Using Availability Indicators to Enhance Context-Aware Family Communication Applications

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Using Availability Indicators to Enhance Context-Aware Family Communication Applications

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To my husband, George F. Riley,

and my sons, Matthew and Michael Riley.

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SUMMARY

Family conversation between homes is difficult to initiate at mutually agreeable times as neither participant has exact knowledge of the other's activities or intentions. Whether calling to plan an important family gathering or simply to connect with family members, the question is: Is now a good time to call? People expect friends and family to learn their activity patterns and to minimize interruptions when calling. Can technology provide awareness cues to the caller, even prior to the initiation of the call?

This research focuses on sampling the everyday activities of home life to determine environmental factors which may serve as an indicator for availability. These external factors may be effective for identifying household routines of availability and useful in determining when to initiate conversation across homes. Several workplace studies have shown a person's interruptibility can be reliably assessed and modeled from specific environmental cues; this work looks for similar predictive power in the home. Copresence, location, and activity in the home were investigated as correlates to availability and for their effectiveness within the social protocol of family conversation. These studies indicate there are activities that can be sensed, either in real-time or over some time span, that correlate to self-reported availability. However, the type and amount of information shared is dependent upon individual preferences, social accessibility, and patterns of activities. This research shows friends and family can improve their predictions of when to call if provided additional context, and suggests that abstract representations of either routines or explicit availability status is sufficient and may be preferred by providers. Availability prediction is feasible in the home and useful to those outside the home, but the level of detail to provide in particular situations needs further study. This work has implications for the development of groupware systems, the automatic sensing of activity to deal with interruption, and activity recognition in the home.

CHAPTER I

INTRODUCTION AND MOTIVATION

To communicate with a family member or a close friend, one considers calling or going in-person, but it is often difficult to know when it is a good time to interrupt. Some households rely upon an answering machine or service like caller id to screen incoming calls, but these techniques only serve the interrupted party, not the initiator. Envision a world of context-mediated communication, where knowledge of availability (in some appropriate form) is made known to trusted parties prior to any communication action. Just as answering machines and caller id allow potential recipients to make decisions on how to filter interruptions, one may provide mechanisms that allow a caller to preview activity status of an individual in advance of the call. Although it is easy to think of how such context might support appropriate social protocols, it is not clear what kind of contextual cues could be accurately and acceptably extracted from a home to communicate availability.

Providing context-mediated communication services requires knowledge of factors predicting a person's availability for interruption. In office settings, studies indicate that one is least accessible when any human speech is detected prior to the interruption [22]. Patterns of email access and other desktop computing interactions also predict presence in a workplace and may be used to infer communication times and modes [5]. Individuals use mental boundaries on their various roles to manage accessibility; these boundaries are enacted through visible artifacts and behaviors, often associated with particular locations and times [62]. Do similar detectable patterns of predictable interruptibility exist in the home? There are several research initiatives attempting to enable homes with awareness of inhabitants' location and activities [40, 57], but these do not yet provide information on which activities and locations are useful in predicting household members' amenability to interruption. This work examines environmental features of home life as predictors of availability. The goal is to use technology to detect implicitly and share these conditions to

enable human-to-human negotiation of conversation initiation.

1.1 Technology for Home Audio Communication

Family-to-family and family-to-friends conversation which dominates home communication if the focus of this work [76]. What can technology bring to the home that will enable the human to initiate conversation within their close social network? If persons are colocated, then they may take advantage of context cues they can see, hear, or infer. Between locations, one relies upon their memory and technology to provide "virtual" context cues of presence and interruptibility. How will families use enhanced services intended to increase their sociability? How will the mixed blessing of better access fit into home life? This research will identify candidate environmental home factors that are reliable predictors for "busy" families with young children, rather than final answers to these questions. There are costs in adopting any technology, and often a gap between the expected initial uses and the actual use made over time, as seen in studies of new mobile phone users [68]. The challenge lies not just in identifying the important context cues, but also in understanding how the technology may be adapted to support existing needs, such as negotiating the appropriate time to talk.

1.2 Supporting Social Protocols of Communication

Designing household interfaces that support appropriate social protocols across spaces and provide differing amounts of context is an interesting challenge. It is particularly important that context about the status of the callee be communicated to the caller, so that the appropriate social protocol for initiating a conversation can be performed by the caller. Prior to initiating any action to connect to the remote partner, she considers many factors, including time, schedule, reason, urgency, attention desired. What is the time of day at the recipient? Is this time within the appropriate window of time for the household to accept an external interruption from this caller? What is known of the day-to-day and hourly schedule of activities, including dinnertime and activities away from home? Even when one feels comfortable knowing the schedule, which of these are interruptible or on the

other hand are not amenable to disruption? Is the reason for this conversation urgent or time-critical? Is this conversation coordinating and delivering info? Is it fulfilling a social obligation? Or is it both coordinating and building social relationships? What level of attention is expected of the recipient, can it be shared with other household tasks? We will examine how these questions shape the household's understanding of availability and how specific shared context data may be used by the families to determine availability.

1.3 Purpose of Research and Thesis Statement

While there is much research in the workplace investigating availability, there is only recently a similar effort to study interruptibility in home life. This research has begun to explore availability relative to one specific interruption, conversation with a geographically remote, but socially close family member or friend. Recent studies of office workers have achieved availability predictions on par with a person's ability to judge interruption, that is, 70 - 85% reliability [21]. The goal of this work is to find home life indicators providing similar accuracy when used by a geographically distributed family member to determine availability. The work will also contribute an initial framework and relevant features from the home to facilitate building computational models for availability in home life. These findings are a starting point, for perception technology, pervasive communication services in the home, and the design of household communication technology artifacts.

This thesis focuses on understanding how context-aware audio communication may be adapted and used by families to support interpersonal conversation between homes. This research investigates environmental factors of real families in their home life that may be used as predictors of conversation availability. Follow-up evaluations have focused on different aspects of home life availability, specifically, the relevancy of routines, the concerns of context-providers, and the usefulness of availability indicators. The thesis statement is as follows:

> *Technology can assist humans in determining mutually appropriate times to initiate interpersonal conversation. The natural activities of home life may be sampled as a set of environmental factors which then serve as an indicator for family availability.*

These external factors will be effective for identifying household routines of availability and useful in determining when to initiate conversation across homes.

In this statement, *technology* refers to sensors, perceptual computation and other technology in the environment that either detects human activities or marks a change in the home—either of an artifact or a person. This declaration concerning sensing simply frames the remainder of the thesis, which is validated. This work focused on the sampling of everyday activities in family life to define a model of availability and to determine empirically a set of predictors for routine activities and their correlation to availability for inter-home family conversation. One potential validation of home availability modeling would be to match or exceed the 77% accuracy of a human viewing an office situation [21].

This research has focused on how technology can effect the initiation of distributed conversation, determining environmental predictors of availability, and understanding how families might use these indicators. The studies addressed four broad, inter-related questions:

- Are there environmental factors of the home that correlate to availability and how reliable are they?
- How do families define their availability for between home conversation?
- What guidelines can we provide for the design of context-aware digital household artifacts to share with those outside the home?
- How would families benefit from the use of communication interfaces reflecting these environmental cues for availability?

1.4 Overview of Thesis

Family conversation between homes is difficult to initiate at mutually agreeable times as neither participant has exact knowledge of the other's activities or intentions. One conversation may include time-critical requests and information that is important to at least one participant. In other instances, the conversation is an informal sharing of personal

and family activities, connecting socially across space in place of face-to-face conversation. A callee may not be able to engage in a lengthy, serious discussion or the caller may not tolerate background sounds of the remote household activity. The activities and people engaging in them may contribute to this mismatch between desired communication and its fulfillment. In this thesis, family availability is investigated through four studies, adding to the understanding of availability within the home and shared between homes.

To understand how to support initiation of between home context-aware communication, we initially focused on external factors of the home environment, family policies and preferences, and household routines as predictors of availability. First, environmental factors of home life which significantly correlate with one's availability were explored, to determine if context-aware home communication was feasible. Subsequent studies looked at how household routines describe home life availability, what information would be shared with whom, and how useful such context may be in predicting availability.

1.4.1 Availability Studies and Methods

These research questions were investigated through a series of four studies, summarized in Table 1. The ESM Factors study was chronologically the first. It demonstrated the feasibility of this line of research and defined interesting issues for continued exploration. The DayRM Routines and CDA Shared Awareness studies were developed simultaneously, but ES^3M Using Factors was designed later in time, using some results from the first three studies. This association of study names to methods and research questions serves as a map to chapters 3 - 6, where the implementation and results of each study are discussed relative to the contributions for specific research questions.

While the studies share research goals and subject demographics, the methods varied according to the specific questions of interest and scope of the goals for each. Thee ESM Factors and CDA Shared Awareness studies explored the breadth of features and artifacts in the home that are feasible indicators of availability and would be shared with others. While the DayRM Routines and ES^3M Using Factors studies investigated more specific availability questions, as follow-ups to the initial explorations. The research question also

Table 1: Overview of 4 Studies, Methods, Research Questions

ESM Factor Finder	**Availability Factor Finder** **Experience Sampling Method, Initial Study** **Are there environmental factors in the home**
DayRM Routines	**Role of Routines** **Day Reconstruction Method Study** **Are external factors effective for identifying household routines?** **How are routines useful in initiating between home conversation?**
ES^3M **Using Factors**	**Using Factors to Predict Availability** **Experience Sampling-Simulation-Survey Method** **Does context assist people in determining better times to call?** **What are the context sharing tensions between accuracy and privacy?**
CDA Shared Awareness	**Exploring Shared Awareness** **Cooperative Design Activity Study** **How do families use context-aware communication interfaces?** **What are the design guidelines for sharing availability?**

influenced the type of data collected: qualitative, quantitative, or a combination of these. When informed by prior study results, subsequent data and analysis was structured to focus on specific situations, particularly in ES^3M Using Factors. At times, the research questions required more investigator direction, such as in the fleshing out of issues during interviews for ESM Factors and when the research question was very specific, as in ES^3M Using Factors. The role of context was explored, from the perspective of the provider of cues and the friends and family who would use the information to determine when to call. In addition to the two roles, there are also issues of who would have access to the information and the appropriate types of information, as illustrated in Figure 1. In this figure, the "filter" represents both the selective disclosure of context (who gets what) and the appropriate "chunking" of implicitly sensed data (inference and representation). These features are summarized for the studies in Table 2.

1.4.2 Subjects

While the methods varied from study to study, the demographic group of interest was the same—"busy families." The studies examine family members with rich communication networks including spouses, children, family, and friends. Specifically, this research focused on married couples with young children in the home. This work was most interested in

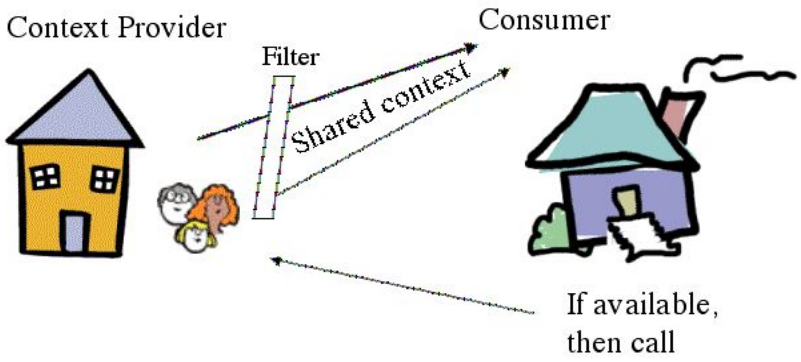

Figure 1: Supplier vs. Consumer of Context Information

the interactions and routines of "busy families," where caregiving tasks and routine, daily activities require coordination and communication, often across households [62]. Parents of children participating in team sports and extracurricular school activities were recruited. This ensured participants had at least one child of the appropriate age, as well as a *busy* schedule of activities outside the home, where coordination communication would most likely be needed. The studies looked at routines that are of particular interest to families with young children, mealtime and children's bedtime. Although the "busy family" is a relatively narrow demographic, it is representative of middle-class, American family home life, with demands for attention from simultaneous activities and frequent interruptions. Other social structures of the home may not have these same routines or coordination strategies, but all will have routines of some type and the ubiquitous "work" of the home—interpersonal communication.

