

Portable, But Not Mobile: A Study of Wireless Laptops in the Home

*Allison Woodruff
Ken Anderson
Scott D. Mainwaring
Ryan Aipperspach*

Electrical Engineering and Computer Sciences
University of California at Berkeley

Technical Report No. UCB/EECS-2006-88

<http://www.eecs.berkeley.edu/Pubs/TechRpts/2006/EECS-2006-88.html>

June 18, 2006



Copyright © 2006, by the author(s).
All rights reserved.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific permission.

Portable, But Not Mobile: A Study of Wireless Laptops in the Home

Allison Woodruff¹, Ken Anderson², Scott D. Mainwaring²,
and Ryan Aipperspach^{1,3}

¹ Intel Research Berkeley, 2150 Shattuck #1300, Berkeley, CA 94704 USA
woodruff@acm.org

² Intel Research, People and Practices Research Lab, 7144 SW 29th Ave
Portland, OR 97219

{ken.anderson, scott.mainwaring}@intel.com

³ Computer Science Division, University of California, Berkeley
Berkeley, CA 94720 USA
ryanaip@eecs.berkeley.edu

Abstract. We report a qualitative study of the use of physical space and wireless laptops by ten United States households. Although wireless laptops purportedly offer the opportunity and affordances to go “anywhere in the home,” laptops were generally used in a small set of particular places rather than moving fluidly through the home: wireless laptops were portable, but not mobile *per se*. We present principles that influence laptop movement in the home. We also present a model of people’s use of space in the home, identifying a small set of favored places of long-term use and a larger set of kinetic places used for specific tasks. We discuss how the principles we have identified generally promote use of laptops in favored places and generally discourage use of laptops in kinetic places. We discuss how our findings are relevant to the design of technologies for the home.

1 Introduction

A number of significant studies have examined the use of computing technology in the home [8,9,13,16,24,25]. Two increasingly popular technologies have the potential to dramatically change patterns that have been reported previously, particularly when taken in combination: wireless home networks and laptops. Forrester estimates 3.8 million United States homes with home networks and laptops as of December 2004, and forecasts 30 million such homes by 2010 [21].

The wireless laptop offers continuous connectivity in a portable device, and while it certainly falls short of the original ubicomp vision [26], it is an important step towards it. The wireless laptop is touted as having great potential to change the nature of computing in the home. Rhetoric suggesting that people can compute “on a whim at any time and in any room” is extremely common [21]. Nonetheless, little is known about specific day-to-day practices with wireless laptops.

The much vaunted opportunities for the wireless laptop (and more broadly for ubi-comp) are strongly tied to choice of physical context. Physical space plays a large role in people's day-to-day lives, influencing for example sensory, ergonomic, cognitive, and social experience. We are therefore interested in examining the physical contexts in which people choose to spend time and use technology in the home. We believe that by studying current practices around choice of physical context, we can gain insights (1) for the design of future technologies and (2) for the design of physical context (from furniture to architecture) amenable to emergent behaviors and technology use.

More specifically, we are interested in questions such as: Where specifically do people spend time in the home, and why? What are the properties of different places in the home? In which of these places do people use computing technology, and why? Based on these investigations, we hope to learn more about which characteristics of space and devices are or are not favorable to computing technology in the home. For example, we hope to learn more about the interaction of space and computing so we can understand which form factors and I/O methods are appropriate in different places.

Households with wireless laptops are an excellent population to inform such questions, as household members have the opportunity to compute "anywhere" in the home and they have well-established practices that can be examined (in contrast with participants in short-term interventions or laboratory studies). In this paper, we report a qualitative study of the use of physical space and wireless laptops by ten United States households. To our knowledge, this is the first study of the day-to-day use of wireless laptops in the home.

We present novel findings on people's use of space and wireless laptops in a range of United States homes. We characterize specific places in the home, and discuss the settings in which laptop use is and is not prevalent in the home. Wireless laptops are not generally used anytime, anywhere, but are instead mainly used in four kinds of favored places in the home. We discuss principles that influence where wireless laptops are and are not used. We believe our principles and findings can be used to reason about how future devices may be used in the home.

The remainder of the paper is organized as follows. We first review related work and then discuss our method. We then turn to findings, followed by discussion of the findings and design implications. Finally, we conclude and discuss future work.

2 Related Work

The home has long been considered a compelling domain for ubiquitous computing, and many exciting technologies have been proposed for this venue [12]. The home is however plainly a complex domain for which it is difficult to design, and the promise of many technologies is as yet unfulfilled. Further, even when domestic technologies succeed, their role in home life and the reasons for their success are not always well understood. While some important initial work has been done in the domestic arena, researchers have lamented the paucity of research on the home environment as compared to the extensive body of literature on the work environment, and have called for

more research to deepen our understanding of home life and the use of technology in the home, e.g., [3,5].

One of the main areas of inquiry has been the use of desktop computers and the Internet in the home [8,9,13,16,24,25]. These studies have tended to focus on the social context of computing [9]; Venkatesh and his colleagues explicitly model the home as two main components – the social space and the technological space [24,25]. However, some work has also considered physical space, typically at the level of rooms or general areas of rooms. Mateas *et al.* conducted a study of the use of desktop computers in the home, explicitly considering not only social context, but spatial and temporal context as well [16]. They identified general areas (although not specific places) that represented “behavioral clusters” in the home, such as “Work Space” and “Private Space.” Frohlich and Dray also conducted a study of the use of desktop computers in the home [8]. They studied the rooms in which desktop computers were located and asked household members in which rooms they would hypothetically like to use different computer applications. In all these studies, the desktop computer was statically positioned, frequently in the home office if the family had one, or sometimes in other areas of the home such as the parents’ bedroom or the dining/kitchen area of the home. Frohlich and Kraut [9] observe that the placement of the computer has complex social implications and can create social tension, and they raise the possibility of portable machines that can be carried between different rooms.

