members are sharing with other family or friends.

3.2 Multiple Paths through the Ecosystem

Once captured, families move photos through their ecosystem to store, print, put on display, or share them with others. Here the photos are moved between various devices and locations to accomplish the activity. For all of our families, the large majority of photos had a primary path that they would always follow through the family's ecosystem. For example, consider the routine of Jim and Michelle, an empty-nest couple from our study. Jim is the primary organizer and will move all of the family's photos from their main digital camera to the family computer and then to CDs for backup. This routine is regular and happens after each family outing or event. Given that all photos follow this path, we classify it as the family's primary ecosystem path. Subsets of a family's photos also follow one or more secondary paths (in addition to the primary path). For example, in Jim and Michelle's family, Jim will send copies of some of the family's pictures to extended family via email. Here they move from Jim's computer to that of his extended family. This would be classified as a secondary path for the family because not all photos follow it.

3.2.1 Digital Paths

For 9 of 22 families, photos moved along a primary path that was *digital*. This meant that pictures were transferred from capture devices to a computer where interaction with the pictures occurred primarily on digital files [18]. The goal of moving media along this type of digital path is to have digital copies of images in desired locations (e.g., a computer collection, online, emailed to another person). Families also had secondary paths that were digital and these allowed them to get *certain* digital files representing the pictures in other locations. Sometimes these locations may be more personal in nature (e.g., a personal laptop). Our interviews along with previous studies have shown that digital photo locations include computers, external hard drives, DVDs/CDs, or memory cards [12,21,22].

We noticed that the movement of photos along digital paths often involved an intermediary device. For example, a family may have a primary storage location that is on a removable hard drive or DVDs. Photos will first be transferred from the camera to a computer and then to the storage device. Later, photos may be removed from the computer, left as a duplicate collection, or forgotten about. This highlights the fact that collections will sometimes segment and be in multiple locations. In some cases, intermediary devices were used because of technical limitations; other times they were used simply because this was the family's routine, even though media could move directly between devices.

3.2.2 Print Paths

For 13 of 22 families, photos moved along a primary path that involved *printing* [12,18]. In this situation, families aim to have printed copies for most of their photos. For 8 of 13 families, this path involved transferring photos to a computer and then to a printing facility (a kiosk, home printer, or online printing service). This meant the computer was mostly an intermediary device where the digital file representing the pictures was either deleted or much less important than the print. Only 5 of 13 families had a routine where the print path bypassed a computer and photos moved directly from the capture device to a printing device. In these situations again, most digital files representing the pictures were deleted. Families also had secondary print paths in order to print a subset of their pictures for sharing or placement within the home. Similar to existing research, we found that print paths allowed families to place printed photos in albums, frames, or random collections (e.g., shoeboxes, piles) [12,21,22].

3.2.3 Discussion

Previous work has shown the varying locations that family members store photos [12,21,22] and described the routines for sharing [9,13,21], but they do not articulate the paths that photos move along to accomplish these activities. It is these multiple paths that cause flow challenges. First, photo collections may end up segmenting into multiple collections found in multiple locations or on different devices. In some cases, this is valuable because it lets family members have backup copies of photos in certain locations or specific photos in their own personal locations. Yet, from the perspective of the primary organizer or display manager, this can make it difficult to know the location of photos or what photos are available for sharing. This suggests that *devices could utilize a central repository of digital photos.* This could be combined with automation so that photos always flow to this central location. Similarly, photos could be made accessible from this repository to any device, anytime, or anywhere.

Second, the use of intermediary devices may increase the complexity of moving photos through an ecosystem. Users may have to use interfaces on several devices as opposed to just one on a single device. This suggests that *devices could incorporate additional functionality that permits media to move directly between devices.* Some photo devices already incorporate such features, yet this could be expanded to all photo devices. For example, one could imagine sending photos from a camera to a remotely located digital frame. However, what is not clear for this design suggestion, as well as the previous one, is how users would utilize such functionality and what control mechanisms would need to be in place for the design ideas to be successful.

3.3 The Reliance on Explicit User Actions

The movement of photos throughout all of the ecosystems that we saw relied heavily on explicit user actions. This occurs when moving photos for storage, sharing, and display.