Table 2: Overview of Features of Study Effecting Methods Used

	Study Features			
Study	**Research Stage**	**Data Type**	**Directed by**	**Provider or Consumer**
ESM	Early Exploratory	Quantitative Qualitative	Investigator	Provider
DayRM	Refining Questions	Quantitative Qualitative	Shared Investigator and Participant	Provider
CDA	Early Exploratory	Qualitative	Participant	Provider Consumer
ES^3M	Later Specific Focus	Quantitative	Investigator	Consumer

1.5 Contributions

These sampling studies of actual family life revealed a number of promising factors correlating to availability, including some room locations and activities. For instance, the kitchen is a prime location for sensing aimed at activity recognition, as interruption is more acceptable in the kitchen than other rooms in the house. As expected, engaging in face-to-face conversation indicates one is less available for interruption, independent of the room. Several leisure activities, including TV, movies, and game playing, are significantly correlated to availability. The results of these studies indicate there are environmental factors in home life that can be sensed, either in real-time or over some time span, which correlate to self-reported availability.

This research also contributes to understanding how household routines are valuable as availability predictors. This work found that people talk about availability in their home life relative to routines—patterns of activities characterizing home life. Using relatively easily sensed location information, statistical modeling showed mealtime, children's bedtime and leisure routines may be predicted with moderate accuracy; the accuracy improved, when simulations of more complex sensing of activities were added, such as eating, eating, doing laundry. Leisure routines are positively correlated to availability, but children's bedtime routine has a negative correlation. Mealtime is not a *consistent* availability indicator; individuals reported being moderately available during actual meal routines, even though they generally claimed to *not* be available, when asked about availability policies. Routines are

predictable from fairly simple location sensing, but provides enough information to identify some availability status. Routines may provide an appropriate representation of home life patterns to predict interruptibility, without distracting details.

Another contribution of this research is to provide design guidelines for household services that share context and enhance communication with friends and family outside the home:

1. Provide for individual differences at initial start-up and as family life evolves
2. Provide situation context to augment implicit knowledge
3. Balance context shared with sensitivity to social protocols and accountability
4. Portray the social *face of the home*, not just information

These impact the design of services for between home communication and sharing context. These guidelines influence sensor selection and placement, the inference required to make sense of sensor data, as well as the determination of what context to share with whom.

These studies determined that people are not accurate at predicting availability of friends and family, but additional context information improves their prediction accuracy. People are expected to learn activity patterns and learn when to interrupt friends and family, but they are no better than random guessing at predicting availability for a generic day and time, e.g. Tuesday, 5:30 p.m. When current situation information is supplied, e.g. mealtime or in the kitchen with children, then prediction accuracy improves. This research looked at providing three context conditions: detailed activity and location; household routines; and the combination of both activities and routines. All context conditions improve availability prediction and are statistically significant. However, this data did not reveal a statistically significant benefit of one type of context over the another. Thus, the context which is least intrusive and socially acceptable for sharing may provide as much benefit as very detailed information.

These formative studies of home life availability also highlight three areas in providing computer support for the collaborative labor of home life:

- Personal preferences toward availability are significantly different, between individuals and in response to the same situation. For instance, reading a book and listening to music are leisure activities that were portrayed as by some individuals as correlated to availability and not by others.

- In home life, rhythms and routines appear to have more complex definitions, than comparable patterns of activities in office work. Activities in the home setting are not as constrained. Individuals routinely move between multiple bedrooms, the kitchen, and various living areas, each with its own set of devices. For example, there is a breadth of activities both predicting leisure and on average three different activities occurring within any single leisure time.

- Balancing privacy desired with one's shared availability, is an on-going tension in the social construction of home life and its boundaries. In home life, communication is social and relational, not focused on tasks and data. Sharing information for the purpose of enhancing call initiation, changes this balance, in ways that may actually detract from the social purpose.

In the remainder of this thesis, Chapter 2 summarizes the background and related work in technology enabling home and family conversation, defining context-aware communication, and understanding interruptions and availability. Chapter 3 discusses the natural indicators of availability, their accuracy and scope in the household. Chapter 4 investigates household routines and their relevancy to availability. Chapters 5 examines the need for additional context when predicting another's availability. Chapter 6 describes how this information may be used in the design of a home-based service and how is it shared. The sum of these individual contributions are discussed, along with their impact on the design of home technology in chapter 7, along with the direction of future work suggested by this thesis.

CHAPTER II

BACKGROUND AND RELATED WORK

In this chapter, we discuss work related to family communication and interruption. We begin with research in domestic environments and technology, specifically the prominent role of communication in home life. We look at how communication technology supports interpersonal communication, including telephone enhancements and their use in everyday life. Sharing awareness between communication partners is another approach to facilitate communication in many settings. What are the specific contextual indicators of interruption, in the workplace or at home? We also discuss the implications of shared-context in negotiating social interaction across homes.

2.1 Technology in the Home

The home is not just filled with family members, food, and furniture, but is also *technology-filled* for entertainment, communication and the often invisible household infrastructure. Work and home life are frequently inter-twined, encouraging the migration of workplace technology into homes. But, there are several importance differences between home and the workplace [31]:

- greater diversity within family and structure,
- differing motivations,
- organizational structures.

Offices are built to accommodate technology and businesses hire experts to install and modify new technology. Homes are not designed to handle technology on this same scale and home owners generally expect to "plug-in" new technology, have it work and look good. Home spaces accommodate the special needs of babies, young children, the elderly and even pets. In contrast, offices support the adult population, accommodating special

needs of wheel-chairs and the blind. Home consumers are more often concerned with the aesthetics of the technology and their desire to own it, then with any productivity gain [31]. Finally, families are not miniature corporations in either the way they make decisions or set values [31]. These differences motivate the investigation of what sociology and ethnographic studies can contribute to the computer scientist's view of technology at home.

2.1.1 Effects of Technology on Home Life

There are a great variety of single-function, stand-alone technologies in the home (e.g. refrigerators, vacuum cleaners, televisions) [91]. These technologies are well integrated into the home and were designed for household tasks, not transformed from industrial appliances. On the other hand, the acceptance of the telephones into homes is an interesting example of an "office" technology integrating into the household. In Fischer's study of telephone adoption and use, safety and business were most often cited as reasons for acquiring a phone, but they were actually used to support a variety of existing social practices[20]. Similarly in the 1980s when personal computers entered the market and the home, researchers began looking at how home computer use changed behavior at home [93]. These studies show time allocation at home changed, most significantly for those household members with prior computing experience and varied with the number of children in the home [93]. Others documented significant changes in home-use of the PC between the 1980s and the 1990 [91]:

1. new technology, like Internet, multimedia
2. more areas in home are targeted
3. more software targeting household needs
4. acceptance of computer as useful in the home
5. home is a new target for technology innovation

From these longitudinal studies, Venkatesh also found the computer was both used and perceived as an essential communication tool for the home. Venkatesh sees the household as a social and a technological space, where both dimensions are needed to identify family

dynamics to determine how new technology may be used [91]. In a pioneering longitudinal study of how the Internet was used by 229 individuals during their first year, interpersonal communication (use of email) was found to be a stronger driver of use than information gathering and entertainment [44]. Interviews portrayed email as a means to both maintain and "energize" relationships [44].

In addition to these empirical studies, ethnographic work in the home also highlights the value placed on communicative activities and the need to distribute technology across spaces within the home. Interactions and coordination of activities common to the routine of households evolved around shared use of space and existing technology in the house [63]. They termed this problem "space overload"; when technology is fixed in a particular location, as opposed to being distributed throughout the home, problems can arise over shared use of the space [63]. Another study found communication between collocated household members was most often in small time blocks and dispersed over multiple spaces within the home [49]. These intra-home communication patterns and the desire to decentralize technology both suggest that any computationally enhanced communication system should be accessible throughout a home, instead of being centered on the few places that might contain a personal computer or even localized to special-purpose appliances hung on the walls.

2.1.2 Effects of the Home on Technology

Taking the view of Venkatesh [91], that family dynamics influence the adoption and use of technology in the home, we look at how families interact at home. Even in the 1960s, the relationship of family interactions and patterns were compared to the house size and room layout [85]. The relationship was more complex than a simple proportion of square feet per potential personal relationship within the family. Ethnographic methods have been used to understand the complexity of family routine at home and the technology within homes. O'Brien *et al.* worked with eleven families in the United Kingdom, who varied in composition and how they used various technologies, but each had routines and allocations of space arranged around the technology [64]. The interactions with technology

were managed activities, part of the implicit and explicit family procedures. Like the other home studies, they found technology needs to support distributed activities in the home and aesthetic ally pleasing technology. Domestic routines are also part of the ethnographic explanation of how to make technology "invisible in use" [88]. In another ethnographic study of routine activities and technology use in the home, the communication places are distributed, but articulated in routines [11]. Each of these detailed accounts of home life speak to looking deeper into the everyday life of the home, not taking the averages or the norms as descriptive. Instead, these speak to examining the details that more richly describe the family specific routines and space allocations, that both effect the use of technology and are effected by the technology.

2.1.3 Designing Technology for the Home

These lessons in the richness and individual differences between families provide the basis for many home-based technology investigations. "Technology probes" are one such technique used in households both in Europe and the U.S.[38]. These simple, but adaptable technologies are useful to understand the users in the real-world, to provide an engineering field-test of the technology, and to inspire users and technologists to think about new designs. These probes were playful and showed a wide variety of uses, leading to the creation of new technologies for families. The Digital Family Portrait was similarly informed by field tests and Wizard of Oz studies to acquire realistic and rich user experiences shaping iterative development [55]. The Casablanca project has explored new forms of home communication through lightweight ethnographic studies and by deploying prototypes within homes [32]. They found new approaches to home communication were welcomed, especially those using simple, "lightweight" interactions. Home users want technology to facilitate existing communication needs, while not obligating them to extend existing social interactions and responsibilities.

2.2 Interpersonal Communication

Communication plays a prominent role at home, and is closely linked to the adoption of technology into the home. Time use studies indicate 28% of "free time" (11.1 hours per

week on average), are spent in socializing and home communication, that is, not paid work, family care or personal needs, [76]. Conversation is evenly split between home, telephone and correspondence plus resting. However, time in conversation is lowered by longer work weeks, among married people, having more children and younger children in the home. Interpersonal communication is an activity of choice and possibly obligation in the home. We look at current technology support for conversations at home, enhancements to these services, and understanding how we use communication technology.

2.2.1 Communication Technology in the Home

Interpersonal communication is defined as contact between persons, ironically synchronous audio technology is most often device or location-oriented. A lack of knowledge of the whereabouts or activities of other family members can hinder effective and civil communication. To facilitate conversations between remote parts of the home, some households utilize intercom systems, but these systems have their drawbacks. They require one or both parties to go to specific parts of the house or hold onto a handset in order to communicate. They also offer little ability to direct communication to a person within the house when the location of that person is initially unknown. The initiator may poll through each station or broadcast to all locations. Both methods intrude on others and may have such negative effects as to deter their use, like waking a sleeping child. Baby monitors are another technology used in homes for security, peace of mind, and to detect changes in audio levels. Handheld walkie-talkies are a mobile version of the station-to-station intercom. Here the device may be associated with a particular member of the household, but they must both have the device with them and have service activated for a connection to be made. Telephones are more widely deployed than the intercom, in over 98% of American owner-occupied home units and 95% of rental households [7]. The phone again relies upon connecting devices, with no knowledge of the situation at the other end, or if the intended recipient is present. In the usual intercom model or telephone station model, the participants are tied to the location of the equipment. Some research systems have tied location information to telephone systems [94] but they still require explicit interactions with a device, taking attention away from the

primary activity of person-to-person communication. Current audio technology support for informal, interpersonal communication uses a device or location based connection and lacks support to enable the caller to determine, prior to initiating a call, if this is an appropriate time.

2.2.2 Augmenting Telephony

Several projects have attempted to provide more awareness of the other person and to lower the connection creation cost of telephony services by enhancing phone system functionality by integrating contextual information into telephony systems. In some instances, the telephone owner explicitly enters contextual information to be shared with any callers. Once the potential caller has this context information, the application allows the caller to decide the appropriate communication action, such as continue the call, leave a message, or even cancel the call [52, 70]. Turning this around, Quiet Calls and Taming the Ring enable the recipient of a cell phone call to discretely send an appropriate pre-recorded voice message, such as "in a meeting, I will call you later" [59, 71]. In this case, the recipient determines the context to send to the caller in real-time and the caller is still expected to respond appropriately. These additions to telephony provide some means of negotiating communication situations and supporting person-to-person connections. Many augmented telephone systems integrate the contextual information with the ability to easily initiate the appropriate communication. For instance, live addressbook uses click-to-dial technology to automatically create the connection between the phone numbers currently specified for each person in the call [52]. This has the added benefit of providing one personalized interface to control calls, relieving the caller of dealing with other phone interfaces (pay and metered). Calls.calm provides a means for the caller and callee to interact and determine a good choice of time and communication channels [70]. This smooth transition into the connection seems to "stretch" the initiation for the caller in a very natural and productive manner. Augmented telephone systems are exploring how to lessen the interaction cost by coupling the connection request with the contextual data, usually explicitly entered by the callee for use by caller to determine when and how to communicate.