The suggestion of portable devices resonates with O’Brien *et al.*’s study of home life and the use of audio-visual technology and a prototype set-top box [19]. This work focuses primarily on the social context for the use of technology, although this naturally leads to discussion of issues such as coordination and ownership of space, particularly the way in which noise-emitting technologies such as the television can mark out space. They discuss the importance of the portability of devices such as small televisions and stereos to distributing functionality throughout the home.

McClard and Somers present a rare study of the use of portable tablets they deployed in homes [17]. They report on a seven-week intervention in which they provided wireless networks and tablet computers to thirteen families. Their work strongly emphasizes that the tablet can be used “anywhere.” (On a related note, Forrester reports survey data indicating that laptops are used to some degree in every room in the home, although most often in the office [21].) Participants liked that the tablet was portable and could be used in “comfortable” positions and locations such as a couch, an easy chair, or in bed. The participants’ responses make clear that the tablet, with its somewhat limited functionality and awkward text input, was not considered to have equivalent functionality to a PC. In one of the only other studies of wireless computing, Grinter *et al.* [10] explored the collaborative administration of home networks, some of which were wireless.

Issues such as communication, coordination, and organizing systems have also been explored [4,6,23]. Crabtree *et al.* [4] present a study of domestic routines for managing communications such as physical mail coming in and out of the home. Their study shares our interest in a fine-grained analysis of locations in the home, but focuses on locations for display of communication media and the role these play in the coordination of action among household members. We have a complementary

focus on the locations in which people spend time in the home. For example, Crabtree includes a notion of ecological habitats to describe where communication media dwell; as we discuss later, we use a similar notion of habitats to describe where people dwell. Elliot *et al.* explore similar notions to Crabtree regarding communication and coordination information in the home [6], finding that people placed information in many locations in the home as a nuanced way of sharing information within the household.

To evaluate the use of technology in the home, we need to understand not only where technology is used in the home, but more broadly how people use space in the home. The existing literature from the social sciences is surprisingly sparse regarding daily use of space, particularly regarding specific patterns of use of places and objects; generally researchers have focused on broader issues such as identity, territoriality, gender, and power, and discussions are often at the level of rooms rather than specific places within the room (see e.g., [11,14]). In a notable exception, Oswald reports favored places for elders [20]. These favored places are motivated by a tendency towards environmental centralization, particularly when people suffer from a loss of mobility. Favored places offer the ability to maintain competence through a process of miniaturization, establishing “control” centers that include items such as remote controls for the television and the door opener. Oswald however does not discuss in detail the characteristics of these places, and the population he is studying appears to use them somewhat differently than the more general population in our study.

In our work, we present a study of the day-to-day use of wireless laptops in the home. We apply principles of laptop movement to novel findings regarding people’s spatial occupation of the home; to our knowledge we are the first study to contextualize our findings about technology use in a discussion of specific places where people spend time in the home. We also present a fine-grained analysis of the types of places people use technology and their posture in these places. Despite the significance of issues such as fatigue and comfort in the home, and their impact on the use of technology, seating position and posture are rarely considered elsewhere in the literature (a notable exception being McClard and Somers [17]), and our findings are complementary with theirs, as they were studying the use of a device with a different form factor.

3 Method

The data presented in this paper was collected as part of two related studies within a broader project on the use of technology in the home. The lead author visited all homes in both studies and there was high overlap in interview content and procedure.

3.1 Participants

The participants consisted of the 28 occupants of 10 households, as well as the 6 occupants of 2 pilot households. Two households were recruited from a local univer-

sity community, and the remaining eight households were recruited via Craig's List, an online classified ad service. Participants were compensated for their participation. All households had wireless networks and at least one laptop computer. Households had a range of laptop and desktop computers (some PCs, some Macs), with an average of slightly more than one computer per person.

Households were chosen to represent a diverse range of household composition and life stage. All households had multiple inhabitants; some households had children of various ages, while other households consisted entirely of adults, e.g., married couples who did not have children or "empty nesters" whose children had grown up and left home. Participants were from a range of ethnic and cultural backgrounds and had varying occupations, such as kindergarten teacher, health care analyst, tech support person, furniture salesperson, or student. Although technical knowledge varied, participants tended to be somewhat technically oriented, which is not surprising given that these households are leading adopters of wireless home networks.

Eight of the households were located in the San Francisco Bay Area, and two households were located in the Portland area. The homes were in a range of neighborhoods, including for example suburbs, an ethnic residential neighborhood, and a quickly developing urban district. The homes in the study consisted of a range of housing types, from large "McMansions" to one-bedroom apartments. Our recruiting favored various types of open plan layouts because we were particularly interested in the use and coordination of more "flexible" and shared space, although some of the houses had traditional layouts.

3.2 Procedure

Data was collected during 2005 and 2006. Each household was studied in some depth through multiple interviews, which included home tours, discussion, and a variety of mapping activities (e.g., creating and annotating floorplans, using felt maps to do "walk-throughs" of recent days [16], and interpreting visualizations of location data collected by sensors installed in some homes). In all but one home, all household members were present at all interviews. The primary interviews (usually two interviews per family, for a total of approximately three to four hours per family) were typically video-taped and transcribed. We had a number of additional informal interactions with several of the families, and we typically took notes on these. Additionally, in some households, textual and photo diaries were kept by participants, while in other households ultra-wideband sensors¹ were used to track the locations of the participants and laptops, and application use was logged on laptop and desktop PCs. Time-lapse photography was also collected in some of the public areas in some of the homes. Households typically participated for approximately one to three weeks, although one household participated for approximately four months, and we conducted brief follow-ups with a few of the households after several months had elapsed. Further details about data collection appear in [2,14].

