LINC in the Home:
Field Trials of a Digital Family Calendar

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ABSTRACT

Digital family calendars have the potential to help families coordinate, yet they must be designed to easily fit within existing routines or will simply not be used. To understand the critical factors affecting digital family calendar design, we extended LINC, an inkable family calendar, and conducted a four-week field study of its adoption and use. We found that a digital family calendar must be designed to provide at-a-glance awareness from a highly visible location within the home; provide flexibility in location selection; and, be accessible from outside locations (e.g., work) so that people can view and update it as needed.

Categories and Subject Descriptors

H.5.3 [**Group and Organization Interfaces**]: Computer supported cooperative work

General Terms

Design, Experimentation, Human Factors, Verification.

Keywords

Family, calendars, home, coordination, awareness

1. INTRODUCTION

Coordinating and maintaining awareness of family activities often requires a complex organization system involving planning events, rescheduling them, coordinating activities, and much more [1,9,15,16]. Family coordination routines also extend beyond the home to include scheduling and coordinating events while mobile or at work [1]. At the heart of many families' coordination systems is a paper calendar that families use to record and stay aware of each others' activities. Paper calendars are easy to use, mobile, and personalizable [2], yet they are not easily available from the many locations that family members frequent as they go about their everyday activities. Some families use multiple calendars to overcome this problem, yet this brings additional challenges of synchronization [2].

Technology offers promise for family calendaring. Via networking, digital calendars can make calendaring information ubiquitous and simultaneously accessible from a variety of locations. This lets families more easily view, coordinate and update their activities and events. The challenge is that we cannot simply migrate digital calendars from the workplace into the home [4]. Workplace calendars are focused on an *individual's* appointments where meeting requests can *assign attendees* to an event, but this is not how family coordination is handled. Instead, family calendars need to be much more focused on activities that affect the *entire family;* the calendar provides family members with an *awareness* of these events which in turn leads to coordination [8]. Families also need a digital calendar that is as simple to use as the paper calendar that many are already accustomed to using.

Research efforts have already looked at designing digital calendars to specifically address these family needs. Neustaedter and Brush [8] designed an inkable family calendar called LINC that could act as a first adoption point for digital calendars in the home. Plaisant et al's [13] Family Calendar addresses the needs of families to share calendar information between multiple families (namely grandparents and their children's families). Commercial family calendars for the web are also cropping up at an increasing rate (e.g., OurFamilyWizard, and Trumba) all marketed at being *the* solution for family organization by providing a shared family calendar that is accessible anywhere with an Internet connection.

Despite the increasing proliferation of digital family calendaring solutions, we do not know of any studies of the actual use and adoption of digital calendars for *intra*-family coordination. Consequently, our research concerns two major efforts. First, we extended the inkable family calendar, LINC, to make it 'real' and deployable to everyday families (Section 2). Through these extensions, people can access LINC from multiple locations, including multiple LINC clients, a web page, and a mobile phone, where all clients synchronize events using a server. Second, we moved LINC out of the research lab and into the homes of everyday families. We performed a four week field study of its adoption and use in the daily lives of four families (Sections 3 and 4), concentrating on uncovering critical incidences in LINC's usage and the implications they bring to the design of family coordination technology (Sections 5 and 6).
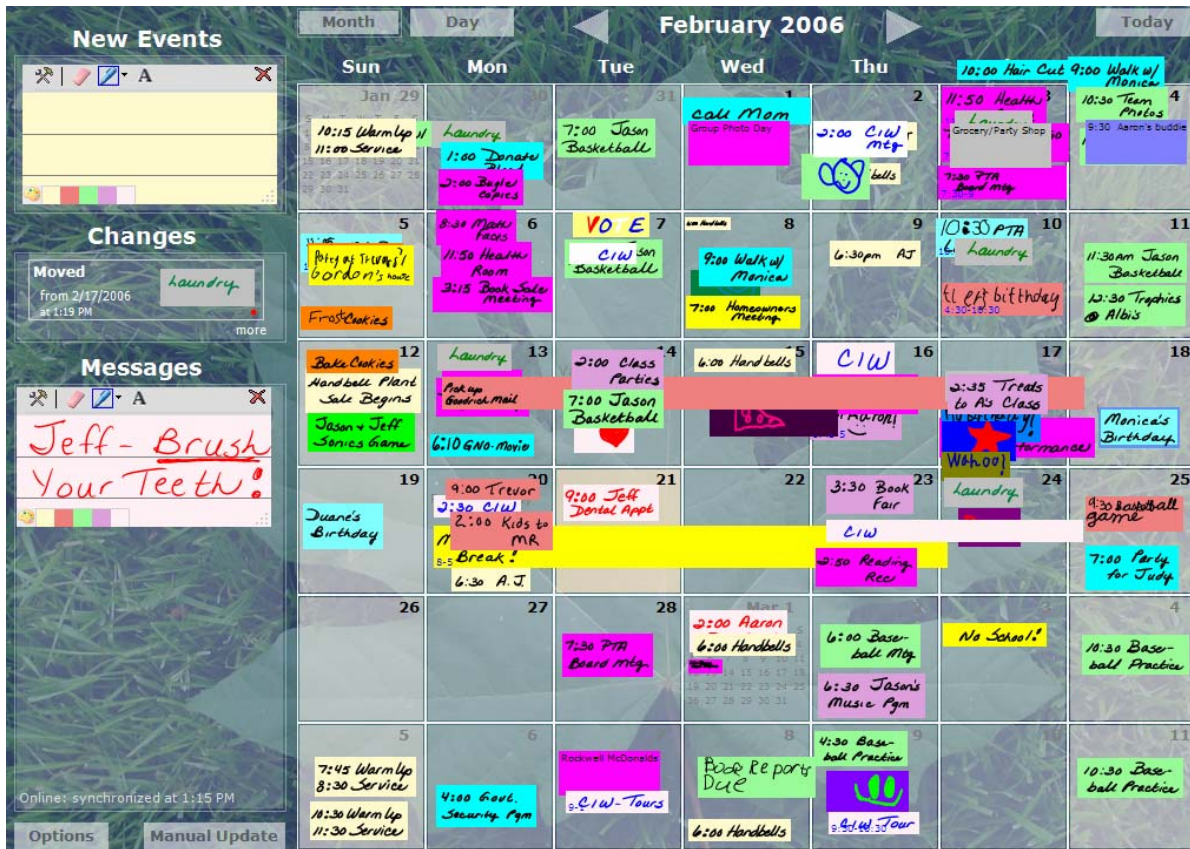
Figure 1. The "Isaacs" Family Calendar in Month View