2.2.3 Understanding Communication Technology

There is a temptation to believe technology will be used as designed, for practical uses, and as an expression of the culture where it is used. We focus on the "user", adapting communication technology to sometimes contradictory uses and independent of marketing advice on how to use it. In *Calling America*, Fischer takes a historical look at the adoption of the telephone across the U. S. He attributes adoption to both need and desire, like other consumer goods, and its use was to enhance existing social patterns, not to create new relationships over long distances [20]. This is in contrast to the American use of the automobile to go "touring" and widen their world. More recently, we have seen the mobile phone nearing ubiquity (over 158 million subscribers in America) [7], and seek to understand its adoption and use. In a study of 19 first-time mobile phone users, security, safety and business-related reasons prompted the acquisition [68]. As with landline phones, the mobile users actually put them into social use, rapidly modifying their perceptions with personal experience. In just six weeks of use, each participant had developed a phone routine to fit with their individual situation, including increased mobility, increased accessibility, and calling on demand [68]. Both landline and mobile phone adopters shared practical reasons to acquire new technology. In practice they were used as tools for socialization, but in ways unique to the individual or community.

Another view of communication technology is to study the conversational styles and expectations that evolve in use. Longitudinal studies of home phone use in the U.K. revealed the influences of factors, like role, location and gender, on patterns of interactions and social use [46]. For instance, we each have life rhythms we expect callers to know and use to call at appropriate times. They found some gender differences in phone use. Men tend to use the phone as a tool and more often are characterized as wanting to be contacted. In contrast, to the prevalent female view of the phone to facilitate social relations and to be more proactive in contacting others. Push-to-talk, two-way cellular radios are another wide-area, private voice communication that have been explored recently [96]. In this exploratory study of half-duplex, lightweight interaction within a very close social group, the technology decreased the conversation commitment, resulting in delayed responses and

interleaved activity. There were many conversational styles exhibited, and in particular intermittent conversation, where long pauses breakup the communication sequence. In this way, cellular radio resembled instant messaging. Instant messaging lacks the emotional affect of audio, but it's persistence supports the use of IM as a social space [58, 28]. Teenage use of IM closely mirrors their real space relationships and is subject to the same peer expectations of being "on" and available for socializing and event planning, while attending homework on the same computer. While we are more interested in synchronous voice communications, the lessons learned from the use of lightweight IM and cellular radio, indicate support for less synchronous and lightweight interactions may help promote two-way audio communication. In addition, the practices of phone use point to support of life rhythms when initiating calls and varied support depending upon how one is using the technology, as a tool to make arrangements and to build relationships.

2.3 Context-Aware Communication

We are interested in exploring *context-aware communication, that is, "the class of applications that apply knowledge of people's context to reduce communication barriers"*, as defined in [81]. Schilit characterizes these applications by the form of the communication action and the acquisition of context, along a continuum from manually-entered to automatically-sensed. The augmented telephony systems discussed in section 2.2.2 are examples of context-aware communication applications, as are the variety of media space applications. Media spaces provide presence information along with seamless interactions. The persistent connection of media space uses the medium itself to create a group interaction [6]. Desktop conferencing tools couple awareness information with a means of creating a connection, usually through a GUI [15, 42]. In contrast, the Somewire audio-only space finds the graphical and tangible interfaces are not suited for audio space interactions, but that presence information is highly desirable [83]. An audio space acts like a service and seems to work best with a simple interface; users do not understand or use most audio controls, such as fading, bass and treble. Media spaces and desktop conferencing couple presence information with interactions, inherently enabling persistent, context-aware, lightweight communication. The

philosophy of less is more for interface design is one lesson taken from the variety of media space interaction techniques surveyed.

2.3.1 Representing Digital Social Interaction

Explicit scaffolding of social interaction, especially to enhance group communication, has been explored in many digital forms. The Talking in Circles visualization provides persistence to the conversation, enabling group membership, similar to the Cocktail-party effect, and awareness information, such as length of time chatting [77] . The "social proxy", an animated, graphical representation of chat in Babble, portrays the group conversation and individual presence with a simple graphical expression of the digital activities of people [18]. ContactMap, a desktop representation of a user's social network of contacts, provides visual presence of a contact and serves as a reminder signal, to whom and when to communicate, through a variety of modes [95]. In addition to serving as memory aides, these desktop communication tools use visualizations to overcome the fading of speech and graphical animation to support conversational turn-taking. Visual representations of context and animations of activity may be good design choices to augment voice communication.

2.3.2 Use of History in Digital Interactions

While conversation is usually considered synchronous, there are also benefits to supporting asynchronous talk over a period of time. Time lines showing key events chronologically, and sometimes accompanied with visual or written commentary are often used to show social interactions [73, 18]. Lifelines were one of the first to show personal history and provide user interactions to manipulate the view to find trends and irregularities [73]. Babble's Timeline social proxy provides a line per participant providing a sense of the rhythm in an on-line text chat and a sense of those "listening" as well contributing [19]. The sense of rhythm is also portrayed in studies of Awarenex users' visualizing their raw data over time and the data fit to a model over blocks of time [4]. Users held a wide range of preferences across the visualizations, as well as the accuracy achieved and privacy concerns raised. Donath et. al. have designed a series of graphical chat programs to enhance social interaction and communication, and [13]. In PeopleGarden, a flower represents personal data, and

the collection of flowers for all members of the on-line environment forming a garden, a visualization of relative longevity on-line, and patterns of interactions [97]. By contrast, Chat Circles originally had a separate history view, but eventually integrated interaction with a spatial representation [92]. Each of these visual representations of communication, portrayed the advantages to enhanced interaction through persistence of both synchronous and asynchronous communication channels.

2.3.3 Context-Awareness at Home

Until recently, most context-sharing research looked at productivity tasks and technology-enhanced environments, more appropriate for office work, than to the home [15, 42]. Mobile and wearable personal technologies have brought these explorations to social interactions that integrate to some degree into home life. For instance, audio signals and presence information may be quite a problem and disruption in the home. One single-user solution, Nomadic Radio, a wearable device relying upon contextual information to infer location, uses an audio-only interface to signal email and news updates, as well as providing "Voice-Cues" to identify the sender of an email [80]. This wearable device also provides awareness to the user via a background sound of flowing water, again tuned to the user model it builds and location information. This system illustrates some ways the audio channel may be used for mediating communication, notifying and providing background awareness, in a wearable, single-user technology. A wristwatch with context sharing, WatchMe, is designed to keep intimate family and friends connected via a variety of communication channels and shared cues [48]. The prototype conveys location, activity and speech info and signals when it has been viewed. Impromptu, hosted on a PDA, provides person-to-person audio communication via an audio interface, augmenting the connection set-up action with context and channels changes [82]. The caller is allowed to "eavesdrop" on garbled audio once the potential recipient activates their device. The mobile phone is another personal device providing location information to facilitate effective communication among family and friends. In a recent study of the Reno prototype, users preferred manual location disclosure, as it

does not suffer from the costs that automatic reporting incurs[84]. These personal context-sharing solutions depend upon the participants wearing or carrying technology and devoting cognitive resources to the shared context received and sent.

Instead of outfitting the individual with technology, other researchers are equipping the home environment and sharing what the home knows about its occupants to facilitate social interactions. Casablanca investigated how media space ideas could be adjusted to family and home life, using both ethnographic studies of homes and prototypes of novel communication technology [32]. These home implementation studies showed homes are distinct from workplaces, demonstrated the potential for research in social communication, and offered design guidelines for such household concepts:

- home users desire for self-expression, valuing minimal info, and simple designs;
- look to ease the cost of fulfilling social obligations, without adding to them.

Following up on the distinct ways families use communication devices, "technology probes", simple, open-ended and co-adaptive concept devices used within homes, have informed the design of family communication technology [38]. A messageProbe and videoProbe highlighted the many coordination needs of families as well as their desire to have fun within the family. A recent field test of ASTRA, a system supporting family awareness through lightweight, mobile sharing of pictures and freehand drawings, provided some evidence of affective benefits [47]. In fact, the distributed family members that saw each other less-frequently benefited more from these every-day shared experiences. Each in-home study explored the benefits of designing communication and awareness technologies for use by active families between homes and for mobile family members.

Other investigations of technology in the home have focused on supporting the elderly at home, their health concerns, social connections, and memory aides. Qualitative data and prototype trials in elderly households have provided general design guidelines [53]:

- meet social needs of reciprocity, diversity, broadness
- overcome social barriers of memory, pacing and infringing on independence.

One prototype developed in response to these guides, is a two-way communicator of availability for a synchronous activity, walking and exercising together, but one can envision its use for availability for conversation, as well [54]. While disruption and recall are a problem for all, Cook's Collage is evaluating the effects of a visual display as a memory aide for cooking, especially for the elderly [89]. There are social benefits to both the elderly and their distributed family when activity information is shared [79]. In the Digital Family Portrait long-term field trial, sharing an elderly parent's in-home movements with her son via a traditional, but digital, portrait, led to more awareness and an increased sense of connectedness. While the portrait shared a qualitative sense of activity derived from a single type of sensor, invisible to the home occupant, others have utilized a collection of sensors [2] in home field trials. These findings reinforce many of the points stated in other home research, including, individual differences matter, the need to respect participants' home life, privacy issues are quite subtle, and there is no *normal* week. From the data gathered by mobile devices and the environmental sensors [41], some researchers envision *just-in-time* interfaces delivering appropriate information to motivate long-term healthy living [39]. We can use the design and data gathering lessons learned in these investigations of how technology can enable the elderly to live independently, while bolstering social needs and overcoming some social barriers.

2.4 Routines Define Home Life

Just as temporal rhythms exist in work practice, time-based routines both define and interact with home life. Longitudinal studies of home phone use in the U.K. revealed the patterns of interactions and social use and how callers are expected to know life rhythms and use that knowledge to call at appropriate times [46]. Routine behaviors are frequently seen in home life, not just in the allocation of activities and childcare, but to minimize the overall mental cost of when and what to do, ordering the chaos of competing roles in the home [62]. Social protocols explicitly pay attention to these boundaries, especially when interrupting at pay attention to these boundaries, especially when interrupting at home, one is keenly aware of the prevailing routines of the household. While exploring how to

make technology "invisible in use", Tolmie et al. provide a working defintion of domestic routines [88],

> *"Routines mean that people can get out the door, feed themselves, put the children to bed, and so on, without having to eternally take pause and invent sequences of action anew or open up their every facet for inspection or challenge or to constantly have to "account" for what they are doing with explanations or rationales."*

This sets the challenge, defining routines is a task of revealing the unnoticed. Ethnographic studies have investigated domestic routines involving "the knock on the door" [88], organizing systems [87], and communication activities [10]. These studies show the communication centers of the home are distributed, but articulated in routines [10]. Organizing systems in the home, such as lists, calendars, and notebooks, organize the routines and schedules, and also the social interactions among the household members. [87]. Each of these accounts of the home point to looking deeper into everyday life of the home, examining the details that more richly describe the family specific routines and space allocations.

2.5 Understanding Interruptions

Our interest in using technology to enhance between home awareness is based on the assumption family members want to find better times to interrupt one another to communicate. The start of a conversation is inevitably an interruption, whether desired or tolerated, but one the initiator intends to be mutually beneficial as reported 64% of the time in the office [65]. As we have seen in other studies of technology benefits to home life, beneficial interruptions may result in finding a time to exercise with a friend [54] or *just-in-time* reminders of healthy living choices [39]. One way technology may positively effect social interactions is to provide information to the human that will help in determining or negotiating a time for interaction, whether walking with a companion or conversing. We are encouraged by predictors of availability, presence and rhythms in the workplace and seek to look for comparable indicators in home life.

2.5.1 Defining Interruption

Our home and work lives are communication intensive, using telephones, email, instant messaging, and face-to-face conversation. In fact, some managers in the workplace find interruptions as integral to their job [36]. The telephone is an example of how people engage in an isolated conversation while working on another task, but it is also the source of disruption to good decision-making [51]. McFarlane has developed a taxonomy of human interruption and investigated one of its general factors, method of coordination, the method used to determine a time to interrupt the human [51]. In a study comparing the four techniques, immediate, negotiated, mediated and scheduled, negotiated was found to be best overall, but not for every situation. These results are based on a computer-based interface for multiple tasks and disruptions, not the typical home life routine. Horvitz and Apacible have represented interruption as a model of the cost, including not just desktop computing events, but also calendar events, and fused visual and auditory events from the environment [34]. Notification Platform, a tool associated with this model, enables users to tag video segments of themselves with personal cost labels and and dollar value. This provides the basis for building and testing models using a Bayesian network, with the ultimate goal of model reuse and transfer. Attention is a constraining factor in notification systems, that are interrupting by definition. To account for the constraints of attention, McCrickard and Chewar propose framework of attention costs vs. utility benefits of the interface, including comprehension, reaction, interruption and satisfaction [50]. For the initiation of conversation between homes, the attention costs would be relative to the context of the interpersonal relationships, the current situation context, the individual cognitive and mental load abilities, and the type of information communicated. While none of these models has been applied to the "busy family", we build from these models of interruption and attention costs to develop a framework of interruption for the home.