¹ Discussion of quantitative methods for analyzing the sensor data appears in [1]. Note that these quantitative methods were not used as part of the analysis reported here, and that here we focus on qualitative data and findings.

4 Findings

In this section, we present the findings from our study. Because wireless laptops offer unique affordances for the use of space, we focus primarily on issues to do with the use of the laptop in the home and the use of space. Naturally, any study in the home reveals a rich and complex set of issues, such as sharing of technology and family coordination, but space constraints unfortunately prevent us from exploring all of these here.

4.1 Principles Influencing Location of Laptop Use

From our interaction with the participants, we have inferred a list of principles that seemed to most powerfully affect location of laptop use in the homes we studied. The principles represent attracting or repelling forces that impacted laptop movement and use. Naturally there was individual variation, so while these were the major themes, not all of these issues pertained to all participants in all homes. Note that while we had anticipated that varying signal strength of the wireless network would play a role in where the laptop was used, this did not emerge as a significant theme.

The laptop functions as part of an assemblage. Laptops are drawn to established locations with appropriate infrastructure.

Laptops typically required infrastructure and space to enable general and sustained use. Needs varied somewhat by person and circumstance, but laptop assemblages frequently included some subset of the following items: a mouse; a horizontal surface on which to spread papers or books, use a mouse, and place the laptop itself; a power adapter; peripheral devices such as printers, monitors, keyboards, or speakers, and wires and other attachments to these devices; pens and pencils; and/or a phone. Jack describes actually entwining himself in such an assemblage. He says he sometimes sits on the couch with the laptop on his lap, a power cord running to his left, and wires to speakers running to his right; this means he can not get up from the couch without moving the laptop and disconnecting wires or trying to lift them over his head. In practice, a laptop is not simply a device, but is indeed a configuration of devices or infrastructure to support laptop use.

Jack: So we have a laptop and wireless but we're definitely wired too.

The laptop is more likely to be used when it is at hand. The laptop is not always conveniently situated or booted.

A number of situations arise in the home in which the laptop would be useful for quick tasks. For example, one may wish to "google" for the answer to a question that arises in conversation or "fill time" by briefly checking email. However, the laptop may not be at hand in those situations, and the costs of retrieving and/or booting it often dominate the benefits it would provide. Therefore, opportunities for lightweight or even longer-term computing tasks may go unfulfilled.

Laptops are in some senses surprisingly inconvenient to move from room to room or even from place to place within a room. A difference of just a few feet can make the difference in whether the laptop is used or not, and weight and wires are both inertial forces. Laptops often need to be detached from power or peripherals or closed before being moved – and closing them risks automatically putting them in standby mode or shutting them down, which can lead to further delays. Further, laptops are moderately heavy and difficult to carry in one hand, and they are even more difficult to carry when one wants to bring along dangling infrastructure such as the mouse, mouse pad, or the power adapter. Additionally, if one is sitting (or lying) down and is tired, getting up to go get a laptop can be an unappealing notion indeed. Even when laptops are conveniently located, an additional obstacle is that they may not be booted and the boot cycles are not short. Participants told stories about walking to other rooms to use a computer that was already booted elsewhere in the home, rather than using the unbooted laptop right next to them.

The laptop is “fragile.” People tend to avoid putting laptops in “dangerous” locations like the kitchen or the bathroom.

Many participants expressed concern that their laptop could be damaged by hazards such as water, cooking spatters, young children, or hard knocks. In practice, this meant that they were concerned about putting their laptops in dangerous locations such as the kitchen, the bathroom, or other locations where they might be bumped, dropped, or spilled upon. Tom expresses some of these concerns, and discusses his perception that a consumer electronics device is more appropriate for “unsafe” venues:

Tom: The thing that bugs me sometimes is either [my teenage son] took it or [my teenage daughter] took it. They're in the kitchen with it, they got it open, it's sitting on there, and they're listening to their iTune collection... and I'm going, 'Don't you guys have iPods? Didn't I get you iPods with your own music on it?' You know. I don't really want this laptop sitting here because I said, cracked screen, knocking it, stuff like that... giving them \$150 thing to walk around I... feel a lot more comfortable than letting them run around with a \$1,000 thing.

In some cases, participants overcame their reservations and used their laptops in these more unsafe locations or situations. The important thing to note is that there is a cost-benefit tradeoff between the risk to the laptop and the value of using it in a given situation. Anne (the only participant who reported using the laptop in the bathroom) recognized that it was not always “safe” to use it in there, but appeared to derive benefit and was careful to position it “dead center in the middle of the counter.” Different household members sometimes had different perceptions of the risk to a laptop, or at least different cost-benefit analyses. Mark discusses borrowing his girlfriend Anne's laptop for a friend to use while they were outside playing basketball.

Mark: I was going to say, I didn't tell you that John came over and we were playing basketball. We had the garage open and I brought the laptop in the garage just because he wanted to check something. So I was like, “No problem.”

Molly: Of course you would leave that out, so she wouldn't kill you.

Anne: We'll discuss matters later.

Mark: So there's a little counter in the garage and I just put it on there for my friend to use the Internet.

Molly: He shares that now, so she won't kill him. Last thing we need is the basketball to hit the laptop.

Mark: We were just outside playing basketball and he was like, "I've got to check something for my school." And I was like, "Okay." Then I just brought the laptop outside so we didn't have to go back in. I wanted to keep playing and he wanted to check it really fast. So it does come in handy to have the wireless laptop... I left it there until we were done. The basketball wasn't anywhere near it so it wasn't going to break it.

