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Did You Leave the Calendar On?

Exploring trade-offs between availability and power consumption in the home

Abstract A paper calendar placed in the kitchen is always available and can be glanced at from across the room. In a field study of the LINC digital calendar prototype, we achieved the same level of availability at the cost of leaving a computer running all the time. This brought to my attention the tension between the benefit of providing an ambient display that is always available and the cost in terms of power consumption. As we design and build future ambient displays for the home, we need to carefully consider this tension between availability and energy use.

Keywords Domestic technology, home, power, calendars, ambient displays, environmental sustainability

1 Introduction

Homes are popular places for ubiquitous computing. For example, Weiser's original vision of the disappearing computer begins with Sal interacting with her coffee machine and pen at home [10], while more recently Taylor et al.[8] described several novel devices for the home. In [7], Rodden and Benford proposed information appliances, interactive household objects, and augmented furniture as key types of technology to explore for homes. Many devices designed for the home including digital photo frames, the location-dependant information appliances described in [2], and HomeNote and the Whereabouts Clock from [8] could be considered ambient displays, designed to have information available at a glance.

Motivated by challenges many people face in trying to manage family scheduling, Carman Neustaedter and I designed and built LINC, an inkable digital family calendar. With the LINC prototype our goal was to unite the flexibility of paper calendars with the advantage of having

A.J. Bernheim Brush Microsoft Research One Microsoft Way Redmond, WA 98052, USA ajbrush@microsoft.com digital calendar information that can be easily shared and available in multiple locations. LINC is designed for pen interactions with the intention that LINC would be always running on a display in a kitchen or other high traffic location in the home. In our studies we have prototyped this interaction using a slate tablet computer.

In LINC, each event is written on a sticky note that can be dragged to the appropriate day on the calendar. Options allow the user to choose a color for the note, create copies and leave additional information. In addition to the main LINC client application, we have also built LINC Web and LINC Mobile to allow family members to view images of their calendar using Internet Explorer and Windows 2003 Smart Phones. See [5] for more details about the design of LINC.

2 Making LINC Always Available

Availability is an important feature of a paper calendar, and paper family calendars are often placed in the kitchen or other central public location (e.g. the paper calendar example in Figure 1). In a survey on personal and household scheduling I conducted with Tammara Turner [1], "Always available (e.g. no need to turn on)" was the second most popular reason for using a paper calendar and was selected by 83% of the 233 respondents using paper calendars. Comments by respondents also highlighted the value of availability. For example, "I like the flexibility and visibility of it (hanging in kitchen, no need to turn it on)", and "It's easy to use. I don't have to turn it on or worry about batteries running down or worry about someone stealing it."

Thus a major design goal during the month long field study of LINC conducted by Carman Neustaedter, myself, and Saul Greenberg (see [6] for more details) was to make LINC always available so the prototype would function as an ambient display and families could easily glance at their digital calendar. To do this we gave each of the four participating families a slate Motion Computing LE 1600 tablet running LINC with the power management features adjusted so the screen and computer never turned off. We



Figure 1: Example paper family calendar on the left, LINC in the homes of field study families.

also provided a LINC screen saver that showed pictures of the calendar at approximately one-third size. All families in the study placed the slate tablet running LINC in their kitchens (see Figure 1 for some examples).

During the study, we saw support for the notion that families wanted LINC to be always available. The strongest illustration of this arose in one family's house where lights from the kitchen could be seen from the parents' bedroom. Because we had set-up LINC to be always-on, it produced a glow that could be easily seen by the parents when they tried to sleep. We remedied this using a built-in power feature that turns the tablet display off after 15 minutes of non-use. Thus, in order to see the calendar (regardless of the time of day), one had to tap the screen and wait several seconds for the display to turn-on.

This interaction and wait overhead proved excessive for the family's dad and he reverted back to walking by the paper calendar (which still had the family's events on it) on his way out of the house, rather than walking by LINC. That is, even minimal overhead to viewing the calendar had drastic consequences for his use. A mother in a different family also thought that having LINC always running was critical for her use of it and she simply would not use LINC if the program was not available without booting the computer. She told us "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 ... I don't want to run back upstairs and turn the computer back on."