2.5.2 Predicting Availability

Once models of interruption are constructed and tested in desktop settings, there is the subsequent challenge of determining reliable and scalable methods of gathering such data

and extending it to cooperative uses. In an extension of McFarlane's study of the effects of different user interruption techniques [51], Dabbish and Kraut have explored the effects of team membership and the use of awareness displays in timing communications [12]. The awareness data was only beneficial when its use benefited the team, and the high attention cost of detailed context data did not improve the benefits over a more abstract awareness display. This finding is corroborated in Hudson's study of managers, where interruptions were viewed as part of the work and to be managed for the team [36]. BusyBody, an ancestor of Notification Platform modeling interruptions, has been used in field trial to gather data and to construct models predicting the cost of interruption [35]. They found a two-state decision choice for availability was easiest for users. The accuracies of these models were 70 - 87%, and reflected several key variables not associated with the desktop; day of week and time of day were in the top ten variables for all four subjects. Similar interruptibility predictions were achieved in a series of studies first using wizard of oz techniques to hypothesize which sensors would provide the best predictive value, and then following with actual low-fidelity sensing [22, 37]. In this case, machine learning was used to predict interruptibility and was compared to the benchmark of accuracy of a human viewing the video, with no additional context-cues other than the few minutes prior to the interruption (about 80% accuracy). The detection of speech alone was as good a predictor as the human in these models. Further studies using low-fidelity microphones on laptop computers verified the simulated studies [22]. These robust predictors of interruptibility were then applied to a context-aware communication client, MyVine, providing automatically-sensed info about the situation and availability of associates [23]. In this study, the model predicted availability shared and used as a presence indicator, rather than an indicator of whether or not to disturb, similar to the reported uses of Awarenex rhythms of use [4]. While the predictive power of environmental factors in the workplace can replicate the human ability to determine availability, it's appropriation within social protocols is yet to be studied. We are encouraged by these workplace studies to see the potential for similarly predictive external factors of interruptibility in home life. We are interested in determining what such factors would be in the home and how they would be used, within existing social protocols or in

evolving family interaction patterns.

2.6 Methods for Homes and Interruption

It is often difficult for researchers studying home life to get at the richness and complexity of experiences inside the home. Laboratory studies allow researchers to carefully look at variables of interest, but they necessarily cannot account for the complex social systems that typically interest home life researchers [9]. In this section, we look at the methods and approaches others have used for office availability studies, then we look at methods used to study homelife technology.

2.6.1 Methods Used in Determining Workplace Availability

Most methods employed in the workplace to assess availability have relied upon self-reported availability, sampling activities in context. Availability is difficult to determine from observation. Researchers must ask participants for self-reports on such internal status. In workplace studies, investigators instrument the desktop computer to record actions of interest, such as interaction with applications and input devices [34]. When activities off-the desktop are of interest, then video recordings of the office space often provide the context of use, as if an observer were present [34, 22]. Both audio and video are coordinated with the participant's reported availability, to determine predictors, such as presence of other people or conversation in the office. Gathering the participant's availability status may be randomly requested or in response to particular event(s) of interest in the office space. In either case, the participant's response must be recorded along with the activities associated with that status. Availability can be reported as a binary status or it may be a value from a continuum, for instance related to the dollar cost of an interruption [35]. These workplace methods for studying availability rely upon desktop instrumentation and video to record context and to query the individual as to their availability. Neither of these data gathering methods are well-fitted for the home. Homelife is not centered on computer interactions, but is distributed across rooms [64], so a mobile data gathering method would be more appropriate. Homelife is often considered private, so video recordings may be limited to certain "public" spaces or specific times of day, or not desired at all.

Other workplace studies have looked at availability across locations, in the conference room and in the hallway, not just at the desk or in relationship to their computing activities. In one such study, participants were asked to carry a paging device to collect samples as they move about their workday locations, rather than just record activities at their desk [36]. This is an example of the Experience Sampling Method, where the participant is asked to provide some context about their experience just prior to the notification. In this study, the paging device not only alerts the participants, but it also presents the survey and records their responses regarding current context of activity and interruptibility. To supplement the recorded situation and availability information, follow-up interviews help the researchers better understand the survey responses and those occasions when a survey was not completed. While the paging can be intrusive on the participants, it may be less so than an observer or a video. This method would also fit into the fluidness of homelife, allowing the survey to go with the person, from room to room.

2.6.2 Methods Others Have Used in Home Technology Research

It is often difficult for researchers studying home life to get at the richness and complexity of experiences inside the home. Laboratory studies allow researchers to carefully look at variables of interest, but they necessarily cannot account for the complex social systems that typically interest home life researchers [9]. Social scientists have built special purpose homes to study family interactions and privacy, where the spatial arrangements of the house were controlled, but the family life was not controlled [85]. Recently, computer scientists have also begun to investigate actual home environments [57, 2]. The technologists are seeking to understand how people interact with others and their environment and how these activities may be influenced by new technologies. Even in these "home" laboratories, a variety of methods can be used to inform the design and development of useful and usable home technology.

2.6.2.1 Interviews and Observations of Home Life

Research in technology for home life has employed methods from social sciences, but with care to not disturb the privacy expectations and normal routines that characterize home

life. When the adoption and use of existing technology is the focus of the study, familiar techniques, like questionnaires and interviews are useful. Interviews have provided insights into teens' use of instant messaging as a social medium of choice among several media [28]. Other researchers have been interested in the everyday activities of the home, and use ethnographic inquiry to identify these. When the focus is on the home as a location, then contextual interviews take place in the participant's home so the specifics of what is used and where it resides can be directly shared with the investigator [17]. In one series of studies of routine work in the home, twenty-two families were video-taped for several days [10]. In the initial study, cameras were installed in particular locations in the home and revealed the prominence of communication activity centers [11]; their follow-up study focused on communications, enlisted the participants to video communication artifacts entering or leaving the home and to log the context of each [10]. This approach allowed the researchers to gather rich data and to involve the participants as collaborators, where the logs and video served as "conversational resources" to reveal social arrangements that technology would need to respect [10]. To understand the activities and social interactions within the home, either with technology or other home artifacts, researchers may use video or interviews to "observe" homelife activities of interest.

2.6.2.2 Prototypes for the Home

Other researchers in the home have used probes and prototypes to study user interactions in the home. In some cases, designers seek to engage the subjects in storytelling about their home through the use of "cultural probes", articles designed to evoke richer responses than surveys and interviews [24]. Researchers also borrow technology ideas from the workplace and incorporate them into the domestic environment. The Casablanca project was inspired by media spaces, and built prototypes for limited use in homes [32]. "Technology probes" fuse these approaches, by deploying simple, flexible technology prototypes in homes, where the participants become co-designers as they adapt the probe to their particular use [38]. Probes are one approach researchers have employed to gain valuable user input in the absence of actual systems. Prototypes provide some concrete form of the intended technology

to elicit more informed user opinions, prior experience with an actual system [61]. In addition to probing prototypes, high fidelity prototypes have been used to study how people would use a technology service. A field study of the Digital Family Portrait prototype installed to share presence information two family member's homes, showed value to both households, even when the technology was invisible in one home [79]. In another study of everyday memory aides, the Cook's Collage prototype used 'Wizard of Oz" simulation of perception technology, creating a real-time user interaction, informing the design of such an aide and where to focus perception research [89]. Creative use of prototypes have informed the design of new technologies for home use, both in identifying where computation may be most useful and how it may be appropriated within social interactions of homelife.

2.6.3 Diary Studies in Homelife

In other instances, researchers use diary studies to gain insight into people's feelings and experiences to inform the design of future home technologies. Traditional diary studies ask the user to record their experiences and/or feelings in a paper diary, either at scheduled times or in response to a particular event. Unlike observations or video, in the diary the researcher can ask about human feelings that are not discernible, such as when a particular technology might be useful and when it might be annoying. One such study asked participants to record in a portable diary any instances when an audio memory aide would have been useful to them [30]. In this diary study, the participants recorded only situations of interest to the researchers looking at a innovative technology. Another diary study of new mobile phone users, asked the participants to record their experiences with the phones on a voice-mail system [67]. In this case, the technology aided in collecting contextual data from new users, increasing the user participation and providing a rich usage information [67]. Diary studies are a good way to obtain detailed, interpreted responses, while minimizing the intrusiveness into the participant's life. The responses are dependent upon the subject's memory, remembering to record the diary and accurately reconstructing events and feelings. Diary methods have proven to be a good match for home research, where the members move from room to room, and technologies needs to be assessed anywhere in the home.

However, time estimates from self-reported diary studies are often flawed since individuals tend to be poor judges of time when reflecting on their daily activities [1, 45]. The Experience Sampling Method (ESM) was designed as a way to obtain better estimates of how people really spend their time [45]. In this method, subjects wear some form of a pager that randomly goes off during the day. When the pager goes off, the subject fills out a survey—either on paper [25, 45] or, more recently, on the device itself [1, 8, 36, 41]. The survey asks participants to answer questions about their attitudes and activities only at the moment the pager went off. As such, this reduces the distortions observed in methods requiring greater recall and reflection. Because ESM samples subjects at random times, it can provide a fairly good overview of major activities in which people engage. The paging allows investigators to collect data when an observer would be considered intrusive. The device may also control the time gap between the alert and response. Results from ESM studies tend to miss rarely occurring events and transitions between events. While the "beeping" can be inconvenient to the participants, a carefully planned ESM study can provide both rich data insights from the participant's home life and empirical data to support statistical development of models in homelife.

2.7 Summary

Much research has been done supporting conversation across spaces, most often related to the "desk". In the office, the desk is the place where one is "working" and "desktop" computer applications both enhance efficiency and detract with interrupting notifications of email and scheduled reminders. Studies of workplace interruption have found reliable interruption predictors at the office desk. But home life is not office life. Can the activities of the home provide reliable availability predictors, while maintaining the autonomy and privacy of the household sharing its availability? Technology in the home is no longer confined to the personal computer on the desk, but it is merging with the home entertainment system. It is commonplace for homes to have persistent and high-speed connectivity to communication networks. Wireless routers are cost effective in the home, potentially enabling distributed, invisible computing in the home. There are many safety and health

benefits to persuade one of the benefits of additional technology in the home. We propose addressing the gap between what technology is able to do and how the household members would really use it to predict availability. We specifically look at how a home which is aware of particular environmental actions may aid the human in negotiating conversational availability across homes within a close social network.

CHAPTER III

FACTORS PREDICTING AVAILABILITY IN THE HOME

To communicate with a family member or a close friend, one considers calling or going in-person, but it is often difficult to know when it is a good time to interrupt. Some households rely upon an answering machine or service like caller id to screen incoming calls, but these techniques only serve the interrupted party, not the initiator. Providing context-mediated communication services requires knowledge of factors predicting a person's availability for interruption. In office settings, studies indicate that one is least accessible when any human speech is detected prior to the interruption [37]. Patterns of email access and other desktop computing interactions also predict presence in a workplace and may be used to infer communication times and modes [5]. Do such patterns of predictable interruptibility exist in the home? There are several research initiatives attempting to enable homes with awareness of inhabitants' location and activities [41, 57], but these do not yet provide information on which activities and locations are useful in predicting household members' amenability to interruption.

To determine if there are any externally observable factors in home life that correlate with availability, an Experience Sampling Method (ESM) study using PDAs asked subjects for both situation data and availability at the moment. This study examines family members with rich communication networks including spouses, children, family, and friends; more specifically, married couples with young children in the home. Although this is a relatively narrow demographic, it is representative of family home life, with demands for attention from simultaneous activities and frequent interruptions.