This is exactly the kind of opportunistic use of the laptop that seems ideal, but such events appear to be quite exceptional, even when one considers that sometimes they may not be discussed with interviewers because this might reveal them to other members of the household. The fact that sharing this particular event was so problematic reveals the importance of the issue to the participants, as well as the fact that such opportunistic use is not routine.

People sometimes want a "break" from the laptop. People sometimes put mental or physical distance between themselves and their laptop.

Participants had a range of strategies for dealing with work/home boundaries [18] and online/offline boundaries. Participants often said that it was "sad," "sick," or "pathetic" how much they worked or how much time they spent online. Some participants had few boundaries and would, for example, keep a BlackBerry on the night stand and check it in the middle of the night. Other participants would establish rules about times or spaces in which laptops or laptop use were permitted. Some areas were treated as technology-free sanctuaries, peaceful shelters in the home.

Katherine [regarding her husband Sam's use of email late at night]: I just can't understand why anyone would be emailing or responding to email at 11:00... it's hard to imagine that someone's expectations are you're going to be online, reading an email that late.

Anne: [F]or some reason I don't feel comfortable using [the laptop in my bedroom]. I need to be usually down here [in the living room] or somewhere else but not really in my room, because you know I kind of spend a lot of time there, my personal time, it's like my personal haven, so the last thing I want to do is work in there. So phone calls and things like that it's usually down here or outside on location... I usually like to keep my work separate from my personal life.

Another strategy for respite from online stimulation was to have the laptop in a clearly inactive state or put away. The act of closing the laptop or shutting it down was significant. Similarly, a laptop might remain in a bag when someone returned home, to allow them time to "unwind" before facing more email.

The laptop is drawn to activity. Laptops go to places where they will be useful.

Computing can be a focused activity. But computing can also be interleaved with a wide range of other activities from relaxing to socializing – people can check email as a “time-filler” during a commercial, or they can surf the Internet while supervising a napping child. Laptops sometimes follow activities or people. Brad and Jacqueline talk about Brad using his laptop in bed at night so he can be near her:

Brad: It’s pretty easy work, so I do it in bed. At night. It’s like, oh, I wanna do a bit more...

Jacqueline: Yeah, as I’ve gone to sleep... I can’t sleep by myself, so Brad has to go to bed and use his laptop in bed.

Further, computing can be fully integrated in some activities. For example, computing plays an important role in socializing. People can look at photos or choose music together, they can “google” information that comes up in conversation, online news can prompt conversation, or people can chat online about a TV show as they watch it.

4.2 Where People and Laptops Spend Time in the Home

In the previous subsection we described principles influencing laptop use. In this subsection, we discuss the locations in which people and laptops spent time in the home, and discuss how the principles help explain the patterns we saw.

From the rhetoric associated with wireless and laptops, one might assume that the primary benefit of wireless laptops is that they let people compute anywhere in the home. In practice, laptops appear to be in common use in a relatively small number of places in the home; specifically they are commonly used in the four types of favored places we describe. Their use in other parts of the home is much rarer, although provocative and informative when it does occur.

4.2.1 Framework of Spatial Occupation of the Home

In the households we studied, each household member typically had two or three favored places where they spent the majority of their time during waking hours. Examples ranged from a particular spot on the sofa to a seat at the desk in a home office. Note that these places are quite specific locations – they are not simply general areas or parts of rooms. One might imagine that people living in larger houses would have a significantly larger number of favored places, but our findings suggest that the number of favored places per person remains relatively constant. While larger houses may afford more choice of location for favored places, apparently people still establish a relatively low number, due to factors such as habit and the work to develop and maintain them. Participants spent extended periods of time in their favored places, conducting activities such as television watching, computing, socializing, or reading. Favored places naturally develop over time into habitats – places with resources conveniently arranged at hand. Objects such as drinks, books, remotes, and power adapters for laptops tend to accumulate in favored places. Placement of items can be ritualized and the environment can evolve over time to support

convenient use – the spot for coffee, the cushion broken in, or the laptop adapter wedged in the sofa cushion.

In addition to favored places, participants of course had other places they used in the home during waking hours. These were typically kinetic places, used for shorter duration, focused activities that often involved physical manipulations, e.g., a mirror in the corner of the bedroom for doing one's hair in the morning, a door that one tucked one's feet under to do sit-ups, a kitchen counter that was used to make sandwiches for lunch or to prepare the evening meal, or a refrigerator that was visited multiple times during the day to get drinks.

4.2.2 Laptop Use in Kinetic Places

There were a number of resourceful uses of laptops in kinetic places in the home. As mentioned before, laptops are drawn to places where they will be useful. We discussed how Mark took the laptop outside for his friend to check email when they were playing basketball. Laptops were on occasion used for recipes in the kitchen or to check email in the bathroom. A particularly creative use was by Mareesa and Carlo – if their baby daughter had fallen asleep in the car on the way home, Carlo sometimes brought the laptop out to Mareesa so she could sit in the car in the driveway and use the Internet while supervising the child's nap. Mareesa sometimes also brought the laptop to the child's bedroom so she could be with her while she napped.

While we could emphasize the sensational and resourceful nature of these events, on the whole we felt they were much rarer than we would have expected, and that fewer participants took advantages of these opportunities than we would have expected. Further, location logging, application logging and detailed discussion revealed these events to be even more uncommon than initial discussions with participants might lead one to believe. We believe that these events are marked and tend to be disproportionately emphasized by participants because they are creative and memorable. For example, one family that talked enthusiastically about using the laptop for recipes in the kitchen turned out to use it for that purpose only once during the multiple-week study period, while another family that reported such use did not use it for that purpose at all during the study period.