3.3.1 Flow for Storage

Moving photos from a digital camera to a computer or storage device always involved the user explicitly selecting the photos to be transferred and then performing the transfer operation either on the camera or computer. In most cases, all photos were transferred from the device. Families perform this transfer at varying points in time. Some people wait until their memory card is full, while others transfer pictures after each photo event. Additional pruning of unneeded photos occurs either before or after transfer. Here the challenge is the recurring nature of these activities.

We noticed that mobile phones caused an inherent lack of flow for most families. 6 of 11 families who used mobile phones to capture photos never moved these photos from their phones to storage locations. This was primarily because they did not know how to do the transfer or the device was not capable of it. As a result, mobile phones often became stopping points where photos captured with them did not end up being shared or moved to a family's primary collection. Those who did move them sent them to friends via a Multimedia Messaging Service (MMS) [17] and

did not transfer them to their family photo collection. In the case of one adult child living at home, this was because the photos on her mobile phone were more personal in nature. Some others felt they were photos of lesser quality and therefore did not need to go into the family collection. Even still, the separation of mobile phone photos from digital camera photos means that some of the most spontaneous photos [17] may not be present in a family's primary collection.

3.3.2 Flow for Sharing

Photos often move between different family's photo ecosystems as they are shared with remote family and friends. Here the primary organizer, and sometimes other family members, first selects which photos to send to others based on whether or not people will be interested in seeing them. This could be because the family has a relationship with the person, were at the same event, or the recipient could not attend the event but has interest. These photos are then sent via email, prints, web pages, or MMS when people are distributed; thus confirming many studies on distributed photo sharing [13,17,18,20,21,27]. These photos may be accompanied by stories told over the phone or attached to the media as text (in email) or annotations [2,12].

When family members receive digital photos from others via email or on web pages, naturally they must go to their computer and check their email or go to the web page in order to view them. Here, again, we see the reliance on explicit user actions. This contrasts the way family members view photos on display in their home by simply walking by and glancing at a photo frame, which involves considerably less effort. It also increases the burden on the family's photo organizer or other family members who receive photos. We found that they often felt compelled to show these photos to other family members and additional acts are needed to accomplish this such as printing the pictures or forwarding emails.

Viewing shared photos does not mean that the photos will enter the recipient's ecosystem permanently. Digital copies of photos received from others will typically be viewed and then discarded or left where they are (e.g., a web page) without future viewing. Families rarely copy these received images into their own collections. Only 7 of our 22 families did this and, in doing so, were highly selective, transferring few photos. People also occasionally receive printed photos from others in person or in the mail and typically place these in a location that is easy to update, such as a fridge surface [24], rather than in a more permanent location such as a frame. Thus, photos from others will likely enter someone else's photo ecosystem only temporarily.

Photos are also shared in a collocated setting and must be moved from their storage or display location to a location in which they can be viewed easily by others [2,9,12,21]. Existing research has shown that when printed photos are shared, they flow through the sharing space from control centers near the sharer, to personal viewing locations, and then to outlying positions once viewed [9]. When digital photos are shared, they are most often viewed by crowding around a computer [21] or mobile phone display [17,19]. In this situation, media does not move between ecosystem devices.

3.3.3 Flow for Display

Every family in our study displayed photos in their homes on walls, shelves, or other surfaces. Photo display is often deliberate and lets people be expressive [16,25]. Locations were chosen because they were social spaces, high traffic areas, or simply because they were out of reach of children [16,21,25]. The photos we saw were nearly all of immediate family members (parents, children). Most display locations were surprisingly static and people updated these photos relatively infrequently [25]. This meant the explicit acts needed to display the pictures were not recurring, yet it is also had the side effect that more time would be spent selecting pictures for these locations given that they would not be altered for a long time (if at all).

Other locations such as the fridge were more dynamic and families would update photos here every few weeks or months. Thus, the explicit acts needed to update these locations were performed on a recurring basis. These dynamic locations were the most likely locations to contain pictures of extended family or friends, probably because of the ease at which items can be changed on the fridge (e.g., magnetism, frames not needed) [24].

Film photos, as opposed to those captured with a digital camera and printed, dominated the displays found in most homes. This is because of the static nature of most frames' content and the relatively recent proliferation of digital cameras. Families with young children born in the digital camera era were more likely to have digitally captured photos on display than were families whose children were born during the film era.