In the ESM Factors study quantitative survey data was analyzed using both descriptive statistics and a hierarchical logistic regression on availability to identify statistically significant variables to predict availability. Descriptive statistics of the aggregate data were consistent with other time use studies in American homes, showing multiple simultaneous

activities with communication activities dominating [76, 86]. Descriptive statistics of individual availability revealed a large variation, ranging from individuals available only 40% of the time to others available 80% of the time. The hierarchical regression analysis using the aggregate survey data also revealed individual differences were statically significant in predicting availability. The kitchen appeared most frequently out of all the locations and is statistically the strongest availability predictor. The other locations such as living room and bedroom, are weaker predictors than the kitchen, but are still statistically significant. As expected the analysis shows face-to-face conversation is statistically significantly (p = .018) and negatively (B = -.772) correlated to availability. The other activities that are statistically significant are leisure activities and are positively correlated:

- Watching TV or a movie (p = .002, B = 1.237)
- Game playing (p = .002, B = 1.994)
- Other leisure activities (e.g., listening to music) (p = .011, B = .879)

Interview data suggested that availability would be predicted by time of day, but this sampling data and the linear analysis technique did not reveal such a statistical correlation. The participants described their availability in terms of patterns of activities, such as dinnertime and children's bedtime. Routines, changes in activities, and transitional times appear to be the *language* people use when describing availability in the home. The ESM Factors study was designed to sample locations and activities, and did not collect data about routines and transitions. Future studies could gather the appropriate data to determine predictive power of routines. This ESM Factors suggests sensing to predict availability should be directed toward *public* living areas to detect conversation, eating, watching TV and other leisure activities. This work has demonstrated the feasibility of availability prediction in the home and suggests further areas for investigation.

3.1 ESM Factor Finder: Method

To determine relevant and reliable environmental predictors of home availability, this study used Experience Sampling Method (ESM) to gather real situation data on interruptibility

and presence of others, room location, and routine activities in the home for busy families with children. Hierarchical logistic regression was used to investigate correlation between self-reported availability and these environmental factors.

3.1.1 ESM Factor Finder: Method Overview

It is often difficult for researchers studying home life to get at the richness and complexity of experiences inside the home. Laboratory studies allow researchers to look carefully at variables of interest, but they necessarily cannot account for the complex social systems that typically interest home life researchers [9]. While no research method is perfectly reliable, a combination of ESM and interviews was chosen as a way of dealing with the complexity of home life, for more details on ESM see Section 2.6.3. This combination of methods aimed to achieve a balance between the richness of data that an interview provides and the somewhat more objective data that ESM provides.

Eight subjects participated in an ESM study for one week each. Individual availability profiles were generated from the ESM results to help structure follow-up interviews. In these interviews, the subject was asked to review and reflect upon the accuracy of the individual profile. By coupling empirical data collection with participant interviews, it is possible to examine data that the ESM method had "missed" and understand the individual's availability responses. ESM logs of missed surveys provided a means of understanding potentially significant data the sampling technique did not capture. A *missed trial* was recorded in the log with the time and date stamp. This along with the context of the surrounding surveys that were answered helped participants to recall the particular situation when the survey was not completed. The log of completed surveys provided a context for subjects to describe the common threads between availability situations and to provide more details both on their reasons for availability and on how such a service might be used. A number of hypotheses were generated about the predictors of availability based on the interview data. These hypotheses were tested through a regression analysis on the ESM data. Further examination of interview data helped to interpret the findings from the statistical analysis.

3.1.2 ESM Factor Finder:Survey Design

Each participant was given a small personal digital assistant (PDA) to carry with them during their home life for one week. At random intervals, the PDA interrupted the user with an alarm, and presented a brief survey to complete. The interruptions were scheduled to occur randomly once within each 30-minute interval. The survey consisted of ten questions modeled on those of Hudson *et al.* [36], and could be answered by an experienced participant in less than one minute. The survey asked participants questions in the following general categories:

- "Are you alone or with others right now?"
- "Where are you?"
- "What are you doing right now?"
- "How would you feel about someone interrupting you right now?"

Samples of relevant questions are shown in table 3, due to the length, the entire survey is in Appendix **??**. The survey questions were were designed to provide fine-grained responses to these four general questions by providing a series of context-dependent questions. For example, when location response was "home," the next question requested the specific room; if location was "car", then the next question asked whether driver or passenger. There were questions to cover the four categories of activities, derived from Venkatesh's technology use within the home [91]: communication, food related, household tasks, and leisure. Within each of these there were four to five specific activities and "other", where any combination or none could be selected, as fit the current activities.

Two questions determined availability to another adult family member:

1. Would this be a good time for an adult family member to get your help with an activity or task they consider urgent?
2. Would this be a good time for an adult family member to catch up on today's events with you?

Table 3: Sample Survey Questions

Right now I am ...	**My location is at ...**	**My current LEISURE activities include ...**
by myself	Home	Watching TV or Movie
with one other person	Work	Reading
with 2 or more persons	a Store	Game playing
	a Recreation site	Sleeping or Napping
	in a Car	Family gathering
	Other location	Other
Would this be a good time for an adult family member to get your help with an activity or task they consider urgent?		
No, not at all		
Not now, maybe in a few minutes		
Yes, for just a moment		
Yes, for however long		

Participants expected the probes and alarms to be annoying, but all completed the one-week study.

Sony Clies running iESP[1] were used to conduct this study, with the exception of one participant using their own PalmV. The iESP software is an open-source package for managing ESM on PalmOS PDAs. The Clie was selected for its form factor and compatible PalmOS version. The Clie is relatively small and light (easy to keep with you), and has a stiff screen cover, that prevents accidental response to a survey.

When each subject received the device, s/he completed a short survey of demographic information and received training in iESP on the appropriate PDA. The eight subjects each participated for one week, keeping the device with them during individually designated "home life" hours. Two participants were home all day with children, and used the same time range for weekday and weekend, approximately 9:00 am to 10:00 pm. Weekday start times for the other subjects ranged from 5:00 pm to 6:30 pm with ending times between 9:00 pm and 11:30 pm. Weekend start times were between 8:00 am and 1:00 pm with ending times 9:00 pm to 11:30 pm. The pre-study training session provided an opportunity to ensure consistent interpretation of terms used in each question of the survey. Rooms within each person's home were mapped onto the list of rooms presented.

[1]Intel Experience Sampling Program, iESP, http://seattleweb.intel-research.net/projects/ESM/.

If a survey was not answered within a specified time frame, then a "missed survey" was recorded at that date and time. Each question also had a timeout interval. This insured the data was recorded close to the time of the alarm and not recalled later. The completion rate of 85%(644 of 766 surveys administered) is comparable to similar studies [45, 36]. At the follow-up interview, researchers shared a profile of the participant's home activity, clarified comments entered, and probed for why surveys were missed. A token reward of two dollars per day, with a maximum of fourteen dollars, was offered at the post-study interview.

3.2 ESM Factor Finder: Subjects

The study involved participants from the community and university. In particular, the focus was on adults living in a family home with their significant other and at least one dependent child. There were two parents who spent their day at home with the child, one of whom was a graduate student who worked outside the home one or two days a week. Two other volunteers were also graduate students, three were professors from different colleges, and one was self-employed working from a home office. Of those invited, two declined to participate; one did not have time and one did not want an interrupting device in the home.

The eight married participants represented six families; there were two couples in the study. Four subjects were female and four were male. Ages ranged from the 20's to the 50's, and averaged in the 30's. There were four single child homes, one home with two children, and one home with three children. The children ranged in age from six months to nineteen years old. One participant was of European background, two were from South America and the remaining were North American. This is an artifact of the university community, not an intentional design to examine cultural communication differences. Each of these international subjects have lived in America for more than a year. All of the participants used multiple communication devices and technologies, and had at some time owned a cell phone. Many of the personal communication partners listed were in different time zones and overseas.

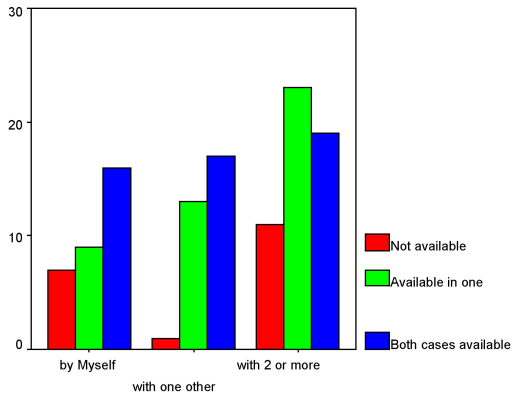

Figure 2: Individual Profile showing Self-Reported Availability Count relative to Whether Alone, with One Person, or Two or More

3.3 ESM Factor Finder: Results

3.3.1 ESM Factor Finder: Individual Profiles and Interviews

To structure interviews,individual profiles were created for each subject based on their responses to the ESM portion of our study. In addition to descriptive statistics, these profiles contained information about the simple correlations between availability and a number of other variables, such as number of people present, location within the home, engagement in conversation and time.

These individual availability profiles were used both to validate the data collected and to refine hypotheses for aggregate data analysis. Each participant was asked how well the various correlations matched their intuition of availability. In Figure 2, the individual's reported availability is shown relative to how many people are in the same location. The bar is a simple count of the number of times the subject reported either not available, available for only one type (or case) of interruption, or availabl for both types of interruption. This person was usually available, but there were more then 5 instances when alone and about 10 instances when with several people when *not available*, as denoted by the red, left-hand bar in each group. Each person was also asked about other factors that might be useful in determining availability. In general, the participants felt the individual profiles accurately represented their availability to interruption.

Comments made by subjects indicated that individual differences might play an important role in determining availability:

"[I am] by myself when [I] need to be by myself, not by accident."

"By myself, ... felt like [I was] more available for interruption."

During the interviews, individuals also spoke of location in contradictory terms. Sometimes, one location might indicate availability, while at other times, it might indicate unavailability. Instead, the important predictor of availability seemed to be activity, as comments about the kitchen were usually qualified with phrases like " in the middle of cooking" or " while helping with homework." Nonetheless, the interviews seemed to indicate the kitchen holds special status because of its role in social activities, such as preparing meals.

Although the literature would suggest that face-to-face conversation might be a good predictor of (un)availability [3], interview data indicate that face-to-face conversation might be more nuanced than that. For some subjects, availability during face-to-face conversation varied depending on the conversation partner. For others, availability had more to do with the larger activity than face-to-face conversation itself. One individual commented that family dinner conversations take precedence:

"My guess is ... when I was having face-to-face conversation and I said I was available, it was not related to a meal."

To further complicate the matter, family members in a home often conceive of interaction as "face-to-face" even if they are in separate rooms. One specifically cited talking between the living room and kitchen, where they are not visible to the other, yet they are engaged in conversation.

Finally, routines emerged as important phenomena in home life, as seen in other home studies [11]. All of our subjects raised the issue of rhythms, especially relating to the normal bedtime preparations for young children. The issue of time rhythms is discussed in more detail in Section 3.4.4.

Before moving on to examine the patterns of data found in ESM results, the aggregate

data across all subjects was examined to determine additional features of interest. Communication (36%) and leisure activities (29%) dominated. In 60% of the surveys there were multiple simultaneous activities, similar to reports in time use studies [86]. Over 80% of the surveys were answered while in the home, over half of these were equally split between the kitchen and living room.

3.3.2 ESM Factor Finder: Hierarchical Logistic Regression Results

Ultimately, this study is focused on determining a set of externally measurable variables that help predict an individual's availability for conversation initiated by friends or family outside the home. A hierarchical logistic regression on availability was conducted on the ESM data for all individuals, as a way of identifying variables that seemed to hold promise. Statistical regression analysis specifically asks questions about the relative importance of a set of variables in predicting an outcome. Each survey asked participants to indicate availability, so the analysis was able to use reported information about the individual's state to attempt to predict answers for availability. Logistic regression means the predicted outcome (availability) is a binary variable. To obtain this availability variable, a dummy coding scheme was used. For the survey availability questions, Listed in Section 3.1.2, those responses reported as "available" were given a value of one and otherwise a zero.

Hierarchical regression allows one to enter sets of variables in multiple steps. Each step asks whether the new set of variables allows one a better prediction ability over and above the previous set of variables. In other words, each step accounts for a certain amount of the variability observed in the dependent measure (availability). Subsequent steps ask whether or not the new variables explain any of the remaining variance. While ordering of these steps is debatable, this analysis has tried to follow standard psychological practice of moving from more distal predictors of availability (e.g., individual differences) to more proximal ones (e.g., current activities). Note that ordering does not affect the final outcome, only the interpretation at each step. Since this is intended to be an exploratory analysis, loose measures of significance have been used. Therefore, $\alpha < 0.1$ is regarded as significant and $\alpha < 0.2$ as marginally significant. With these looser significance ranges, this analysis

provides indicators of promising areas for future research.

The ESM hierarchical logistical regression analysis is shown in Table 3. NOTE: Values in Table 3 indicate the final values in the regression analysis, not the intermediate values at each step. $\triangle R^2$ was significant at $\alpha < 0.05$ for steps 1, 2, and 4. For step 3, $\triangle R^2$ change was marginally significant (p =0.053). Step 5 was not significant (p = 0.898). Positive B-coefficients indicate that individuals are more available for interruption and negative B-coefficients indicate less availability.