These events are informative not only because participants are highly interested in them but also because stories about them tend to be accompanied by revealing descriptions of why using the laptop in a given location is troublesome. In fact, most of the principles described in Section 4.1 seem to discourage the use of laptop in kinetic places in the home. Although laptops may require less infrastructure for short-term tasks than for long-term tasks, lack of items in the assemblage was still often an issue. Participants were often reluctant to use laptops without power or a mouse. Further, lack of an adequate place to put a laptop was plainly a barrier – certainly the laptop is most easily operated with two hands for typing, so it is difficult to use it while standing up and holding it – and even more difficult to operate while walking or doing other physical activities. Kinetic places in the home are many and varied, so laptops were often not at hand, and it was rarely worth the trouble to detach from power and peripherals and move the laptop. Concerns about breakage also made it less likely that the laptop would be brought to more active areas in the home. Desire for a “break” from the laptop also sometimes limited its movement in the home.

4.2.3 Laptop Use in Favored Places

In general, participants had a small number of places where they spent extended periods of time during waking hours in the home, and their laptop (or a desktop) spent some time in almost all of these places.

We can see that most of the principles described in Section 4.1 presage the use of laptops in these favored places. We discuss the relevance of these principles in turn. First, laptops are part of an *assemblage* and they require a place for that assemblage. Favored places include habitats that have horizontal surfaces and often other desirable infrastructure such as power outlets to facilitate the use of other objects such as lamps. It is natural to extend these locations to incorporate items such as power adapters strung along for laptop use, and in fact the assemblage is often visible in a favored place even when the laptop is not currently there.

Second, laptops are more likely to be used when they are *at hand*. The laptop is more likely to be at hand in a favored place, simply because people spend a large amount of time in a small number of favored places and the laptop tends to be in one of those places (which is of course a self-reinforcing phenomenon). Further, favored places tend to incur extended-duration use, and the costs associated with settling in with a laptop, such as connecting the power supply and organizing supporting materials, are more acceptable than in shorter stay spots. Additionally, laptops may be kept at hand but not used continuously, particularly in the comfortable places described below. For example, a laptop may be set aside to eat, or it may be picked up during commercials or when an episode on the television prompts use. This type of intermittent use matches well with the use of other objects in favored places – many objects in favored places are kept at hand but not used continuously. Laptops fit well with the scale and treatment of these other objects: laptops can be stacked and tidied with magazines or papers, remotes can be put on top of them, or laptops can be removed entirely if the room is cleared of clutter in anticipation of visitors.

Third, laptops are perceived as “*fragile*.” Favored places tend to be in “safe” locations in the home – locations where objects like books, furniture, and the human body itself are less likely to be damaged. Laptops fit comfortably into these environments. In fact, the laptop has some relationship to the human body in terms of nurturance needs. The laptop needs some of the same things as the human body on a somewhat similar time scale: it needs fuel on a multi-hour time cycle; it does not perform well in direct sunlight (the laptop screen is not very usable in bright light, and people have an aversion to sitting in direct sunlight, moving out of their favored places or adjusting the blinds if direct sunlight hits, or choosing favored places that do not receive direct sunlight); and the body and the laptop both seem attracted to soft seating – given concerns about bumping the laptop, it is in some senses easier to place it rather carelessly on a soft surface than to place it carefully on a hard surface so that it does not bump, and we saw many laptops “sitting” on a couch or an ottoman rather than a coffee table. Therefore, it is somewhat natural that the laptop would be compatible with existing places for sitting.

Fourth, recall that people sometimes wanted a “*break*” from their laptops. In some senses, putting laptops in favored places seems to work against this, since for example they enable people to frequently check email from the couch. Laptops do however

have some nice affordances for boundaries, e.g., it is highly significant that laptops can be closed, turned off, or put in their bag by the front door.

Fifth, recall that laptops are *drawn to activity* and to places where they will be useful. We discussed above that some of the situations in which laptops can be useful do not occur in favored places – but many do. Because people spend the majority of their time in favored places, many activities in the home naturally take place there. Additionally, the habitat in favored places often includes a television, books, and other resources compatible with laptop activity.

4.2.4 Change on a Multi-Week and Multi-Month Time Scale

Although we have found that the number of places in which the laptop is routinely used is fairly limited, we would like to emphasize that participant's ability to choose these places is significant. This choice is exercised with some frequency. There was naturally some variation from day to day. But even more importantly, we learned that the use of space and laptops within space was highly contingent on routines that change on a multiple-week or even multi-month time scale. Use of favored places and laptop use were highly sensitive to current routines and projects. Seemingly small changes such as a difference in a child's nap schedule, a change in the weather, or a new project assignment at work could greatly perturb the system, meaning for example that laptop use ceased entirely in one location and began in another.

4.3 Types of Favored Places

Because people spent the majority of their time in favored places and because laptops were used more frequently in these places, we conducted a more detailed analysis of favored places. (Space constraints unfortunately prevent us from a more detailed discussion of kinetic places.) While the stereotypical notion of "dad's favorite chair" does appear to have some basis in reality, we learned that there are not simply favored places, but importantly, there are different types of favored places. Clustering of favored places revealed four major clusters. These four clusters can be usefully organized into a two-by-two matrix. The first axis is comfortable versus ergonomic, and the second axis is open versus closed. We discuss each axis in turn.