2. LINC: A DIGITAL FAMILY CALENDAR

LINC is an inkable digital family calendar designed to be a simple awareness appliance that would provide the benefits of a digital calendar, yet still be as simple to use as a paper calendar [8]. The original version of LINC was a standalone client running on a Tablet PC designed for laboratory studies. Consequently, we extended LINC into a form that we believed was deployable to everyday families: we improved the usability of the existing interface, and we extended its design so that people could access the calendar from a variety of locations. We first describe LINC's usage then outline how LINC now provides ubiquitous access.

2.1 Scheduling and Coordination with LINC

We describe LINC's design metaphor by walking through a typical usage scenario. Figure 1 shows the February events of the "Isaacs" family from our field study; "Kayla," the mother, is its primary scheduler.

Adding and viewing events. To add an event to the calendar, Kayla hand-writes on an empty sticky note under 'New Events' with the Tablet PC stylus (Figure 1, top left). Kayla can change the color of the note by tapping on the color options at the bottom of the note, or she can change the ink color with the toolbar at the top of the note. Kayla then drags the note on to the calendar where it shrinks to fit. Kayla can resize notes by dragging the bottom right corner of any note. This technique also allows her to create events that span multiple days like the yellow partly-covered 'Mid-Winter Break' that spans Feb. 20 to 24th. Kayla can also type events if she prefers, and these will appear as typed text. An

example is the 'Grocery / Party Shop' on February 3rd. Kayla decides she wants to see more details for a day, so she taps the 'Day' button at the top of the screen (Figure 1, top). The Day View appears which shows the selected day plus the two subsequent days. In either view, Kayla can double tap any note to raise an Options dialog, where she can set explicit times for an event. However, she rarely does this. Instead, she often just writes times directly on the note (as shown in the many examples in Figure 1). The Options dialog also lets Kayla create reminders that will appear at the appropriate time in the 'Messages' region (Figure 1, left) or create copies of notes when events recur.

Change awareness. Other family members also use the calendar. For example, her sons have added pictures and put on information about a basketball game (Figure 1 on Feb. 25th). To see what changes have been made to the calendar recently, Kayla can look at the last change under 'Changes' (Figure 1, left), or the last 100 changes by clicking 'more.' Along with each change, Kayla sees a textual description of the type of change and a small image of the prior version of the note. When Kayla clicks on a change, the event is highlighted on the calendar with a blue border like 'Monica's Birthday' on Feb. 18th.

Personalization. Kayla can personalize the calendar through several means. She can decorate the calendar's background with a photo; in Figure 1, we see she has used a nature photo. As well, Kayla and the family can decide how they want to use note color and pen color; this will be discussed later. Finally, the handwriting itself lets each calendar user freely format notes in a way that fits their personal style.

Figure 2. LINC Mobile and LINC Web

2.2 Ubiquitous Calendar Access

When family members are mobile or at other locations (e.g., work), they cannot check or update the calendar [1,4,8]. Thus, one of the obvious benefits of a digital calendar is to makes its information accessible anywhere. To realize this ubiquity, we extended LINC to synchronize across multiple family calendar clients running on different computers. We also created two new versions, LINC Mobile and LINC Web, that let family members access the calendar on a mobile device, and from a desktop PC.

Multiple LINC clients. Unlike the original version [8], our modified LINC can be installed on multiple computers; calendar events are synchronized through a remote server. While LINC normally runs in offline mode, it attempts to synchronize with the server (and thus other LINC clients) at a designated time interval (default is 20 minutes). We use a simple scheme to synchronize event changes, where the most recent change is always used. This synchronization feature lets multiple LINC clients run autonomously from any location (provided that an Internet connection is available during synchronization). We anticipate this will enable LINC to run from *multiple locations within the home as well as at work*, making awareness information and event reminders ubiquitous to any PC running LINC.

Desktop computers. LINC is originally designed for an information appliance, where the device is not running other applications. Our new version relaxes this, as we anticipate that LINC may also be installed on a normal computer. Because calendar visibility is important, we created a LINC screensaver that displays the family's calendar at approximately one-third the size, transforming it into a 'nearly' always visible calendar even if it competes with other applications.

LINC Mobile and LINC Web. Mobility is an important factor in calendar use. The Tablet PC offers some mobility within the home, but is less than perfect outside of it due to wireless network range, form factor issues, and device availability.

Obviously, a phone interface to LINC would greatly encourage its use while family members are on the move. *LINC Mobile runs on a Smart Phone and displays images of the family calendar* (Figure 2, left); it acts as a client to the LINC server. After initially entering the family name and password using the Smart Phone's keypad, any month the user requests is provided by the server. Users can then pan and zoom to look at the events.

Family members may also be in places where they are unable to install the LINC client (e.g., a work location with restricted computer access). In these situations, web access to the calendar would be beneficial. Similar to the way LINC Mobile works, *LINC Web runs in any web browser and also displays images of the family calendar* (Figure 2 right, shown at reduced scale).