The first stage of the regression analysis asks whether or not individual differences predict availability. The analysis method is designed to operate on rational numbers. It does not make sense to represent individuals statistically as rational numbers. Orthogonal contrasts were generated to test for the statistical differences between individuals. For the purposes of this study, significant values for these orthogonal contrasts indicate that some individual differences exist. The exact meaning behind each of these contrasts is less important. Results from this step indicate that a number of individual differences exist. This finding is explored in more detail in Section 3.4.1.

In the second step of the regression analysis, the predictive power of location, time, and day of the week over and above the observed effects of individual differences are examined. Five different locations were examined:

1. Living room, including the family room
2. Kitchen
3. Someone else's bedroom (usually a child)
4. Other rooms in and around the home, including patio and yard
5. Locations away from home

Once again, location is a variable that cannot be represented as a rational number which is required for the linear regression analysis. When faced with these nominal variables, they can be coded in many ways (e.g., orthogonal coding, dummy coding, effects coding). Each coding scheme lends itself to different types of interpretation. While none of these schemes

	Variables	B Coefficient	Wald Statistic	Significance (p-value)
Step 1 Subject	Individual Differences (n=8) Computed as 7 orthogonal contrasts	.451	1.822	.177*
		.165	.554	.457
		.671	3.960	.047**
		.857	14.185	.000**
		-.739	12.839	.000**
		.361	1.363	.243
		-1.663	10.125	.001**
Step 2 Location Time	Living areas vs. kitchen	-1.395	9.074	.003**
	Out of home vs. kitchen	-1.426	9.766	.002**
	Others bedroom vs. kitchen	-2.547	15.734	.000**
	Other rooms vs. kitchen	-1.247	8.818	.003**
	Time of day	-.001	1.382	.240
	Weekend Day	.579	1.799	.180*
Step 3 Companionship	Alone vs. with others	-.372	2.014	.156*
	With one other vs. two or more	.204	1.494	.222
	One adult with child(ren)	-.190	.313	.576
Step 4 Activities	Face-to-face conversation	-.772	5.639	.018**
	Telephone call	-.373	.457	.499
	Email	1.846	2.618	.106*
	Eating	-.238	.455	.500
	Food preparation	-.016	.001	.973
	Meal clean-up	-.187	.126	.722
	Other food activities	-.898	1.702	.192*
	Watching TV or movie	1.237	9.573	.002**
	Reading	.761	2.422	.120*
	Game playing	1.994	9.390	.002**
	Family gathering	.547	.527	.468
	Other leisure	.879	6.419	.011**
	Laundry/Housekeeping	.769	2.402	.121*
	Personal/Family info management	1.827	4.546	.033**
	Other household tasks	.424	1.136	.287
Step 5 Bedtime	Bedtime routine for children	-.165	.017	.898

Figure 3: ESM Hierarchical Logistical Regression Analysis

seemed ideal for coding the location variables , dummy contrasts provide the most readily interpretable results. In dummy contrasts, one value of the variable is chosen as a baseline against which one compares all other values. The kitchen was selected as the baseline measure because many subjects suggested that the kitchen tended to indicate availability. Significance for this set of location variables indicates that availability in a given location is different from availability in the kitchen. Results from this second step of the analysis indicate that interruption in the kitchen is more acceptable than other rooms in the house. Interruption is particularly bad in someone else's (presumably a child's) bedroom. The time variable is also included in the second step. The "time" variable is the number of minutes elapsed in the day and the "weekend" variable is a binary indicator of weekday vs. weekend. Time and day do not appear to matter much, but this may be a limitation of linear regression analysis, which is discussed in Section 3.4.2.

In the third step, variables measuring companionship and the presence of children were added. The survey structure guided companionship to be represented as two orthogonal contrasts:

1. Companion Contrast 1: Is there a difference in availability when a subject is alone vs. when s/he is with other people?

2. Companion Contrast 2: Is there a difference in availability when a subject is with one person vs. when s/he is with more than one person?

In addition to companionship, the third step also included another computed, binary variable to indicate situations when a subject is the only adult with his/her child(ren). Results of step three indicate that only the first companion contrast is marginally significant. It does not seem to matter how many people are around or if any of them are children.

The fourth step of the analysis asked whether self-reported activity is useful in predicting availability over and above the measures already examined. In this step, the fifteen binary, self-reported activity variables were included. Of these, five were statistically significant for predicting availability: talking face-to-face, watching TV or movies, playing games, performing other leisure activities, and managing personal information (see Section 3.4.3).

Other food activities, sending and reading email, reading more generally, and housekeeping are marginally significant. Since this research is exploratory and uses loose significance levels, further research is needed to determine the practical significance of these variables. Rather than attempting to identify definitive predictors of availability in the home, the analysis seeks to highlight seemingly important predictors so that future research can begin with a more limited set of variables.

Based on interview results, the fifth (and final step) attempted to examine children's' bedtime routines. To do this, a binary variable was constructed representing when an adult was alone with a child in either the bathroom or the child's bedroom engaged in specific activities (face-to-face conversation or other household task, for bathing child) between 7:30 pm and 9:30 pm. Results indicate that this added no predictive power above the previous variables. As discussed in more detail in Section 3.4.4, routines seem to play an important role that is not adequately captured by the ESM Factors data.

Table 3 summarizes the variables added at each step and their final significance levels. This statistical model shows significant effects for individual differences, locations, and a variety of activities. Regression produces a statistical model that is basically an additive linear equation. For example, this model indicates that knowing someone is in the living room helps predict availability. It also shows that knowing when someone is playing games helps predict availability. This indicates that one will have even better predictive power if one knows that individuals are both in the living room and playing games. In Section 3.4, these factors are explored in more detail before describing the implications of this work.

3.3.3 ESM Factor Finder: Availability Prediction Accuracy

While the focus of this study is the identification of factors that predict availability, the accuracy of that prediction is also important. The statistical model accuracy will be relative to the baseline accuracy computed when the model *guesses* that every prediction should be *available*. For this data, the baseline is 67% accuracy, as shown in Table 4. The accuracy of the model, using the ESM Factors survey data (through step four), is shown in Table 5. The data has 255 self-reported *not available* surveys and 411 reported as *available*. The

model is only able to correctly predict the *not available* situations in 61% of the cases, but the model is much better at predicting *available*, 95%. This yields an overall prediction accuracy of 84% for this model.

Table 4: Prediction Accuracy when *Guessing Always Available*

Self-Reported	**Best Guess Prediction Accuracy**		
Availability	**Not Available**	**Available**	**Percentage**
Not Available	0	255	0%
Available	0	511	100%
Overall Percentage			**66.7%**

Table 5: Model Prediction Accuracy, for step 4

Self-Reported	**Model Predicted Availability**		
Availability	**Not Available**	**Available**	**Percentage**
Not Available	155	100	60.8%
Available	25	486	95.1%
Overall Percentage			**83.7%**

3.4 ESM Factor Finder: Discussion

Through the interview data and the statistical analysis, a number of interesting factors arose. Individuals have unique predictors of availability to outside interruption. Location provides some useful information for determining availability, but certain spaces seem more important than others. Leisure activities seem to be more powerful predictors of availability than other activities. Interviews indicate patterns of activities and transitions play an important role, but this is not supported by linear analysis of this sampling data.

3.4.1 ESM Factor Finder: Individual Differences Matter

The regression analysis and interview data portray varying individual inclinations toward availability. For example, three of the subjects answered the ESM survey that they were available approximately 70% - 80% of the time. Two subjects were only available 40% - 50% of the time. (The remaining three subjects were available approximately 65% of the time.)

Not only were some subjects more available to interruption than others, but from the

interviews, individuals also treated some similar situations differently. For example, some subjects stated that they were not available when friends or guests were over:

> *"[I was not available] with the people there... or if other people we had scheduled to come by for meals."*

Others indicated that this was a great time for interruption:

> *" And the friends were there. And because it was a birthday party, I wouldn't have minded people calling."*

Likewise, individuals treated availability differently when preparing food:

> *"I wasn't available] we were in the middle of cooking"*

> *"You know, I'm available when I'm cooking dinner and I'm not as available when I'm eating dinner."*

Since many leisure activities (e.g., watching TV or playing games) turned out to be significant predictors of availability, it is somewhat surprising to see that reading only had marginal significance as a predictor. This also may have to do with individual differences. Some individuals are available while reading, others indicated that this is a terrible time for interruption:

> *"Basically if I'm reading a book, I just don't want to be bothered."*

This is in keeping with Janice Radway's findings in Reading the Romance [74]. In this work, Radway described how a group of stay-at-home mothers used romance novels as a way of carving out time for themselves. If Radway's findings can be generalized to other genres, it's not surprising that one might find differing levels of availability during reading.

While this study was not designed to examine couples, two couples did participate. While exploring the contrasts between individuals, there was a remarkable correlation between members of each couple. This suggests that individual differences may be reduced within family units. Further research is necessary to explore this hypothesis.

3.4.2 ESM Factor Finder: Some Locations Matter

The kitchen figured prominently in both the interviews and the survey data, usually correlated to availability. However, in some homes, the kitchen as a physical room comprises multiple activity areas. For example, one might be available in the food preparation area of the kitchen, but not available when assisting a child with homework at the table. Subjects often pointed to open and fluid home designs as ambiguous indicators of availability.

Bedrooms are more consistent availability indicators, the child's bedroom in particular:

> *"Yeah, now see when I was in others bedroom, that's usually when I'm putting the kids to bed and I'm pretty much not available then. If I'm in my bedroom, I'm more likely to be relaxing and so I'm more available."*

The Other's Bedroom contrast is significant ($p < .001$) and negatively correlated (B = -2.547) to availability. Interviews show the *Other's Bedroom* is most often the child's room, where the parent could be attending to, playing with, or reading with the child.

The kitchen is the most significant location to predict availability. Each of the other locations are also statistically significant predictors, but have less influence than the kitchen. The living room, family room and den are considered together in the living areas contrast, and all other rooms within the home are included in the other contrast. The out of home contrast includes the car, recreation sites, and homes of other family and friends. Some room locations may be useful in determining where to deploy sensing relative to providing the high correlation to availability, or with concerns for privacy or safety.

3.4.3 ESM Factor Finder: Activities and Availability

While the ESM Factors data highlights differences in availability between office workers and family members at home, there is some consistency in predictive activities. For instance, the most prominent activity in this data is face-to-face conversation (46% of the surveys). It is significantly (p = .018) and negatively (B = -.772) correlated to availability. In other words, engaging in conversation is likely to make individuals less available for interruption. This is similar to Hudson *et al.*'s office-based study which found talking in the office predicts unavailability 75% of the time [37]. Although Hudson *et al.*'s tuned model predicts

unavailability with 90% accuracy, the model from this study is a stronger predictor for availability, see Table 5. It is possible that this result may stem from the propensity of the data towards availability; overall the participants were available 67% of the times they were surveyed, see Table 4. One would expect this number to decrease if missed surveys were accurately coded and included, as participants indicate they were most often not available when a survey was missed.

However, the social construction of conversation at home versus in the office may be quite different, from this interview:

> *"For most of the time I was in face-to-face conversation, the conversation was not so important that I would not allow myself to be interrupted."*

Although, the self-reported data showed conversation is not a time to interrupt, some subjects spoke of being more interruptible when they were in conversation. Thus, even a significant predictor, has situational and individual variation. Participants indicated that they were more amenable to conversation when already engaged in one. Many subjects characterized home conversation as short and sporadic. This interaction style naturally seems to lend itself to interruption.

Leisure activities accounted for 29% of all activities reported. Watching TV or a movie ($p = .002$, $B = 1.237$), game playing ($p = .002$, $B = 1.994$), and other leisure activities (e.g., listening to music) ($p = .011$, $B = .879$) were significantly, positively correlated to availability, see Section 3.3.2. Leisure activities were frequently mentioned:

> *"... [I] think it accurately reflects what's going on. Clearly I don't have that many TV shows that I don't answer the phone for! Only one or two."*

Reading is marginally significant ($p = .120$) and positively correlated ($B = .761$).

Note that the survey only asked about availability for close friends and family. It did not address the tensions of controlling work-oriented interruptions relative to home life [36]. There are also specific instances of leisure activities where participants talked about not being available—when a PC game cannot pause or when a certain "soap opera" is broadcast.

3.4.4 ESM Factor Finder: Relevance of Time-based Rhythms

Based on the interview data, it seems that time plays an important role in interpreting availability. Not surprisingly, though, the regression analysis indicated that time was not a significant predictor of availability. Regression analysis techniques, such as the one employed here, assume a linear relationship between predictors and the independent variable. In other words, this analysis technique presumed that availability either linearly increased or linearly decreased as it got later in the evening.