Comfortable places are (not surprisingly) most strongly characterized by comfortable seating – usually a sofa, but sometimes a soft chair or even a bed. Comfortable places generally support a wide range of seating positions and minor variations in location, for example, a person may sit on a couch with the laptop on the coffee table, or lie down and prop the laptop on their knees. They typically have a low or small table nearby, such as a coffee table, which contains resources such as a drink, a book, or a laptop computer. Comfortable places are often associated with unstructured time and support a wide range of activities such as television watching, talking on the phone, socializing, reading, or computing. These activities are often interleaved. Computing tasks were likely to involve more "relaxed" tasks such as web surfing, IM, or email (note that a recent Pew Internet Report discusses a dramatic increase in the number of people using the internet "for fun," going online "for no particular reason"

Table 1. The four types of favored places used during waking hours

<i>Type</i>	<i>Comfortable-Open</i>	<i>Comfortable-Closed</i>	<i>Ergonomic-Open</i>	<i>Ergonomic-Closed</i>
<i>Canonical example</i>	Family room couch	Bed with view of TV	Informal dining table	Desk in home office
<i>Occurrence</i>	Very common	Less common	Common	Common
<i>Seating</i>	Couch or soft chair	Bed or soft chair	Upright chair	Upright chair
<i>Seating positions</i>	Multiple	Multiple	Single	Single
<i>Horizontal surfaces</i>	Coffee or side table	Nightstand	Table at desk height	Desk
<i>Task</i>	Focused or not focused	Focused or not focused	Somewhat focused, primarily computing	Focused, primarily computing
<i>Location in home</i>	Central	Not central	Central	Not central
<i>Openness</i>	Open, spacious	Confined	Open, spacious	Confined
<i>Visual properties</i>	Good view and light	Lesser view or light	Good view and light	Lesser view or light
<i>Media</i>	View and control of entertainment center	Smaller TV	Often has view of entertainment center	Usually no TV
<i>Facing</i>	Outward facing	Outward facing	Outward facing	Facing wall
<i>Clutter</i>	Useful to tidy	Useful to tidy	Useful to tidy	Can stay cluttered
<i>Computing Device</i>	Laptop	Laptop	Laptop	Laptop or desktop

[7]). Most of the comfortable places we observed were associated with the use of a laptop, although a small number were associated with only a television.

By contrast with comfortable places, ergonomic places are characterized by upright chairs positioned in front of dining tables or desks. The position of both people and laptops are more static in ergonomic places than in comfortable places. Ergonomic places are often associated with focused computing tasks and/or tasks that involve using a mouse or spreading out papers or books on a horizontal surface. Ergonomic-closed places (described below) offered the advantage that these projects could be left spread out, while such objects typically needed to be tidied up in ergonomic-open places. Ergonomic places seemed to be associated with a higher level of mental activation or alertness for some participants. All of the ergonomic places we observed were associated with the use of either a laptop or a desktop (and all the desktop computers we saw were in ergonomic places).

Open places are centrally located in the public, central spaces in the home, such as the family room or the dining room in an open plan home, or even the occasional spot outside. They often take advantage of the best views and light the home has to offer. Seating in these areas generally faces the room and/or other people, and these places offer proximity to social activity in the home. These places typically have a good view of the entertainment center (including items such as TV, gaming station, and stereo). These areas are usually in the “front-stage” of the home, so it is often desirable to tidy them.

By contrast with open places, closed places are in less central areas of the home – typically home offices or bedrooms. These areas are more confined and offer more privacy than the open areas. Here privacy often means audio isolation – one might go to one’s room to watch TV or talk on the phone without disturbing others, or conversely one might go to one’s room to read or compute without being disturbed by TV watching or social activity taking place in the open areas of the home.

Table 1 presents a summary of the characteristics of the four types of favored places. While the patterns are strong, naturally there is a small amount of variation so



Figure 1. The four types of favored places. These are the locations in which laptops were most commonly used in the home, arranged as to whether they are *Comfortable* or *Ergonomic* and are in the *Open* or *Closed* areas of the home. *Comfortable-Open*: Sam likes to watch TV while he works on his laptop. His wife Katherine works on her laptop at the dining table nearby. *Comfortable-Closed*: Gaby finds a comfortable position for using the laptop on the bed. *Ergonomic-Open*: Jack and Margaret’s dining table doubles as a desk. While Margaret works at the desk, Jack works at the couch nearby. Sometimes they switch places. *Ergonomic-Closed*: Kumar likes to work in the home office for privacy while his children young play elsewhere

the table captures canonical types rather than hard and fast rules. Figure 1 shows examples of each type of place.

Unlike Oswald, who observed that elders had a single favored place, we introduce the notion of individuals having an ecology of favored places that offer different experiences. Our participants typically had a set of favored places of different types. For example, one common pattern was to have a comfortable-open place paired with an ergonomic-open place, while another was to have a comfortable-open place paired with an ergonomic-closed place. Some participants also mentioned that sometimes they liked to move to different places because they found it “refreshing” or because it helped keep them awake.

Anne: Yeah, I’ll use my laptop in here [at the kitchen table] sometimes if I want to be like sitting up or just kind of have a change of scenery. I’ll sit in here, kind of face out if it’s a nice day.

Table 2. Advantages of laptops in each type of favored place. Bold items indicate situations where a laptop offers an advantage over a desktop computer

<i>Type</i>	<i>Comfortable-Open</i>	<i>Comfortable-Closed</i>	<i>Ergonomic-Open</i>	<i>Ergonomic-Closed</i>
<i>Facing</i>	Outward facing	Outward facing	Outward facing	Wall facing
<i>Seating positions</i>	Multiple	Multiple	Single	Single
<i>Clutter</i>	Useful to tidy	Useful to tidy	Useful to tidy	Can stay cluttered

Favored places had clear owners, although use was of course coordinated and sometimes even shared. More common than sharing was complementary use of favored places, for example a husband’s place on the couch and a wife’s place at a table nearby, both used together in the evening.