3.3.4 Discussion

Existing research has described the acts of photo sharing [e.g., 9,13,20] and photo display [16,21,25]; we build on it by articulating the flow of photos as a part of these acts, as well as descriptions of the routines surrounding the receipt of photos (previously not explored). Our results show that there is a widespread reliance on users to perform explicit acts to move photos through their ecosystem. This suggests that *there may be ways to automate certain activities* around photo storage, sharing, and display. For example, given that most photos are moved from digital cameras to a storage location, it would seem fitting that this be done automatically. Devices could also potentially learn what content people typically share with others and then automatically make it available. Photos being sent to remote families for sharing could appear in more natural viewing locations such as frames spread throughout the home, rather than on a web page.

Of course, there are potential issues with these approaches. People enjoy browsing through their photos and conversing around them [9,13]. People may also not be comfortable with various degrees of automation as it pertains to sharing or placing photos on display. What is not clear then is what aspects of family photo routines could be automated such that users would feel comfortable with them and the acts would not take away from the enjoyment users have in managing their photos.

4 DESIGN STAGE ONE: DESIGN CONCEPTS

Our interviews highlighted several possible design directions to improve the flow of media in digital photo ecosystems. In the remainder of the paper we explore these ideas to understand their nuances and how they may need to be designed for in practice. We did this through two design stages; Stage One is described here and Stage Two is described in Section 5.

Individuals from our first 10 families participated in the first design stage following their interviews. Our goals were twofold. First, we wanted to probe our participants about the design ideas we saw emerging from our interviews to see how they could be refined or improved. Second, we wanted to see if there were other possible ways that did not come out through the interviews for improving the flow of photos in their ecosystems. To accomplish these goals, we introduced participants to four vague design concepts presented as sketches [6]. Here we do not refer specifically to sketches in the form of hand-drawn pictures. Instead, we refer to the presentation of ideas in such a way that they invoke the same mindset as one would get from a hand-drawn sketch. This meant we presented our design concepts in a fashion that was deliberately vague in order to provoke thought and exploration [6]. The four concepts and their descriptions were:

1. *Memory Capturer*: this device captures memories for you and can be placed in your home or carried around with you.

2. Interconnected Photo Frames*:* these devices are used to show/play memories, can be placed in your home or those of family/friends, and are connected together in some way.

3. *Mobile Accessor:* this device lets you access your entire photo collection regardless of where you are. It can be carried around with you or placed in your home.

4. *Creative Outputter:* this device allows you to create some sort of printed output from your photos and can be placed in your home or those of family/friends.

Figure 1 shows a collection of Styrofoam pieces of varying sizes and shapes that we showed to participants. To understand the size of these shapes, the bottom-most rectangle is roughly 5×7 inches. We asked participants to choose a size and shape of Styrofoam that they felt best represented each design concept. Participants were also told they could choose a different size than was available if they wanted. We then asked them to describe how they saw themselves using the devices, how media would move between them, and the reasoning behind their decisions and ideas. The Styrofoam pieces gave each design concept a physical representation that was used to ground our discussions with participants. It also provided a physical object that participants could add to and draw on using paper, pens, markers, etc. Some participants used these pieces to sketch their ideas and build an interface for the device. Others simply talked through their ideas while referring to the Styrofoam representations. As participants discussed the concepts with us, we probed them about key aspects relating to ecosystem flow.

4.1 General Device Ideas and Shapes

Participants described the four concepts in a similar fashion as existing devices that they were already familiar with. That is, the *Memory Capturer* and *Mobile Accessor* were seen as small devices much like a digital camera or mobile phone. Participants saw them first as devices to support collocated photo sharing and second as photo capture devices. *Interconnected Photo Frames* were seen as devices for supporting collocated photo sharing in one's home where people favored small sizes (4x6 or 5x7 inches) over larger ones (e.g., television). The *Creative Outputter* was seen as a larger device (roughly 12 x 6 x 6 inches) because people thought it would need to contain large parts to support its printing capabilities. Participants felt it could be used to print on 3D objects such as mugs, or create scrapbooks, collages, or calendars.