LINC Mobile and Web are our first steps at providing family calendar access from *any computer or mobile location* where the standard LINC client is unavailable. An obvious limitation is that people cannot add or update calendar events from the web or Smart Phone, and this will be added in future versions. In spite of this weakness, these clients give us real world "design probes" [7] so we can better understand how often family members make use of LINC Web and LINC Mobile, and whether they address family coordination and scheduling needs.

3. FIELD STUDY METHOD

In the remainder of this paper, we describe how families have used this new version of LINC.

Overview. We deployed LINC to four households over a period of four weeks; two families were from Seattle, U.S.A, and two were from Calgary, Canada. We describe each family in detail in Section 4. Our goal for the field study was to draw out the critical design lessons for digital family calendar adoption and use. This meant understanding: families' existing coordination routines; how and why these routines changed, if at all, during LINC's usage; and, what aspects of the routines LINC handled well and what aspects LINC did not handle well.

Why a field study? Studying the real-world usage of digital family calendars is critical to our understanding of how to design family coordination systems that meet families' needs. We believe that a field trial methodology provides the necessary longitudinal use of such a calendar, where families use their *own* calendar information within their *own* domestic routine. This *real usage* allows us to understand the *actual* real world challenges of adopting and using a technology on an everyday basis. While lab studies offer complimentary findings, they cannot draw out this kind of contextual information. Of course, there are tradeoffs. Lab studies can economically evaluate a large number of participants to draw out significant findings. In contrast, field trials often involve in-depth study of a small number of participants, where a vast amount of data is collected about longitudinal and ongoing usage of the technology. We opted for the later approach. For field studies, our number of participant families is actually larger than the norm, e.g., [13,14,17] each used two households. This was intentional, as we wanted to see how the digital calendar worked for families with different coordination routines.

Initial Interviews and Survey. We began with initial contextual interviews involving each participant family, each lasting about an hour. A researcher went to each family's home and interviewed them about their current coordination routine. Children were interviewed only if it seemed appropriate, and this was decided after discussing the family's calendar routines with the parents. To ground the questions, the interviewer asked participants to describe and show us what artifacts (e.g., calendars, day-timers, notices) were used for coordinating family activities.

Initial Deployment. At the conclusion of the interviews, we spent up to an additional hour with each family introducing them to LINC and setting it up in their home. Families were each given a Motion Computing Tablet PC that ran LINC for the duration of the study. Setup also involved family members picking a location

Table 1. Summary of participant families *before* the field study.

	Composition	Coordination Routine	Primary Calendar	Existing Successes	Existing Challenges
Leonard (Seattle)	Homemaker and Manager; Children: 10 & 13	Mom is primary scheduler and reminds others	AOL Online Calendar; Mom has access from any computer	Mom 'owns' the calendar	Getting others to check the calendar because it is digital
Isaacs (Seattle)	Tour guide and Tech support; Children: 7 & 10	Mom is primary scheduler and reminds others	School district paper calendar and notebook stay with Mom	One person in charge; One location with all events	Getting others to check the calendar; Synchronizing calendar and notebook
Newman (Calgary)	Accountant and Firefighter; Children: 15 & 17	Dad is primary scheduler; All check the calendar	Paper calendar in kitchen on door by exit to garage	Publicly viewable calendar location for all family members	Scheduling remotely
Chambers (Calgary)	Two computer teachers; Children: 3 & 3 months	Mom is primary scheduler and reminds others; Dad also checks	Large paper calendar on fridge near phone	One person in charge; Publicly viewable calendar location for all family members	Synchronizing calendars; Scheduling remotely;

to place LINC and the researcher going through a short hands-on tutorial of how LINC works. Participants were also given instructions and a CD with LINC so they could install it at work (if desired).We also pointed them to the web page for LINC Web.

The Four Week Study Period. Each family then used LINC as their primary family calendar for four weeks. Smart Phones with LINC Mobile were given to the two Seattle families for the last two weeks of the study to see how the addition of mobile calendar access would affect the family's routine. (Due to the pragmatics of international mobile phone plans, the Calgary families were not given Smart Phones). We gave each family a journal for which they were asked to report any findings and thoughts that came up throughout the week. To remind family members to create entries, the journal was initially placed next to the Tablet PC LINC location. At the end of each week, a researcher visited the family's home to discuss how they used LINC over the week. To ground discussions, we used descriptions from the family's journal and events recorded in LINC as conversation pieces. During deployment, we fixed minor interface bugs that appeared, but did not perform any major changes. The field study concluded with an exit interview with each family, which lasted about an hour.

4. THE STUDY FAMILIES

We now describe our four study families and their existing coordination routines. Table 1 provides a summary. While our families are fairly similar in composition, they differ in a crucial way: each family has a different coordination routine.

The "Leonard" Family (Seattle) already adopted AOL's digital online calendar as their primary family calendar. Mom routinely accesses it from the computer at the top of the stairs, but loves being able to check it from different computers, even when out of the house. She will sometimes print it out to take with her. While the family routine works well because mom 'owns' the family calendar, login and access issues of this digital calendar has made it challenging for other family members to check it. Consequently, they rely on Mom to remind them of activities.

The "Isaacs" Family (Seattle) uses a paper calendar as the main family calendar. Their calendar doesn't have a 'typical' location in the house as it generally stays with Mom; she takes it out of the house and to work with her, especially if she knows in advance that she will need to schedule something. This makes it challenging for others in the family to check the calendar. Mom also uses a notebook to track tasks; thus, she faces the additional challenge of keeping the calendar and notebook synchronized.