The interview data, however, suggests that time does not play a linear function for predicting availability. Instead, time tends to follow certain rhythms, similar to those described in [5, 36]. In particular, dinner and bedtime routines seem to affect availability. As one participant commented:

> *"We usually eat at 7:00. [My child] usually goes to bed between 8:30 and 9:00. So those are activities that would have precluded my availability."*

Based on the interview data, there seem to be more complex time rhythms as well that the ESM Factors data was unable to assess. Since the ESM Factors study only covered one week for each subject, researchers were not able to observe events that separate the weekend from weekdays nor were they able to observe events that reoccur on weekly or monthly schedules.

At the same time, the ESM Factors study did not allow researchers to observe the transition events that interviews indicated were important. One does not know how frequently or when location changed, or whether our probes simply occurred at a transitory location such as walking through the dining room to the kitchen. There are also transition activities, such as "walking out the door" or arriving home, where participants were not available for that frame of activities.

3.5 ESM Factor Finder: Contributions

In some ways, these results replicate similar studies of interruption and time use in the workplace [36, 22]. In many ways, however, the findings indicate that individuals tend to

have strikingly different predictors of availability in personal and professional life. Studies of workplace environments have developed metrics that work best predicting when not available (90%), but that predict availability less effectively (75%). The ESM Factors results, however, are the opposite. The ESM Factors model seems to do well at predicting available states (95% accuracy), but poorly at predicting when not available (61% accuracy), see Table 5. Despite this significant difference, there are many lessons applicable to domestic environments.

3.5.1 ESM Factors: Domestic Availability Prediction

The ESM Factors has found predictions of availability are highly individual. There are factors to availability that will need to be adapted to the individual household, such as recognizing transitions between availability and not available: changing rooms, preparing to leave home, or cleaning-up after a meal.

One motivation for this work is to determine if there are any externally observable factors in a home environment that correlate to self-reported availability. If such factors exist, then sensing can be focused on sensing and perception techniques to predict those activities, either in real-time or over some time-relevant time interval. This preliminary study suggests it may be most useful to target sensing to particular locations in the home, most notably in and around the kitchen, and toward particular activities, specifically face-to-face conversations, eating, and leisure activities.

This work highlights the potential in detecting patterns of activities. Though the data analysis does not bear this out, interviews suggested that transitions between activities link better to being not available than to the particular activities themselves. If the triggers to change availability could be established empirically, that would motivate statistical approaches to activity recognition, which might be better at detecting boundaries between changing activities than at identifying specific activities. While this work does not explore these transitions deeply, this would be relevant future work.

Previous research conducted primarily in work environments suggests that individuals tend toward unavailability (perhaps because they are constantly dealing with the previous

interruption) [36]. This study, however, suggests that individuals in home environments tend toward availability. The social construction of interruption might help explain one anomalous finding in our data. In the ESM Factors surveys, subjects were asked to indicate their availability to both an urgent interruption and a casual interruption. Follow-up regression analyses on each of these variables indicated the measure for a child's bedtime routine strongly predicted unavailability in the urgent condition, but had no significance in the casual condition. Why should subjects be less available to urgent interruptions than casual interruptions? One hypothesis is that this has to do with the degree of interruption implied by each. Urgent interruptions imply a full interruption where participants must drop everything. Casual interruption suggests partial engagement where subjects could continue preparing the child for bed while dealing with the interruption. For instance, the primary caregiver for a young child may have enough *spare* attention to engage in routine chat about daily life, but would not be able to handle a call on an urgent matter, from one interview:

> *"It depends on the level of commitment, you know I can answer a quick question, but I can't have a conversation with anyone because of the bath."*

In the chat situation, the close friend or relative will not feel slighted if the parent must divert all of their attention to the child. This hypothesis is not investigated in depth in this thesis work, but is a future research is needed to explore this.

3.5.2 ESM Factors: Model of Home Availability

In addition to the statistical correlation of various environmental factors predicting availability, the ESM Factors study has also influenced the development of a framework describing home availability, based on the ESM survey reasons for availability and interview data. A characterization of availability within home life is important to support family specific needs and to aid designers and developers of context-aware communication services. Dinner and bedtime activities, for example, were important to our families with young children, but these routines may not even exist in childless households. Often everyday activities are

Table 6: Dimensions affecting household availability

Term	Definition	Examples
Policies held	Explicit and implicit rules governing family social protocols handling interruptions.	May minimize individual preferences in deference to family availability.
Social closeness	The degree of informality and intimacy in communication.	Greater the social closeness, the more accessible, may override some or all policies in very close relationships
Attention available	Cognitive and emotional resources available within the interrupted household	The interrupter may be willing to share attentional resources, depending upon the purpose of the interruption and the other two dimensions, closeness and interruptee policies.

so routine, that it is difficult to make the invisible, yet important features, visible to technologists. A framework supports communication between designers, developers and family users. The purpose of this description is in contrast to other interruption models that provide automated predictions of availability [22, 34]. This model is intended to support person-to-person discussion of availability in home life.

Three characteristics of the interrupted household were evident from the ESM Factors data, (as shown in Table 6): policies held, social closeness, and attention available. By examining home availability based on this framework, a context-sharing communication interface can be described and evaluated in terms of its costs and benefits to its users.

First, there are the rules and policies that inform the social protocols of communication, insuring home life remains private and protected from public scrutiny. One such rule was built into this study of home life. The surveys were only delivered during the block of time the participant designated, based on their household policy of when they would accept an interruption from outside the home. This schedule implicitly assumed there are times when one is at home, but not available. Rules are part of desktop-computer based predictor systems, as well [35]. People adopt policies to protect privacy and use routines to minimize "thinking" about everyday routines at home [62]. Not surprisingly, many of these rules are

time dependent: Do not call after nine o'clock at night. Do not knock on our front door before eight a.m. Others are routine-based: We do not allow dinner time interruptions. I am not available when getting my child ready for bed at night. From the perspective of the household, these policies form a protective guard for the family. But they may also provide an inviting gateway to those who are familiar with these bounds, and use them to determine an acceptable time to interrupt [98]. These "house rules" are relatively stable over time, but amenable to change in response to seasonal schedule changes, such as summer vs. school year, and transformations in the family itself over time. The household rules enable those outside the household to understand the socially acceptable interruption times and activities.

The second property in the availability model is social closeness, the degree of informality and intimacy in communication. Accessibility may vary not only from household to household as a policy, but appears as a set of boundaries within each household. The perceived intimacy of one's social interactions corresponds to the access afforded, even differentiating between *close* family and friends. The sharing of these accessibility rules is one measure of social distance; the less one knows about the household, then the more formal and structured is the communication interaction. For those with whom one is socially close there is a notion of "ever-availability", which is one of the most important measures for evaluating how good a parent, brother or sister, or friend one is [98]. On the more formal side of communication, from respect and politeness one expects a certain amount of "lead" time for social participation. However, "short notice" of get-togethers may not be a mark of disdain for one's social accessibility, but may symbolize the closeness, where formal lead times no longer apply [98]. These guiding principles provide a window of opportunity for close family and friends, and also protects the private portions of home life from even the most intimate family, while preserving the notion of always available accessibility. This access varies by person relative to the household, and is relatively consistent over time, changing as interpersonal relationships evolve through life experiences.

A third dimension of the availability model is the attention available within the household. The division of attentional resources was indirectly addressed in the study interviews,

particularly when describing bedtime routines. Studies of workplace interruption have highlighted the relatively constant amount of attention and the impart of interruption on task accuracy, completeness and promptness [51]. Workplace studies of interruption define an attention cost [50] and a linear dollar cost [35], seeking to minimize cost by utilizing natural breaks in activity and training predictive systems to look at key events. The ESM Factors participants have indicated several potentially important attentional cues, including transitions and changes in activities, as well as certain household routines, such as dinner and bedtime for young children. In the interviews, they also cite out of the ordinary events that require their attention, and frequently mention louder than conversational audio levels, e.g. shouting. Attention is a very dynamic characteristic of availability, and most sensitive to the situational context of the home, including conversation, sound levels, who is present or not, room location, and possibly who is interrupting. Attention to give to a remote conversation partner is highly dependent upon the situation of the callee's household. The user estimate of time is subjective, but more applicable to the household activities and goals, than monetary or efficiency incentives. Simultaneous activities are prevalent in homes, what characterizes the attention available even while engaged in another activity? Attention is a complex concept, but one that appears to be important to model availability. This is interesting future research, not investigated in this thesis.

3.6 ESM Factor Finder: Summary

The ESM Factors has found environmental factors predicting availability, in spite of it's variance by individual. In developing communication services, learning algorithms may be a good fit in developing personalized clients. While this study has shown the significance of individual preferences within the home, other studies have developed similar personas using probabilistic models based on the individual's reported meeting attendance [90]. There are factors to availability that will need to be adapted to the individual household, such as recognizing transitions between availability states: changing rooms, preparing to leave home, or cleaning-up after a meal. Over weeks or months, the home life schedule changes to accommodate different sport team practice times, school year activities and other variations

to the general schedule of in- and out-of-home activities.

There is a lot of interest in automated forms of activity recognition by researchers in ubiquitous computing and computational perception. The evidence gleaned from this preliminary study suggests that it may be most useful to target sensing to particular locations in the home, most notably in and around the kitchen, and toward particular activities, specifically face-to-face conversations. What is important to stress from this work is the potential for detecting patterns of activities. Though the data analysis does not show it, interviews suggested that transitions between activities link better to being unavailable than the particular activities themselves. Transitional activities provide mental bridges between social roles, as parent, friend, or chef[62]. If the triggers to change mentalities and accessibility could be better established empirically, it would provide further motivation for the inherently statistical approaches to activity recognition that might be better at detecting boundaries between changing activities than at identifying specific activities.

In this chapter, the ESM Factors study found a set of externally detectable factors in home life that correlate with availability. Some locations matter more, like the kitchen and the child's bedroom. Some activities are significant predictors, like face-to-face conversation and many leisure activities. Context-mediated communication requirements are highly individual, both in overall varying inclination to be avaialbility and as differing responses to similar situations. This study also raises privacy concerns, both in the collection of context and with whom it would be shared. Several interesting issues for further research arose from this initial exploration of environmental factors of availability.

CHAPTER IV

ROLE OF ROUTINES RELATIVE TO AVAILABILITY

The ESM Factors study, in Chapter 3, as well as other research into home life finds people talk about availability relative to rhythms and routines, such as dinnertime and children's bedtime. Routine behaviors are frequently seen in home life, not just in the allocation of activities and childcare, but to minimize the overall mental cost of when and what to do and to bound competing roles in the home [62]. Routines are also integral to the family communication centers of the home [11]. In the prior ESM Factors study, it was the exception to the routine that appeared significant to predicting availability. During the interview, several participants correlated time of day and the start and end of a particular routine, but when either time point was "off routine", then availability was negatively effected. For instance, if the young child was having a difficult settling into sleep, then the primary parent would not be available at the *routine bedtime* hour, but may be available later. However, bedtime might now run into the starting time of another activity and preclude one's availability.

Understanding the environmental factors marking the transition into and then out of a specific routine would be useful to recognize when looking for times to initiate conversation [33]. Some of the interesting routines for families with young children are dinner time and the bedtime routine. While there are privacy concerns in revealing details of each of these intimate family rituals, participants in the prior sampling study were very open in detailing these everyday routines. Understanding these routines in detail for specific families may provide insights into the recognition of when the routines begin and end, as well as when a routine is out of the expected range. Routines relieve the family of re-thinking each and every activity, freeing them to be available for other family interactions, such as external conversations.

If availability research is re-conceptualized as a problem of identifying routines—which is

how people talk about homelife—will more useful awareness and availability information be provided? In doing this, the research focus shifts from determining availability, to identifying routines based on environmental indicators, including:

- How accurately can environmental cues model some routines?
- How are household routines defined by the family members?
- How do household members use household routines to describe availability?
- How accurately do routines predict availability?

Time-use data, self-reported availability, and qualitative descriptions of routines and availability were gathered to investigate the role of three routines in portraying availability: mealtime, child's bedtime, and leisure. This approach collected data in real situations that simple sensors could detect to inform the selection and placement of sensors, that are both costly and potentially disruptive to family life. Since time-use data described homelife activities as part of a routine more than 85% of the time, routines provide good coverage of home activity. Using relatively easily sensed location information, such as child and parent in kitchen, statistical models were constructed to predict each routine with moderate accuracy (85% to 95% accuracy). The statistical model accuracy improves to at least 90% accuracy for each routine, when more complex sensing of activities are added, such a watching TV, eating, and engaging in conversation. Leisure is correlated to availability, 82% of the times in leisure routines are self-reported as *available*. On the other hand, households are generally **not** available during children's bedtime routine, just 32% of the bedtime routine samples are reported as *available*. Mealtime is not a consistent availability indicator, but appears to require time-based activity segmentation to determine availability. In general, this study highlights three ways routines are valuable to understanding availability:

1. Routines abstract away distracting details, yet provide insight;
2. Routines segment home life temporally and functionally;
3. Routines mark boundaries and aide transitions from one availability state to another.