The fact that participants' descriptions largely modeled existing devices suggests that our design concepts, even though vague, were not vague enough and already constrained the mindset of the participants. Thus, we did not provide a way for participants to think far beyond what already exists. Nonetheless, we still managed to probe participants about the design ideas coming from our interviews to gauge their reactions. We also had several participants describe similar ideas through the design exercise without our prompting.

4.2 Design Reactions and Suggestions

Participants further built on the idea of removing the need for intermediary devices by simply removing devices altogether. That is, they suggested incorporating several of the devices together into *multipurpose devices*. Participants saw this as a way to eliminate unneeded or cumbersome flow within their photo ecosystem. That is, if there were fewer devices, they would not need to move media between as many locations. For example, half of our participants said they would like the functionality of the *Mobile Accessor* integrated with the *Memory Capturer*. They preferred to carry few devices and this would enable capture and easy sharing within a single device. One participant suggested combining the *Creative Outputter* with the *Interconnected Frames*. This would allow them to create printed output plus position utilize the device as a display when it was not printing.

Figure 1. Styrofoam used for idea exploration.

All participants felt that their existing ecosystem devices did not easily permit the transfer of photos between them. The most widespread suggestion for improving this was to be able select photos on any given device and then choose a destination device, at which point the selected photos would be sent to the other device (this is largely akin to the way people send email). Of particular importance here are two key ideas. First, the transfer of photos does not involve the use of intermediary devices; photos are sent between the two devices of interest. This supports the idea coming from our interviews. Second, this shows the desire for any device to be able to support transfer and receipt of photos over a wireless protocol.

Participants also felt that being able to transfer photos directly from their devices to devices within the ecosystems of family or friends would be valuable. This again reflects the idea of removing intermediary devices. For example, most participants thought that transferring photos to remote families' *Interconnected Frames* would be a good feature as it would let them easily share photos with others in either a synchronous or asynchronous fashion. This sharing was also felt to be more natural as people could view photos on a frame placed in the living room or kitchen, rather than a computer display (likely not in a public home location). Imagining oneself as the recipient of photos in a digital frame caused strong reactions. Most participants wanted to know first what photos were incoming to their frames and then selectively choose which should be displayed and for what time duration. However, the downside of this approach is it could easily be time intensive to go through incoming photos. Participants were reserved about the idea of transferring photos to remote families' *Creative Outputters* as printed media. This was found even when participants envisioned themselves as the sender. Printed output was seen as a permanent decision and could not be undone as easily as could photos that were sent to displays.

5 DESIGN STAGE TWO: WIZARD OF OZ PROTOTYPES

The remaining 12 families participated in Stage Two of our design sessions following their interviews. This occurred several weeks after the first set of interviews and design sessions. In Stage Two, our goal was to explore the design ideas coming from the interviews and previous design session, but, as previously stated, we did not want to incur the cost of designing and evaluating a fully-working and integrated set of ecosystem devices. For this reason, we took a low-cost approach and used Styrofoam and paper to create several designs based on our findings from Stage One of the study. These are described in the next section. We introduced participants to them and pointed out the various aspects of each design but did not explain how the interface would work. Participants then performed a series of tasks with the design concepts. This employed a version of the Wizard of Oz technique [15] where the interviewer acted as the computer and updated the designs based on user interactions. Tasks were aimed at having

participants move media through a photo ecosystem either explicitly or through automated processes. Examples include: send a photo to a friend's frame, or set your frame to automatically show recent pictures of your child. Participants were also told that they could assume device interoperability, network connectivity, and security were available and working. None of the tasks required interacting with a computer or any additional devices. The fact that our designs were of a low fidelity ensured that participant responses were more focused on the design ideas presented rather than fine-tuning the user interface.