The "Newman" Family (Calgary) is unique in that unlike most families [1,8], the Dad is the primary scheduler. This is because his alternating day/night work schedule means he is at home the most. The family claims that the best thing about their coordination routine is that the calendar is accessible to everyone when they are at home. Yet adding events to the calendar while not at home is challenging, and often involves leaving messages on the answering machine. Like most families, the family calendar is very important to the Newmans. In fact, during our first visit when we introduced LINC, Dad told us *"[The calendar] is our life line, [LINC] better work."*

The "Chambers" Family (Calgary) has the youngest family, with two preschool-aged children. After having children, the Chambers found a need to have a calendar located in a place that both parents could see, in this case on the fridge door. Mom is the primary scheduler. She maintains the family fridge calendar, as well as a paper notebook calendar, and milestone calendars for the kids. The Chambers like having multiple calendars each with its own purpose and type of events. Yet this leads to synchronization challenges. They find the best thing about their current routine is that Mom is in control of it. The Chambers also find it difficult to record events when not at home.

Despite the diversity in routines, all families share a common trait: each family is relatively technically-savvy. This helps us control for computer issues that may arise independent from LINC, e.g., home network issues. Past experiences by other researchers deploying home technologies (see [13]) illustrates that a technology can fail during deployment for many reasons, some of which are not necessarily the fault of the technology under investigation. Of course, we do want to uncover problems with LINC that stem from a lack of technology experience, yet we do not want problems with computers in general to confound our findings. For this reason, we controlled for technical expertise.

5. CRITICAL DESIGN LESSONS

Our four study families all adopted LINC during the course of the field trials, though each in their own way. The Leonard and Isaacs families saw increased family involvement in their coordination routine as a result of LINC being easy to view by the entire family. The Chambers and Newman families were able to adapt LINC into their routine with only small changes, and again saw increased family involvement in the coordination routine.

However, this time it was because the calendar was a technology, which made calendar usage more exciting for the Newman children and Chambers Dad.

We now look at our findings in detail to understand the critical design elements that helped the families adopt LINC and also those which hindered its use and adoption. We phrase our findings within the context of critical lessons that suggest how digital family calendars should be designed. While each lesson is presented separately, many of them are highly related and should certainly be thought of as tightly coupled recommendations.

5.1 Flexible and Public Primary Location

We found that having a *highly visible public location within the home* played a crucial role in the adoption and use of LINC. Challenges families faced around the locating of LINC suggests considerations arising from the Tablet PC form factor, and that the ability to move the tablet around the house was highly valued.

5.1.1 Socially-Evolving Calendar Locations

We allowed each family to choose the desired initial location for the Tablet PC running LINC. However, we found that locating the family calendar is a socially evolving process that occurs over time where *families require flexibility in the design to permit location selection.* The most prominent example of this comes from the Leonard family's placement of the calendar. At the onset of the study, the Leonard family faced challenges in choosing a location for LINC. At our first weekly visit we found LINC sitting on their kitchen table, off, and facing the wall. We suspect that their lack of location choice and having the computer turned off simply reflected their existing calendar routine, i.e., they were accustomed to Mom managing the current AOL calendar from her own computer. This family had no *a priori* notion of a 'public' location for their calendar.

After the initial week, LINC moved throughout the home with the Leonard Mom. She used it while watching TV in the living room, in the bedroom when sick one day, and even outside of the home at several evening meetings. Yet by the end of the study, the Leonard Mom proudly showed us how she had decided to place LINC on the kitchen counter next to the stove shown in Figure 3, left, *"It landed up in the kitchen which is where I think it should have always been."*

The flexible form factor of the tablet allowed the Leonard Mom to experiment with many different locations before settling on one that fit her life while maintaining the family benefit of public visibility. In contrast, the Isaacs—the other family where their existing calendar did not have a set location—chose to place LINC on a bookcase next to the kitchen table at the onset of the study. LINC remained there, as they found the public location one of the main benefits of LINC.

The Newmans and Chambers already had highly visible locations for their paper calendar that *had evolved through the calendar's use over time*. For them, it was critical that LINC be placed in locations that allowed them to maintain their existing routines. However, LINC's form factor did pose some pragmatic challenges for these two families. The Newman family had their paper calendar hung from the pantry door, so they could easily see it as they exited the house. For obvious reasons, they could not hang the LINC calendar there. Instead, the Newmans placed LINC on a kitchen counter next to a desk that contained one of the family's

Figure 3. LINC in the Leonard and Newman families' kitchens.

desktop PCs (Figure 3, right); this location was across the room from the pantry door. Despite a less than ideal location, the Newman Dad reported being able to adapt his routine during the first week of the study, so he would walk by LINC on the counter during his exit out of the house. At the end of the study, Newman Dad made some final thoughts on LINC's location:

"At least for me, I can't think of a better place. It's next to the computer, if you're looking at some emails and you go, 'oh yah, I need to add that' then it's right there, you can add it on...we couldn't have had a better location for us. It's very visible."

In this family, the process of checking the calendar evolved to deal with the new location, perhaps because the additional advantage of being close to the other computer was discovered.

The Chambers family was similar to the Newmans as they too were unable to place LINC in their most preferred location: on the fridge where their paper calendar was located. Instead, the Chambers placed LINC on a counter in the corner of the kitchen, a good ten feet from the fridge and adjacent phone. Unlike the Newmans, this new location proved awkward (although they still changed their routine to use it). As Chambers Mom says, location is critical for convenience and easy calendar access:

"It's obviously not a good location. For me, I'd like to have a little bit more options of where I can put it. Here because we are doing [the study] I make a conscious effort to go over and use it, but it's not my first initial place to look because I'm used to looking at the fridge...[the fridge] is just like second nature."

In one situation, Chambers Mom reverted back to using her paper calendar when on the phone simply because the calendar on the fridge was in a more convenient location. She also commented on how location depends on each person's individual routine, *"I tell my students to use a calendar to keep themselves organized and I say put it somewhere you look everyday like your light switch, your fridge, because it's something you look at everyday."*

In spite of these location compromises, LINC's location and its public nature enabled all family members to view the family calendar. This helped increase family involvement in adding activities to the calendar and staying aware of the schedule. This was particularly true in the two families, Leonard and Isaacs, where the previous calendar did not have a set location.