However, the mom in first family, who needed to tap the display to see LINC, felt that having LINC always on was beneficial, but not 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.

3 Environmental Costs

Obviously the approach we took to make LINC always available by using a computer running all the time is not a sustainable one. A white paper available from Microsoft [9] leverages data collected in a 2002 study by Lawrence Berkeley National Laboratory (LBNL) [4] to provide some interesting estimates and insights into the relative cost of

running a computer all the time compared to using built-in power saving features such as sleep. Based on the numbers collected by LBNL, running a Pentium 4 machine with a 17 inch LCD monitor in idle constantly (8,760 hours per year), would be roughly 899 kWh. Looking at computers in a work setting, [9] estimates a savings of 598 kWh per year if the machine uses sleep mode during the 6,160 non-working hours on evenings and weekends (assuming a 50 hr work week).

Doing a similar calculation for the home we can estimate a 318 kWh savings per year if the computer was in sleep mode instead of idle during the night (9 hours per day) and a saving of 532 kWh per year if we assume the computer is only used 9 hours per day (perhaps 7-10 am and 4-10 pm). While obviously electricity usage varies widely in homes across the world, for comparison, the U.S. Department of Energy calculates that the average American home uses 10,896 kWh of electricity per year. So adding another 899 kWh for an always on computer would be an increase of 8.3% while adding a computer running only 9 hours per day (336 kWh per year) would be a 3% increase.

Of course, power usage is not the only environmental impact of leaving computers running when not needed. For example, [9] calculates the carbon-dioxide emissions that are created when generating the electricity needed to power the computer. Without getting too distracted by the exact amount of savings possible for any particular computer, the higher-level point is that we must think carefully about the costs of making displays in the home always available.

4 Sustainable Availability?

It seems clear to me that in the future the cost/benefit trade-off of availability and resource consumption must be considered when designing ambient displays for the home. In my future research I am considering a variety of approaches to design prototypes with sustainable availability. By sustainable availability, I mean that to the user the display appears to be always available and glanceable, but in practice when no one is present the display and computer power off.

The goal is then to determine low cost methods of managing when the display is available. While simple methods that allow users to specify ranges of times that the display is available are appealing, we are also considering low cost sensing methods that would power up devices when people entered the home and power them down when the house is empty. Motion sensors on each device may be enough to do this effectively, or we may need more complicated systems, such as placing sensing at doorways. Note, that building prototypes that can essentially turn-off and come back on in the same state may require additional engineering to recall previous conditions. Other options to achieve sustainable availability might also include leveraging devices such as the long awaited E-Paper [3] and other displays that only need power when they are updated.

Lastly, I should be clear that it may be entirely possible that availability and glanceability for displays in the home is nice, but not necessary. Perhaps, given the environmental costs users will adjust to tapping on displays to pull information. This possibility is definitely worth careful consideration and additional study. My personal experience suggests, similar to several field study participants, that glanceable availability is important. After the LINC field study I modified the tablet in my own kitchen running LINC to go to sleep after a period of non-use instead of staying always on. While my LINC calendar is still usable and used, I definitely have to make a more conscious effort to check it rather than having the calendar available at a glance. A sustainable availability option for LINC would offer me the ideal compromise between resource consumption and usability.

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Biography

A.J. Brush is as a researcher in the VIBE group at Microsoft Research. Her main research interest is human-computer interaction with a focus on computer-supported collaborative work. She enjoys studying how technology can help people and groups with everyday problems, such as family scheduling and staying in touch with extended family members. A.J. received her Ph.D. in Computer Science from the University of Washington in Sept. 2002 and graduated summa cum laude from Williams College with a B.A. in Computer Science and Mathematics.

While A.J. is an avid recycler and has been composting extra food waste in a worm bin since 2000, her fondness for technology means she has many devices in her life. She is also terrible at remembering to turn off the lights (just ask her husband) and hopes by working to build more environmentally friendly technology she can overcome her own bad habits and help others as well.