5.1 Design Concepts

Our design concepts included: a futuristic camera (Figure 2 shows the device sitting in front), three digital frames of varying sizes (Figure 2, left), and a printer in the shape of a cube (Figure 2, right). Each side of the cube was a digital frame. All designs were essentially the same multipurpose device with the same user interface, though in a different size and shape. All devices could capture photos (the frames and printer had a built-in camera) and display them. While they may appear and sound similar to existing photo devices, the novel aspects of them are more abstract. That is, they all incorporated storage and sharing features that are not present in existing photo devices:

1. *Ubiquitous Collection*: All devices had access to one's entire photo collection regardless of their location. This meant that captured photos automatically appear in one's collection without explicit transfer and that the entire collection would be available for sharing from any device. Thus, we automated transfer between the capture device and collection and provided the functionality of the previous Memory Accessor within all three devices. This has the potential to increase family members' knowledge of photos within the family's collection beyond just the photo capturer and organizer since it makes the collection easily accessible from any ecosystem device (e.g., a personal mobile phone or laptop).

2. *Ubiquitous Sharing:* All devices allowed users to easily send photos to devices in other peoples' ecosystems using a World in Miniature view [28] where users select photos (Figure 3, left) and then the destination (Figure 3, right). This assumes family/friends have pre-set their devices to accept incoming photos. The idea of ubiquitous sharing certainly has the potential to make sharing photos easier for the primary organizer, yet it could also allow other family members to more easily share photos given its relative ease from any ecosystem device.

3. *Auto-Updating Display Content:* Users can set frames to learn what content they should display by selecting representative pictures and then have the device update its display automatically over time. New pictures would contain the same people as the selected ones. Such a frame would, for example, allow a user to select images of a child and then have the frame update automatically as new images of the child are captured. This feature could be used to periodically update static display locations with newer content, if desired, or automatically update dynamic display locations more frequently. This in turn could reduce the effort needed to update photo displays for display managers, yet it could also take away from the expressiveness that people enjoy [25].

5.2 Related Designs

Our designs combine ideas presented in existing systems with additional concepts that build on them in important ways. First, multipurpose display-capture devices are certainly not new. Digital cameras and most mobile phones provide this and Conversy et al.'s VideoProbe [8] combines these features within a digital frame. The idea of combining multiple frames within a single device is described by Swan and Taylor [25].

Second, the idea of moving media between displays has also been explored in several related ways. Elliot et al.'s StickySpots [10] lets users move messages to various displays spread throughout a home, although their focus is not on photos. Cherish [16] allows users to send photos to frames in other people's homes, but only if they are in front of their frame. This constraint forces remote sharing to be a synchronous act. SPARCS [5] allows families to send photos to a single frame next to a family calendar. ZoneTag [1] allows users to send photos from their capture device to a web page, and Frame Channel [11] allows users to set up frames to pull and display new content from online photo sharing sites. However, both assume an online site is part of a family's ecosystem, and as our interview findings showed, this is certainly not always the case. Our user interaction for moving media between devices is similar to the methods found in [3] and [28]; yet, we explore the concepts in a different context than they did. We are unaware of any systems that learn what content is desired to be displayed in particular locations.

Lastly, Swan and Taylor [25] articulate that remotely controlled frames and programmed cycling of photos is counterintuitive to the ways people currently use frames within their homes, and indeed our interview findings have shown this as well. We do not intend our design ideas to contradict this notion. Instead, our goal is to provide families with an ecosystem that lets them move photos to locations in a way that matches their routines.

Figure 2. Design Concepts as Interactive Sketches.

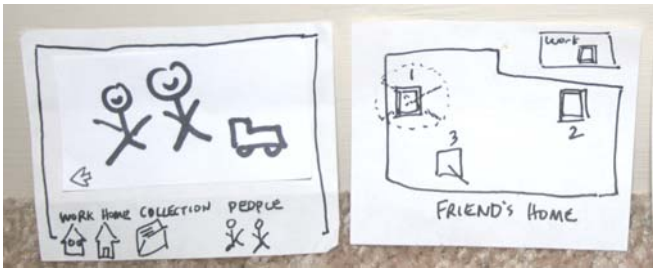

Figure 3. Viewing and sharing digital photos.

5.3 Design Reactions and Suggestions

Our design concepts were received favorably by participants. The fact that each incorporated multiple functions was highly valued, especially the ability to easily display content and share it from any device. The ability to capture photos from all devices was not necessarily needed however; people favored the mobile device for capture. We were also able to gauge reactions to the abstract features that were aimed at improving ecosystem flow.