For the Isaacs, having the family calendar in a publicly viewable location was one of the main benefits of LINC. Isaacs Dad pointed out that the digital version is basically an electronic "replica" of the calendar that mom used so it was very easy for LINC to integrate into their existing scheduling routine. Isaacs Mom felt that family involvement with the calendar increased as a result of having LINC in a central location. She found the kids were adding things to the calendar by drawing pictures (though not all were distinguishable by Mom) and would even routinely ask her to make sure that a certain activity was on the calendar.

The Leonard family also saw a shift in the family's behavior. Family members would now check the calendar, or Mom would tell them to go and look at it instead of her, because it was now in a public location for them to view: "*Its kind of fun though referring my family to [LINC] instead of asking me to know everything…and really that's quite a feature in itself. Before [LINC], calling me was the answer.*"

Leonard Dad enjoyed the fact that LINC was more publicly visible, as it allowed him to get an idea of what family activities were occurring:

"*It makes me more interested in paying attention to the home calendar…I never really accessed the AOL calendar much. [LINC] was something I could access easily without spending a whole bunch of time looking for it…it was very much more visible… The fact that it was easily accessible and I could look at it on Sunday night or Monday morning and look at what's going on and be prepared for it…made it a little bit easier for me.*"

In summary, each family had an established calendaring routine. They needed flexibility to choose the LINC family calendar location that matched their needs and existing routine.

Lesson: *a digital family calendar should be designed for devices that can be placed in many different locations so that families can experiment, evolve, and choose a location that fits with their calendaring routine.*

5.1.2 Mobility around the House Valued
While it is certainly advantageous for families to be able to place a digital family calendar in a single public location, we saw that family members also wanted to move the calendar around the home as they went about their everyday activities.

The importance of mobility is brought to life by Chambers Mom's initial distaste for the tablet eventually evolving into use of LINC throughout the home. At the end of the first week, Chambers Mom strongly desired the ability to use the LINC client on a regular desktop PC with keyboard *vs.* a tablet. She commented, "*I don't really like the stylus because I don't have very good handwriting.*" Despite this, by the end of the study, her opinion (also the Chamber's Dad opinion) of LINC had completely changed: she found it crucial to have LINC portable throughout the home.

"*Honestly if I didn't have the tablet I know I wouldn't use it because it'd be on my computer in the other room and why would I go in there. For me this is how I'd use it, it doesn't make any sense to use it any other way then to have the tablet. I'm not going to go in [to the other room] to check it because I have kids in here. I'm not going to go and type it in because my phone is in here, I'm not going to drag my phone around and type it in, that's why I keep my [paper calendar] in here. Mobility is very important, that's why I like the wireless and the tablet…let's say the boys are playing in the other room, I can take it in to that room and do the things I need to do sitting beside my kids.*"

On a smaller scale, mobility also enabled families to more easily plan and add things to the family calendar. The Newmans and Chambers preferred to add items to the calendar on a flat surface, where they would routinely unplug LINC and move it to the surface of the kitchen island. The Isaacs and Leonard Mom acted similarly, often moving LINC to a table to schedule events.

A downside to mobility is power management issues. All families found the battery life on the Tablet to be less than ideal. Each faced a situation where they had unplugged LINC, brought it to another location in the home, and had forgotten to plug it back in when finished. On the flip side, the power requirements were an incentive to return LINC back to the 'standard' location allowing other people to easily find it.

Lesson: *a digital family calendar should be designed to be mobile within the home, while balancing the need for a publicly displayed calendar.*

5.2 Family Calendar Ubiquity
We have found that in addition to having a highly visible location for the family calendar in the home, *ubiquity of the family calendar, particularly within the home, is vital* to digital family calendar adoption and use. We initially thought that access to the calendar outside the home would be crucial for adoption, and thus our development efforts on LINC Web and LINC Mobile. We were surprised by the value families received from having access to the calendar *within* the home in multiple *fixed* locations.

5.2.1 Multiple Locations within the Home
In addition to physically moving the tablet around the home, another way to have the family calendar available throughout the house is to install LINC on multiple computers. For the Isaacs family, we installed LINC on the desktop computer upstairs, and on Dad's laptop which traveled between work and home. Isaacs Mom pointed out to us that people are not always in the same location within the home. She describes how it was beneficial to have LINC in multiple places:

"*Having [LINC] upstairs also was terrific because if things came in email I could modify them right away…I think if anything [multiple locations] helped enhance [our routine] because I am in different locations…I didn't have to scramble and go and find that paper calendar which may not always be in the place I thought.. So it's very convenient.*"

Despite the Isaacs Mom being the primary scheduler, Isaacs Dad felt his involvement in the family calendar increased because the family calendar was now accessible for him on his laptop in the locations he needed it "*[Mom] is the master scheduler, but it did pull me in a little more having it.*"

For the Leonards, LINC was installed on the den PC and another laptop. While Mom most often used the tablet to create events (because of the ink), she appreciated that LINC was available while she was on the laptop and looked at it there occasionally.

While multiple locations were very important for the two Seattle families, it is certainly not necessary for everyone. The Newmans had another computer in a home office where they could access LINC Web, but they never found the need to view the calendar from this location or install the full version of LINC; the publicly visible calendar in the kitchen was enough for them.