4.3.1 Advantages of Laptops in Different Types of Favored Places

We observe three primary benefits of laptops² relative to desktops. First, unlike desktops, laptops lend themselves naturally to positions facing outward – toward the room, companions, the view, or the TV. They have a smaller screen around which people can see (as opposed to larger monitors attached to desktops), and people can easily shift or orient them so they face in a desirable direction. Laptops also have a smaller footprint which makes them easier to position on outward facing surfaces such as coffee tables; desktops (which are designed to be put against the wall, with wires and fans at the back) are awkward in these positions. The practical result is that laptops allow people to be in different locations in the home with different perspectives; the diverse visual perspectives and social interaction that can be enjoyed are very different than those with desktops.

Second, laptops can be used in multiple positions. Posture can be chosen based on fatigue and task, and variation in physical position can be refreshing.

Third, compared to desktops, laptops can be tidied with relative ease. Laptops can be easily tidied or even removed entirely, for example, they can be hidden away in another room when entertaining, they can be cleared off the table for dinner, or they can be removed from the bed when it is time to sleep.

In Table 2, we highlight the relevance of these advantages to each type of favored place. We can see that in comfortable-open places and comfortable-closed places, people were able to leverage all the advantages of laptops we have just mentioned. Ergonomic-open places do not take strong advantage of the opportunity for the user to sit in multiple positions (although there can be minor shifts in orientation), but these places were very valuable to participants who preferred horizontal surfaces because they allowed them to work ergonomically in visually pleasant locations

² One question that arises is the distinction between laptops with and without wireless capabilities. For example, how many of these behaviors are enabled simply by having a laptop, as opposed to a laptop on a wireless network? While it is difficult to say without making a direct comparison, we do observe that many of the tasks people are doing require Internet access (e.g., web surfing and searching, email, IM, online bulletin boards). Accordingly, we believe wireless is indeed a key enabler given the type of computing being done in the home.

proximate to social activity and media. By contrast, ergonomic-closed places do not particularly leverage any of the opportunities of the laptop – ergonomic furniture in locations such as bedrooms and offices tends to face the wall, and it is natural to leave a device long-term on the desks in these rooms. This is consistent with the fact that ergonomic-closed places tended to have desktops.

5 Discussion

Participants had a set of favored places where they spent time in the home – places that offered different physical, social, and sensory experiences – and the laptop adapted to all of these. Laptops moved with some regularity among favored places, and also occasionally to other locations in the home (as well as to a variety of locations outside the home).

Because of this flexibility, the laptop (especially when wireless) brings computing into the home in a way the desktop does not. Laptops are positioned and repositioned in key locations in the home, from the most public to the most private – in a given day, a laptop may be used in the living room at the hub of social activity and then used in bed before falling asleep. Consequently, laptops can be highly interleaved and deeply integrated with ongoing activity in the home.

In some senses one could argue that the wireless laptop is a triumph – successfully used in a variety of situations in the home. However, we believe this would be an overly simple characterization. There are significant frustrations and lost opportunities, both at favored places and at kinetic places in the home. Accordingly, we now turn to a discussion of design opportunities in these places.

While laptops were satisfactory in all four types of favored places, they were notably optimal for none of them. In its current form, the laptop is a compromise object. For example, it is not an ideal object for comfortable places, and frustrations often arose regarding body and laptop position. Keyboards can be awkward to use when lying on one’s side, the screen can be difficult to see from an oblique angle, laptops can be heavy when propped on one’s knees, and laptops can even be too hot to place in a lap because they emit heat.

Accordingly, we believe that it is an important challenge to develop technology that is customizable to each of the different types of favored places. We believe that our findings about the nature of favored places and the way in which they are used



Figure 2. Left: Part of Tony’s coffee table “pops up” to become a tray for the laptop. Right: Gaby works at nesting ottomans. She puts the laptop and mouse on top of one ottoman, pushes out a second with her feet, and props her legs on a third

can serve as useful constraints for evaluating different models that might be proposed for this customization. Some of the key observations are: (1) people typically had a set of two or three favored places; (2) favored places offer different experiences and have different characteristics; (3) comfortable places involve varied posture; (4) a given place may be used for a wide range of tasks from lightweight surfing to “serious” work; and (5) the location or use of favored places may vary due to changes in routine.

As an example of how the constraints can be used to reason about different classes of design solution, changes in routine suggest that it is unrealistic to build-in technology or carefully instrument the home at a set of pre-designated places. Portable technologies seem more appropriate than built-in technology for favored places. Further, we would suggest that the most compelling designs involve objects that are not simply *portable* but are *reconfigurable* as well. For example, devices with keyboards and screens that expand from a smaller object would fit well with people’s existing patterns. Further note that design of reconfigurable objects in the surrounding habitat is also important. Figure 2 shows two examples of participants who creatively and dynamically reconfigure their comfortable places to add ergonomic elements. Many effective design solutions may lie not only in the design of the technology itself, but also in the design of furniture to better support the technology.

Although the laptop is becoming part of the fabric of daily life in favored places, barriers frequently prevent the laptop from being used in compelling circumstances in kinetic places. Kinetic places have very different characteristics than favored places – they lend themselves well to robust devices that are free of attachments and possibly include hands-free or single-handed interfaces. For example, built-in displays, voice UIs, or smaller appliance devices may be appropriate in these locations.

Overall, appropriate design solutions are likely to be very different for favored versus kinetic places, and we propose that designers consider these distinctions explicitly when designing for the home. We further propose that the principles of device movement described in Section 4.1 may be used to reason about how different form factors and devices may be used in the home.