5.3.1 Ubiquitous Collections

All participants liked the idea of a universal collection that could store all of their photos and be accessed anywhere/anytime by all devices, however, several issues arose. First, there was some concern over having photos automatically move into such a collection directly from a capture device. This was because anything in this collection could be viewable by any family member. In essence, this took control away from family members

and, in particular, the photo organizer. The concern was that some photos may not be "ready" to be seen by others (e.g., poor quality); they could be "bad" pictures (e.g., bad pose or expression); or, they may be more private in nature and intended for a personal collection as opposed to the family collection. Instead of automating this aspect, people wanted to selectively move content in these situations (this replicates their existing situation). This suggests that if automating the flow of photos to a collection is to be undertaken, *privacy models will need to be used to match family needs.* For example, media from one family member could be set to move into a collection automatically but, by default, flagged as private and only accessible by that one person. This would remove segmentation issues but leave the visibility of such content in the hands of the capturer. Such a model could also be device-based and utilize knowledge of whether or not devices are shared devices vs. personal ones.

Second, we found that for all but one participant there was a mismatch between participants' conceptual model of how photos were stored and the actual storage model that was described to participants—one's entire photo collection available anytime on any device. Throughout the tasks the correct conceptual model easily vanished and was replaced with a model of device-centric collections where each device would contain files that would need to be transferred between devices. This model matches the way devices currently work and it is not surprising then that participants had a hard time changing the way they thought about device storage. This suggests careful design to *ensure the correct conceptual model is presented to users* so that they may easily learn and understand the new storage paradigm.

Third, we found that anytime access to one's *entire* collection may not always be needed. Participants commented that when they share photos they are often from recent events or recent images of family members. Here selective batches of photos would be all that was needed in case serendipitous sharing activities arose. In other situations, a larger portion of the collection may be needed. This suggests that *access to a family's collection may need to be context-aware based on the device, its intended use, and its location* where different portions of the collection are made available based on these factors.

5.3.2 Ubiquitous Sharing

Most participants (10 of 12) liked the idea of being able to share photos by sending them from any of their devices to those of family friends. This was most often described in the context of sending to digital frames in the homes of family/friends. This was seen as a more natural way of sharing because it placed the photos in more visible locations than was currently possible. Typically participants wanted to selectively choose what to send to others rather than rely on an automated process. This does not deviate from their current practice however, and, as a result, could certainly be tedious. An alternative solution may be to *recommend photos and intended recipients to users such that they could then accept, reject, or alter the choices*.

We found participants also had a concern relating to the handling of incoming photos. Most participants wanted incoming photos to appear in some sort of holding facility as opposed to being displayed automatically on a frame. This would leave control in the hands of the display manager or other family members. Again, this does not particularly reduce the burden of managing incoming photos. Yet the fact that participants are willing to receive photos within frames as opposed to at a computer is beneficial for it means that selection acts for displaying photos can be done in the actual viewing location (e.g., where the frame is), rather than going to a different location (e.g., the computer room). It is likely though that frames would need to *display visual cues that subtly notify users that incoming photos are available for display*, or else they could go easily unnoticed if not displayed automatically. Naturally, there were some participants who were fine with incoming photos automatically being shown on frames. They suggested a slideshow of incoming photos be played with the ability to selectively hold/pause media on a frame, thereby turning a dynamic display into a static one.

We also found an issue relating to both the ubiquitous collection and sharing. Participants did not want incoming photos being placed with the rest of their own photos in their family collection. They suggested *tagging photos as incoming or placing them in a separate location within the collection.* In many cases, as our interviews found, families do not keep received photos, and this type of separation would allow family members to easily remove photos that they did not want to keep.

5.3.3 Auto-Updating Display Content

The concept of having frames learn what to display and update automatically was confusing, both in concept and in the user interface. Seven people said they would use such a feature and five would not. People were skeptical that a device could decipher what images to show automatically and this caused distrust. People typically wanted control over content that changed or for content to stay permanently. This reflects their use of static display locations and also the role of the display manager. While this concept had mixed reviews, it suggests that if such features are used in frames, the frames should *recommend content for user selection rather than automatically change it.*