Lesson: *a digital family calendar should be designed to be easily accessible from multiple locations **inside** the home for those families who desire in-home ubiquity.*

5.2.2 Calendar Access outside the Home
All of the families really liked the concept of accessing the family calendar from outside the home. Both the Isaacs Dad and Newman Mom would check the calendar from work to stay more

aware of what activities were upcoming and what was being scheduled (both were not the primary family scheduler). Isaacs Dad found one of the best features of LINC to be its accessibility from work, *"I think what works well is that I can pull it up on my work computer. That was definitely a nice thing."* In response, Isaacs Mom said, *"It pulled you into being a part of it more."* Still, Newman Mom did find that it was difficult to remember that she *could* view her family calendar while work, *"It is very beneficial. I guess again it's like anything else…it's remembering it's available. Over time you'd remember."*

A crucial feature we had *not* yet developed into LINC Web was the ability to add events. Chambers Dad found the thing he wanted to do most while at work was add things he had thought of to the calendar. The lack of being able to add events on the web page hindered this process: *"I also had something I wanted to put on it but I didn't remember at home until 4 days later."*

Chambers Dad wanted to be able to view his family calendar on his iPaq, which he normally used to synchronize with his work Outlook calendar. Having the family calendar accessible at work feeds people's desire to easily integrate and synchronize events across the work and family calendar. The Chambers family wanted certain events from the family calendar viewable in Outlook (the work calendar), and vice versa, so when at home Mom could see what activities Dad was up to. However, they commented that only some events should migrate between the work and home calendars: of these they wanted to easily discriminate through visual cues between home and work events.

Lesson: *a digital family calendar should be accessible from a variety of ubiquitous devices and locations, and should support viewing and adding events to it, as well importing certain events from other calendars.*

5.2.3 Calendar Access while on the Move
The Seattle families had the opportunity to use LINC Mobile for the second half of the study, yet they didn't actually find it that beneficial. We think this is largely based on two reasons. First, the form factor of LINC Mobile was not ideal. The families found the display on the mobile phone to be quite small and as a result it was difficult to see what activities were happening. Isaacs Mom did not normally carry a mobile phone and suggested a larger form factor for LINC Mobile,

"I'm going to need something bigger [when outside the home]…I've seen those PDAs, but I'm not sure about the size. I'm used to carrying binders…but thinking about the grocery store I'm not sure I'd want to carry [a tablet]…if I have a PTA meeting I'd take it so [the tablet size] for me and my eyes, it's probably that weening from paper to something similar in size."

Isaacs Mom's comments begin to draw out the second reason we feel LINC Mobile was not as beneficial as anticipated: families typically have great foresight into when they will need to view or add to the calendar before they leave the home. While LINC Mobile was originally designed for remote calendar access from anywhere, there does not appear to be a constant need for this access. For example, Isaacs Mom stated she really didn't need LINC Mobile. She typically would remember what activities she had when out and about. She often had the foresight to know when an outing would require a scheduling activity, and would take the more convenient paper calendar instead of the Smart Phone. The Isaacs Mom was also willing to take a multi-purpose

device like the Tablet to certain activities, as the above quote shows. Leonard Mom faced a similar situation: when she knew she was going to be out and needed to view or add something to her calendar, she would use a printout instead.

In our discussions with the Newman family about how they would visualize their preferred mobile experience of LINC, Newman Dad suggested being able to phone the home calendar and leave a voice event. This was similar to how he currently leaves a message on the answering machine to remind himself to add something to the family calendar once at home. One could also imagine phoning your family calendar and asking when events occur or asking questions like 'am I free tomorrow afternoon?' The Chambers also thought that a mobile phone's display would be too small, and recommended a PDA version instead. Chambers Dad commented that having the calendar on a device that is always with him is not necessary, and he would prefer to leave the device behind if he didn't see a need for it on a particular outing.

Lesson: *mobile use of a digital family calendar is secondary, and is heavily influenced by the form factor of the mobile device, the convenience of using it, and the display size.*

5.3 Always-on and Staying Aware
So far, our findings reveal the importance of location. In this section, we reveal that calendars within a location—particularly the primary location—must be always on, always visible, and easily accessible. This availability allows families to quickly glance at the calendar and see what is happening.

5.3.1 Calendar Must be Always Available
Families don't want to 'boot up' the family calendar to add events to it or check it. As with paper calendars, they simply want to walk up and use it.

The strongest illustration of this arose as a consequence of a design flaw. In the Newman household, the master bedroom is positioned such that lights in the kitchen can be seen from the parents' bedroom. Because we designed LINC to be always-on, this produced a glow at night that could be easily seen by the parents as they tried to sleep. To remedy this, we used a built-in power feature that turns the display off after 15 minutes of non-use. Consequently, in order to see the calendar, the screen needed to be tapped; the screen turned on after a delay of several seconds. This interaction and wait overhead proved excessive for the Newman Dad. As a result, he would opt not to use LINC when leaving the house, and instead checked the paper calendar (which still had the family's events on it). That is, even minimal overhead to viewing the calendar had drastic consequences for its use.

In contrast, the Newman Mom felt that having LINC running on the Tablet PC as an always-on display was beneficial but not necessarily crucial. She suggested that *easily accessible* (i.e., some interaction and a short wait) instead of *always accessible* was enough for her to use a digital family calendar. Newman Mom comments that she sees LINC working as an application on a PC in ways similar to other easily accessible but not always visible applications, such as MSN Messenger (which is automatically invoked on system startup): *"…the kids right now have their MSN automatically on boot up it comes up and signs them in. I would do the exact same thing so [LINC] would be there all the time."*

Leonard Mom found that having LINC always running was critical for her use of it and she simply wouldn't use it if not available without 'booting the computer,'

"It was really helpful to be able to have access. That's been the issue with the way I do my calendar...I like the way this can just be on all the time. Sometimes you'll be running out the door and somebody will call and say hey will you be able to go to <pause>, and oh no, I don't want to run back upstairs and turn the computer back on."

Similarly, the Isaacs Dad commented, *"I wouldn't [boot up the computer] to just to add one appointment".*

An interesting development during the study was that the families reported trying out the Tablet PC for other activities like surfing the internet and checking email. Despite challenges with not having a keyboard for things like replying to emails and typing in URLs and a belief that they were not 'supposed' to be using the tablet for other things during the study, families found having the tablet was valuable for additional activities. They used the tablet particularly for quick things like checking a web page. This leads us to believe a delicate balance between a dedicated device for the family calendar and a full featured tablet computer might be most appropriate for digital family calendars. The device should primarily function as a calendar, but allow people to briefly access other programs like email or the web (which often relate to scheduling activities). After a certain amount of interactivity, the device could revert to the always available calendar display.