As a final observation, our findings in some senses argue against the notion of fully ubiquitous access in the home. People sometimes wanted distance between themselves and technology, and they valued the ability to close or put away a laptop. It is an interesting design challenge to try to resolve the apparent paradox between the notion of having computing “everywhere” and maintaining boundaries.

6 Conclusions and Future Work

We have presented the results of a study of people’s use of space and wireless laptops in the home. We have examined the relationship of where people spend time to the use of computing devices. Participants each had a small set of favored places in the home. Wireless laptops were routinely used in almost all of those places, and we have identified principles that promote their use in these locations. Wireless laptops were used much less routinely in other areas of the home, and we have identified

barriers to their use in these places. We have discussed the relevance of these findings to new technologies and form factors.

There are many excellent opportunities for future work, including issues such as the complex interaction between task and location, moment-by-moment analysis of movement and what occasions relocation from one place to another, a richer taxonomy of kinetic locations in the home, the impact of fatigue on the use of space and devices, the use of ensembles of devices [22] with different form factors (e.g., cell-phones, iPods, laptops) in different locations in the home, and extending the framework of spatial occupation and the types of places in the home to encompass multi-cultural issues.

Acknowledgements

We are deeply grateful for discussions with Paul Aoki, Kurt Brown, John Canny, and Ben Hooker. We thank Paul Aoki and Sara Bly for comments on earlier versions of this paper.

References

1. Aipperspach, R., Rattenbury, T., Woodruff, A., and Canny, J.: A Quantitative Method for Revealing and Comparing Places in the Home. Submitted to UBIComp 2006 (2006)
2. Aipperspach, R.J., Woodruff, A., Anderson, K., and Hooker, B.: Maps of Our Lives: Sensing People and Objects Together in the Home. Technical Report No. EECS-2005-22, EECS Department, University of California, Berkeley (2005)
3. Brush, A.J., Palen, L., Swan, L., Taylor, A.S.: Designs for Home Life. SIG at CHI 2005
4. Crabtree, A., Rodden, T.: Domestic Routines and Design for the Home. JCSCW 13(2) (2004). 191-220
5. Edwards, W.K.; Grinter, R.E.: At Home with Ubiquitous Computing: Seven Challenges. Proc. UBIComp 2001 (2001) 256-272
6. Elliot, K., Neustaedter, C., Greenberg, S.: Time, Ownership and Awareness: The Value of Contextual Locations in the Home. Proc. UBIComp 2005 (2005) 251-268.
7. Fallows, D.: Growing Numbers Surf the Web Just for Fun. Pew Internet Reports (2006)
8. Frohlich, D.M., Dray, S., and Silverman, A.: Breaking Up is Hard to Do: Family Perspectives on the Future of the Home PC. Int. J. Human-Computer Studies 54(5) (2001) 701-724
9. Frohlich, D., Kraut, R.: The Social Context of Home Computing. In: Harper, R. (ed.): Inside the Smart Home. Springer, London (2003) 127-162
10. Grinter, R.E., Edwards, W.K., Newman, M., Ducheneaut, N.: The Work to Make the Home Network Work. Proc. ECSCW 2005 (2005)
11. Hanson, J.: Decoding Homes and Houses. Cambridge University Press, Cambridge (1998)
12. Harper, R. (ed.): Inside the Smart Home. Springer, London (2003)
13. Kraut, R., Scherlis, W., Mukhopadhyay, T., Manning, J., Kiesler, S.: The HomeNet Field Trial of Residential Internet Services. CACM, 39(12) (1996) 55-65
14. Mainwaring, S.D., and Woodruff, A.: Investigating Mobility, Technology, and Space in Homes, Starting with 'Great Rooms'. Proc. EPIC 2005 (2005) 188-195
15. Mallett, S.: Understanding Home: A Critical Review of the Literature. The Sociological Review 52(1) (2004) 62-89

16. Mateas, M., *et al.*: Engineering Ethnography in the Home. Proc. CHI '96 (1996) 283-284
17. McClard, A., Somers, P.: Unleashed: Web Tablet Integration Into the Home. Proc. CHI 2000 (2000) 1-8
18. Nippert-Eng, C.E.: Home and Work: Negotiating Boundaries Through Everyday Life. University of Chicago Press, Chicago (1996)
19. O'Brien, J., Rodden, T., Rouncefield, M., Hughes, J.: At Home with the Technology: An Ethnographic Study of a Set-Top-Box Trial. ACM TOCHI 6(3) (1999) 282-308
20. Oswald, F., Wahl, H.-W., Naumann, D., Mollenkopf, H., Hieber, A.: The Role of the Home Environment in Middle and Late Adulthood. In H.-W. Wahl *et al.* (eds.): The Many Faces of Health, Competence and Well-being in Old Age: Integrating Epidemiological, Psychological and Social Perspectives. Springer, Heidelberg (2006)
21. Schadler, T.: Laptops And Home Networks Transform Behavior. Forrester (2005)
22. Schilit, B.N., Sengupta, U.: Device Ensembles. IEEE Computer 37(12) (2004) 56-64
23. Taylor, A.S., Swan, L.: Artful Systems in the Home. Proc. CHI 2005 (2005) 641-650
24. Venkatesh, A.: Computers and New Information Technologies for the Home. CACM 39(12) (1996) 47-54
25. Vitalari, N.P., Venkatesh, A., Gronhaug, K.: Computing in the Home: Shifts in the Time Allocation Patterns of Households. CACM 28(5) (1985) 512-522
26. Weiser, M.: The Computer for the 21st Century. Scientific American 265(3) (1991) 94-104