6 DISCUSSION AND CONCLUSIONS

Our interviews and analysis of the related work highlight several challenges related to flow in digital photo ecosystems. These include: a lack of shared knowledge amongst family members; segmented photo collections that reside on many different devices or media; cumbersome user interaction resulting from the need to use intermediary devices when moving photos; and the reliance on explicit user actions that can be time consuming or recurring. These challenges suggest design directions to improve shared knowledge, remove the need for intermediary devices, provide a central and always available storage collection, and automate certain photo management activities. With all of these design directions, it is crucial that care be taken to *provide users with feelings of control while not overburdening them with tasks.*

Designs aimed at removing intermediary devices by providing direct device-to-device sharing showed great success in our study. In fact, this is how users envisioned their ideal interactions. We also found multipurpose devices that combined capture, display, and sharing within the same device to improve flow even further by simply removing devices altogether. This consequently removes the need to move media to a new device before acting on it. Yet the caveat is that incorporating additional functionality in devices has the potential to increase the complexity of the user interface. Thus, devices must balance the amount of functionality with the simplicity of the interface.

People also highly valued moving media directly to devices in other people's photo ecosystems. This moves distributed sharing into a more natural context (e.g., viewing on frames rather than computers). Here users often want to *select content for sharing and be in control of its display when media is received*. People are fine with family/close friends directing media to specific locations in their home, but the actual display of such media should lie in the hands of the recipient. It should also be possible to *easily move media from the received location to other locations, as well as remove it.* This reflects people's current routine of often deleting received photos after viewing. These ideas build on Miller and Edwards' suggestion of providing targeted sharing applications that do not require users to switch modes to view photos [20].

Automation for updating the content of displays received mixed reviews likely because of the careful control that current display managers have over this activity. It is likely that *locations which are typically static would not be ideal locations for automated display*, however, *locations that contain dynamic content are more likely candidates*. In both cases, content recommendation could be used to improve user selection.

A ubiquitous collection that automatically maintains a shared collection of all photos and makes them accessible anytime or anywhere is able to: increase the shared knowledge of photos amongst family members; make photos more accessible to all family members; reduce segmentation problems; and, alleviate the need for explicit user actions for placing photos in a family's collection. However, we learned that there are specific nuances that should be designed for if considering such a collection. We suggest that *devices let users set up automatic placement of media in a ubiquitous collection with settings that reflect a family's pattern of use*. This should specify which content should be flagged as private when it enters the collection or which devices automatically move content to the collection. Families may also not require access to their entire collection all of the time. Here it is important to *understand the intended use of a device and correspondingly provide access to relevant photos based on this*.

By reflecting on our results, we also realize that family members develop knowledge of what photos are available in their collection through the explicit acts of moving them around. However, methods that automate flow could easily take away from this knowledge. For example, photo managers may not know what media is available for display or sharing if they no longer have to transfer it to a storage collection. To circumvent this, *designs should provide mechanisms for family members to easily see and understand automated processes.* This may mean being able to see what content is new or has changed, or to see a history of actions that have occurred. Ubiquitous access to family collections could also create tension between family members if people other than those with photo-roles begin to perform operations. These concerns should be mitigated in any design.

Our methodology is certainly not without its limitations. Because the designs are sketches of concepts, they are not fully interactive and unable to be tested as a part of real family routines. This makes participants speculate about their intended use. We tried to mitigate this by having them perform realistic tasks with the devices. This helps, but certainly does not provide us with the same level of knowledge that a full deployment would have. For example, we were unable to explore relationship dynamics between family members through extended use of the designs. Even still, for a low-cost approach, we were already able to draw out important implications that should be addressed in future photo ecosystem devices as part of their design and development. This has the potential to reduce misdirected efforts. Certainly through a full design, develop, and evaluation cycle even more design lessons would emerge. Our work is a first step at fully understanding the nuances of ecosystem flow and the ways in which we can improve it.

There are also likely many other solutions to improving flow which we have not considered or presented in our design concepts. This should be expected, for there are likely an endless number of design ideas for improved flow. In this respect, our work should act as a foundation for exploring additional methods to improve flow in digital photo ecosystems where the lessons we articulate act as a basis for understanding and critiquing ideas. There are also many technical hurdles that must be overcome for the solutions we present to be practicable (e.g., connectivity, interoperability). We do not articulate ways to overcome these, yet our work points to the importance of solving such problems.

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