Lesson: *a digital family calendar should be designed to be always-on, or at least easily accessible via minimal interaction.*

5.3.2 At-a-Glance Awareness Needed

A primary reason why easy access to the calendar is so important is that *families want to be able to quickly glance at the calendar and see what is happening*. This at-a-glance quality lets families easily see activities, where this knowledge can then be used for coordination. In our study, we heard that families want to see and stay aware of what family activities are occurring for the current day *and* they also wanted to see the broader context of how these activities fit into the week or month.

We found that the views we presented for LINC were not necessarily the best at conveying at-a-glance information to family members. Using the month view, families could not easily see the family's daily activities: the notes were too small to read from even short distances. While the day view provided this detailed information, it did not provide the larger context of the week or month. Newman Dad comments,

"We never have it on a month because it's too tiny. For us we just have so much stuff going on in a day that month view is too small. It would be nice to see the whole week... The week often gives you just a general idea of where you're going. Often times we're looking for who has practice tomorrow. The month view is just too small."

For similar reasons, our screensaver showing the monthly calendar did not work in practice. Newman Dad suggested, *"If the screensaver defaulted to the current day that would be huge. We're looking for the current day. You could walk by and you wouldn't have to touch it."* Isaacs Dad also suggested the same thing saying that coordination is about 'Today' and not today plus a couple of days.

We received several suggestions on repurposing the screen real estate to accommodate the families' needs. Both the Newmans and Chambers suggested a combined Day and Month view, where 'Today' would be visible on the side of the calendar next to the month view. They felt this would provide the detailed information they needed for 'Today' along with longer term planning information from the month. Newman Dad said,

"If it had a month view and day view [combined]...I could see where very seldom we would ever change it. The new events, changes, and messages are something you could just drop down if you needed it."

In the future, we plan to experiment with several alternative ways of presenting calendar information that may better meet the needs we saw in the study. We were encouraged that despite the problems with the views presented in LINC, Leonard Mom still felt she could squeeze more events into LINC than her previous AOL calendar (which only shows at most 3 events per day).

Lesson: *a digital family calendar must present a broad picture of the family's activities over a month or week, yet still provide at-a-glance details of what events are occurring 'today'.*

5.3.3 Calendar Awareness is Reminder Enough

Another aspect of being aware of the family calendar is receiving reminders for events. Automated reminders were found to be one of the favorite features for workplace digital calendars [12,13]. Consequently, we added the ability to LINC for families to create reminders, so that people would be visually notified of important activities. Yet none of our four families found much use for automated event reminders, as these did not match the routines our families employed. Because the family calendar is habitually checked daily, family members already have a good sense of what activities are upcoming. Checking the calendar is a reminder enough. Newman Dad explains,

"Because we look at the calendar so many times a day that for me ... a reminder isn't a big deal. If it's in day mode, it's all on there. ...in a business application a reminder may be more worthwhile."

On a similar note, Chambers Mom says,

"We almost don't need reminders. If I were to use reminders it would be to remind [my husband], but then I would just phone him. I'd look at the calendar and 'say do you remember you have this today?'"

Newman Mom commented that leaving messages for individuals relies on them actually seeing the message:

"You'd have to make sure whoever the message was for checked. If I really want my kid to know something, I get a sticky note and stick it on the mirror in his bathroom because he's going to look for sure. [With LINC] I can't be sure he's going to look."

While these findings suggest automated reminders are not needed in a digital family calendar design, Chambers Mom did say that if their schedule was busier they may in fact need them.

Clearly this non-use of reminders emphasizes our previous lesson: it is crucial that family members are able to easily acquire an awareness of the day's activities when looking at the calendar.

Lesson: *a digital family calendar reminds primarily by calendar awareness. However, reminders may have a role if they can reach family members at locations away from their calendar but specific to their routines, e.g., by email or by mobile phone.*

5.3.4 Social Conventions for Change Awareness

LINC contains a change awareness panel that holds system-created annotations of calendar changes. This panel saw very limited use. This was somewhat surprising, for any family member—parent or children—could easily add or change calendar events without the other knowing. We believe explicit change awareness was not used because *changes are often simply noticed visually on the calendar, and as part of existing social conventions* surrounding family calendar use. That is, social mechanisms already in place for alerting family members of changes continued to work well.

Newman Dad commented that change awareness was a function of both the calendar contents and the ongoing talk around it,

"It would be no different than our paper calendar. I don't care if anyone has added or erased, but I look at it and if it has been scratched out then it obviously isn't happening. I can't honestly say that we would normal add something on the paper and not notice it. We'd usually go, hey, did you notice that. Sometimes we will talk about things before we add them."

Leonard Mom commented that she could easily tell who added events by looking at the handwriting. Chambers Dad felt it was important to be able to see changes that happened *during the day* while at work and that these changes should show up in the context of the day:

"We get so busy from day-to-day so if something changes I look at it in the first thing in the morning. If something changes during the day then we're lost anyhow. That would be helpful if it was online if something changed during the day. If I can go online and I would see changes there then I'd know... or if the events could flash or something."

We stress that change awareness also happens outside the calendar. As previously mentioned, interpersonal communication is often used to emphasize changes or to summarize changes for those who don't check the calendar.

While our overt representation of change awareness was largely unused, we still feel it could become a vital aspect of digital family calendars. As an alternative, we could visually highlight those particular calendar activities that have changed; thus there is lesser risk of people missing these changes as they scan the calendar. This may be particularly beneficial for event deletions and detail modifications. Unlike crossed out or erased events on paper, a digital calendar leaves no trace of the modified event.

Lesson: *to augment existing social conventions of staying aware of calendar updates, a digital family calendar should provide subtle visual cues to alert family members of changes.*

5.4 Calendar Personalization

Families are used to providing *rich visual annotations* on their calendars, which can aid coordination by easily showing others who events are for or what has changed on the calendar [8]. In the case of the LINC digital calendar, this means: a) supporting easy association of people or activities to color so they are visibly noticeable, and b) allowing drawing on events, which in turn allows families to be creative and make calendaring fun.

Colored notes were a huge success for family members, although all used color in different ways. Typically, color aided families in quickly knowing *who* had activities on a particular day or if *important* activities were upcoming. Isaacs Mom found that the color system helped events 'jump' out at her and made extensive use of color: pink was for school, her one son's sports were in green, doctor appointments were red, her own events were in light blue, laundry was grey (because she said it wasn't fun). The Newman family wrote "Luggage inspection" in white pen on a purple background because they said they *really* couldn't forget to do this. Chambers Mom said, *"I do like the idea of the colors. I can look at [LINC] and I know, all the green is [my husband's events].* Similarly, Chambers Dad said, *"I just come down in the morning, I look, if there's no colors on there I don't worry about the day. If there's a color on there I know."*

Family members did find the default set of colors not very distinct and would often choose the brightest colors available. Newman Dad comments on how everyone in the family has adopted the family color scheme,

"I think people got in the habit of using colors. Before I'd grab a couple of different colors to fill things in [on the paper calendar] but then you'd just use whatever color after that...I think we're actually getting more into colors now...[Son 1's] color is green. I see [Son 2] has some colors here...I find I only use [the default colors].... [Son 2] did this darker green color but it's not one of the default colors. If your colors in the [tray] were more distinct colors that would be better."

While colors were important, Leonard Mom also asked for additional ways to visually annotate the calendar,

"You know what would be really nice, if there was little symbols. That's something I've kinda enjoyed with the AOL one. I've got little stickers with the calendar they gave me...see look at the little birthday, it also helps you get into it...unfortunately they don't have many symbols, they could provide more."

She soon found she could simply draw on pictures and added a heart for Valentine's Day, *"I liked the colors...I liked how you could draw...it really does look a lot more fun."* Drawing on events was also a popular feature for the Isaac children and made them feel much more a part of the family calendar activities.

Lesson: *a digital family calendar must allow easy annotation of the calendar, similar to a paper calendar. This supports personalization, fun, and allows at-a-glance awareness of who has activities on a given day.*

6. DISCUSSION AND CONCLUSIONS

Our key contributions are the critical design lessons for digital family calendars that emerged from our real-world field evaluation of LINC as used by four families over four weeks. Our field trials have brought forward the fundamental role that both location and flexibility play in the adoption and everyday use of digital family calendars, as discussed below.

When it comes to digital family calendars, *location is a socially-evolved concept that transcends not only a single public location within the home, but also multiple and mobile home locations, and locations outside of the home.* This emphasizes the importance of location as found in other ethnographic studies of domestic environments [3,4,5]. Yet we saw that families all have differing location needs when it comes to a digital calendar. It is here where *flexibility must be at the forefront* if the design is to support the many different family routines [8,16]. Families must be able to adapt the technology to meet the location needs of their *own* routine, rather than fixed needs anticipated by the designer.

We have also built on past findings which show that the family calendar is an awareness tool: the acquisition of awareness information on the family calendar is the key to coordinating everyday family activities [8]. We now know that for this awareness to be easily acquired, a digital family calendar must be *easily accessible and provide at-a-glance awareness information*. While automated reminders are important for workplace awareness [12,13], *accessibility and easy awareness acquisition as a part of existing social convention and customs are crucial for family calendaring*. Flexibility again comes forward as we see a critical need for families to be able to customize and personalize this information to again match their distinct needs.

Of course, our findings are limited in that they are derived from the specific use and reactions of four families using a particular digital calendar. We recognize that not all families will be reflected in the routines that we have presented; there are obvious differences based on geographic region, culture, personal lifestyles, and family idiosyncrasies. However, what is fundamental is that there *are* well-defined needs that are generalizable to the broader Western family culture: the principles of designing a digital calendar to support flexibility in terms of location, easy awareness access, and personalization will still hold true. As well, the usage patterns and routines we have uncovered are also similar to that of paper calendar use [8], which again reflects the critical need for digital family calendars to 'fit' within existing domestic routines, while still being able to extend and meet the new challenges of families adopting this technology to their routines.

For our families, we saw that the LINC digital family calendar, in spite of its imperfections, was able to increase family involvement in the calendaring process. This is good news, for it shows the potential of further digital calendar development. Of course, a natural critique would be that this increased involvement was caused simply by families being a part of a 'calendar study.' While possible, this bias was not reflected in the family interviews. For the two Seattle families, increased involvement was very clearly a result of having a central and highly visible public calendar location *and* having the calendar accessible from a variety of locations. While paper calendars succeed because they are also placed in public locations [8], they clearly fail at being ubiquitously accessible. The Calgary families saw family involvement increase as part of their interest in the calendar being a novel technology. Again, one could argue that this novelty could wear off. However, the interesting realization is that children are increasingly being exposed to computers in schools where one could anticipate they would expect and be more comfortable with family calendars that are a part of the digital realm in the future.

Would families continue to use a digital family calendar if they were not part of a study? Each of the study families expressed a willingness to use digital calendars in the future. For obvious reasons, using the Tablet PC as a dedicated calendar is still prohibitively expensive, especially when compared to the inexpensive paper calendars that many families still enjoy. However, we anticipate that future display technologies will continue to drop in price, and that affordable calendar appliances that realize our design factors will come about.

7. ACKNOWLEDGMENTS
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