To the friend or family member wondering, "Is it a good time to call?", routines may reveal "just-enough" sensed context, while preserving family privacy.

4.1 DayRM Role of Routines:Potential and Complexity of Routines

When the exploration of shared awareness and availability determination is focused in the home, there are many new challenges. In homelife, there is frequent movement between rooms, rather than the expectation of finding someone available at one particular location, like his/her desk in the workplace. To share information about activity while in home life, sensing will need to follow the variety of home activities from room to room using multi-room sensor deployment and to identify the person(s) involved. In the home, schedules and lists are organized "as needed and where needed," usually for the person handling the tasks [87]. Household schedules may or may not be closely aligned to time; some follow the begin and end times of television shows [63]. In other cases, parents manage their children's hunger with scheduled meals and their need for rest with specific bed times [62]. The use of *routines* is colloquial and fluid in the everyday language of practical activities of the home.

Just as temporal rhythms of activity coordinate and become one with work practices [5, 75], "routines" both define and interact with home life. Lacohée and Anderson's longitudinal studies of home phone use in the U.K. highlighted the way callers are expected to know life rhythms of the recipients and use that knowledge to call at appropriate times [46]. Routine behaviors are frequently seen in home life, not just in the allocation of activities and childcare, but to minimize the overall mental cost of when and what to do, ordering the chaos of competing roles in the home [62]. Social protocols explicitly pay attention to these boundaries. Especially when interrupting at home, one is keenly aware of the prevailing routines of the household. While exploring how to make technology "invisible in use", Tolmie *et al.* provide a working definition of domestic routines [88], p. 400,

> Routines mean that people can get out the door, feed themselves, put the children to bed, and so on, without having to eternally take pause and invent sequences of action anew or open up their every facet for inspection or challenge

> or to constantly have to "account" for what they are doing with explanations or rationales.

This is the challenge: to appropriate routines is to reveal the unnoticed. Ethnographic studies have investigated domestic routines involving "the knock on the door" [88], organizing systems [87], and communication activities [10]. These studies show the communication centers of the home are distributed, but articulated in routines [10] and organizing systems in the home, such as lists, calendars, and notebooks, arrange the routines and schedules, and also the social interactions among the household members [87]. Each of these accounts of the home point to looking into the complex social interactions in everyday home life, examining the details that more richly describe the family specific routines and space allocations.

Routines also aide the transition between different *mental states*, such as workplace and homelife. For instance, the getting ready for work routine may include coffee brewing, dressing for the office, reading the paper, or other ordinary activities that are accomplished with no decisions, freeing one's mind to look ahead. Nippert-Eng likens this function of routines to a dimmer switch, easing the adjustment from dark to light [62]. The mindlessness of a routine allows the person to prepare for the "non-routine" ahead, whether it is to change from thinking about work-tasks to the home or transitioning within one of these realms [62]. Routines not only enable one to achieve goals, but they also aide the movement between mental states. Enhanced knowledge of routines may help friends and family outside the home more accurately predict when the other person is more receptive to interruption.

This dynamic conceptualization of routines is a challenge to the use of routines. Like the office-based availability prediction systems, this research seeks to identify salient features in the domestic environment to provide appropriate awareness information. These features must be determined dynamically based upon the current situations, but at this phase of exploration we are looking for a "starting" set of features. Dourish describes this dilemma as "embodied action," that is the routine, activities and context become meaningful within the on-going interaction with people [14]. To capture the meaning-making features of particular routines, one must achieve a balance between quantitative data suitable for computational models and the rich set of situational interactions that give those cues meaning. The

ultimate goal of this research is to provide an appropriate abstraction of information to the communication initiator, sufficient to determine the appropriate social interaction, but not too much as to overwhelm or invade the privacy of the home [12, 60]. This study uses formative evaluation of environmental indicators, focusing on those features in the home that sensors can potentially detect, such as room location and co-presence. Envision the intrinsically dynamic nature of routines as a first step in meeting the challenge to find the most accurate representational form and to portray the interaction of persons, locations, activities, and rhythms of home life.

4.2 DayRM Role of Routines: Method and Instrument

Richly detailed and measurable descriptions of routines could guide applications that infer higher-level activity based on simple metrics of activity. As seen in ESM Factors (Chapter 3), some of the interesting routines for families with young children are dinnertime and the bedtime routine and are the focus of this research [62]. Understanding features of the environment that may predict one or more of these routines would be a first step to developing a shared awareness communication service—to support caller access to close family or friends.

4.2.1 DayRM Routines: Method

We choose to use The Day Reconstruction Method (DayRM), a diary-based method, was used to collect empirical evidence on the complexity of routines and availability in the home. The DayRM was designed to gather better estimates of how people spend their day and the experience associated with specific activities and situations [43]. DayRM participants first construct a diary of episodes of their home life activities from the prior day, refreshing those events in their memory and the associated feelings. Next, subjects answer questions about specific situations or episodes from the "reconstructed day" and the feelings they experienced, similar to the intent of Experience Sampling Method (ESM) surveys. Using only the most recent day is intended to evoke specific affective memories to minimize recall errors and biases [43]. DayRM data gathering enables more complete coverage of the day, thus providing evaluation of contiguous episodes for an entire day, rather than samples.

This continuous coverage is well-suited to the exploration of routines, to determine how pervasive they are in home life and to associate specific situationally-relevant features, such as location, co-presence, and activities. The DayRM is also an efficient data collection method: less burden on participants and not disruptive to normal activities.

Using the DayRM enabled a broader study across more households, and also provided two types of rich information: time-use with associated availability features and affective responses to open-ended questions situating the more objective data. The continuous coverage of the day enabled the exploration of how well routines cover home life and to associate specific situationally relevant features with particular routines, such as location, co-presence, and activities. DayRM survey data was gathered from twenty-five volunteers covering their prior day experiences. They were then asked a series of open-ended questions reflecting upon their dinner and children's bedtime routines and availability. While there may be privacy concerns in revealing details of each of these intimate family rituals, participants in the sampling study were open in detailing these everyday routines. The study hypothesis is:

> Each of the routines of interest, mealtime, children's bedtime, and leisure, can be modeled from environmental cues more accurately, than availability models from the same factors in the prior ESM Factors study (76% accuracy).

The hypothesis was tested through a regression analysis on all the episode data, across participants. Further examination of the open responses helped interpret the findings from the statistical analysis.

4.2.2 DayRM Routines: Survey Instrument

A multi-part, paper and pencil DayRM survey was constructed to gather data describing participant experiences, their routines, and their availability policies for the household. A critical component was the participant generated diary. To avoid bias, it was essential to have the participants recall and record their diary of previous day episodes before they were aware of the points of interest to the researcher. Therefore, the survey sections were in separate sealed envelopes. Prior knowledge of the nature of the questions might have

biased the reconstruction of the day and recall of feelings associated with the activities. The DayRM survey instrument is included in Appendix B.

The four-part DayRM survey includes:

1. Participant Demographic Information
2. Diary of Prior Day Home Life
3. Survey of Experiences and Routines for each Prior Day Episode
4. Open-Ended Reflection on Routines and Availability

The diary structured the recall of the prior day's home life activities in a confidential diary. The day was reconstructed in time sequence, envisioning home life as a series of episodes, similar to making a movie. For each episode, the diary entry included who was involved, where it happened, and the activities during that slice of time. This diary was private to the participant and was not returned to the researcher.

Part three asked the respondents to use their diary answer a series of questions describing each of their home life episodes and to classify the prior day as typical or not. Each participant was asked:

"Was yesterday a typical day for your family?"

"What was different or what made it typical?"

This question was designed to compare the data to other time-use studies and to determine if routines and availability varied according to whether or not the person consider this to be a normal day. The rest of this segment of the survey was designed to duplicate the questions in the prior ESM Factors study of home availability indicators, see Chapter 3. By using identical questions, this study would be able compare both the accuracy of the availability model generated and the significance of specific factors seen in the prior home-based data analysis. For each episode, the following information was collected via checklists:

Start and end time of this episode

Where are you? If at home, which room?

Where is each member of the family, who is at home?

What activities were you doing?

Are you in a routine? If so which one?

What is your availability at this time?

The room location list for the participant and the household members included: kitchen, family room, dining room, my bedroom, child's bedroom, other at home location. The checklist of 23 activities were derived from Venkatesh's four activity categories : food related, household tasks, communication, and leisure [91]. For example, household tasks included: laundry or house cleaning; yard work; shopping; managing money; bill payment; and managing personal records. Other categories were similarly structured. The question concerning routines was also a checklist, with no description for any of the routines. Interpretation of the routine was left to the subject:

This episode is part of your normal routine during...

Mealtime

Children's Bedtime

Leaving or returning home

Schoolwork time

Leisure time

Other routine

Not part of a routine

Additionally, for each episode, two questions determined self-reported availability to another adult family member:

Would this have been a good time for an adult family member outside your home to get your help with an activity or task you would want to give your full attention?

Would this have been a good time for an adult family member outside the home to catch up on the family events and activities?

Each availability question had the same checklist of choices, but the participant was prompted to respond relative to one specific person and purpose of interruption for all episodes:

Yes, I could be available for a few seconds to a minute

Yes, I could be available for (estimate minutes) or longer

No, it would be difficult or awkward to be interrupted

No, I would prefer not to be interrupted

Part four consisted of open-ended questions reflecting on their overall notions of availability and specific routines. They were asked:

From yesterday, list three indicators that dinner time has *started* in your household?

From yesterday, list three indicators that dinner time is *ending* in your household?

These were asked again with regard to children's bedtime. They were also asked to share general indicators of availability:

In general, what do you think your household members believe to be a good time to call you or your family?

They were asked when is it *not* a good time to call. These questions were included to probe their more general household policies concerning availability for phone conversations.

The questionnaire was administered individually, and was designed to be completed in 45 to 90 minutes, although several reported taking somewhat longer. Respondents were given gift certificates to neighborhood restaurants and stores in appreciation of their participation.

4.3 DayRM Role of Routines: Subjects

This study was interested in the routines of "busy families" with young children, where care-giving tasks and daily activities require coordination and communication, often across households [62]. The survey was distributed during the children's regular school term, to study routines while school is part of the *routine* of family life. The recruitment focused on parents of children participating in team sports and extracurricular school activities. This selection ensured participants had at least one child of the appropriate age, as well as a *busy* schedule of activities outside the home and school. While the children were engaged in the

sports or extracurricular activity, the participating parents were able to use that time to work on the survey. Most participants took the survey home to complete, returning them at the next after school activity or by mail.

Over two weeks, 41 questionnaires were distributed; 25 were completed and used in this analysis. There were 17 females and 8 males, including 4 couples. Almost all were married (22); one participant couple were parenting children as significant others, and there was one single mother. The average age was 38 years, ranging from 29 to 50 years of age. All had elementary-aged or younger children in the home, the youngest child was less than a year old. Most were Caucasian (17), with 4 black participants, and 4 of other ethnic background. They were highly educated; 13 held graduate degrees, 5 did not have a college degree. Their occupations include: parent, teacher, executive assistant, physician, engineer, financial analyst. None of these were technologists by vocation, but our participants used email, cell phones, and computers in their homes.

4.4 DayRM Role of Routines: Results

Across the twenty-five participants, a total of 249 episodes were collected; the average number of episodes recorded for the day was 10 (SD=2.8), the fewest reported was 6, the most 18. The average duration of an episode was 58 minutes (SD=41) and 57 of the episodes were 30 minutes. The shortest was 5 minutes and the longest 3 hours and 40 minutes. There was negligible difference in the number of episodes reported by men or women.

4.4.1 DayRM Routines: Routines in Home Life

Routines provide nearly continuous coverage of home life. The survey asked whether each reported episode was part of a specific routine or not, summarized in Table 7. Although routines were expected to be widely cited, on *typical* days only 4 out of 113 episodes were *not* within a routine. Recall that the entire day was classified explicitly by the participant as *typical* or not. Even on *atypical* days, routines accounted for nearly 80% of the episodes (104 out of 135). Overall episodes not in a routine accounted for just 14% (35 of 249 episodes). Thus, identifying the particular routine would add potentially valuable context to persons outside the household, by describing a large portion of the day in homelife.

Table 7: Routines Cover Home Life (computed from number of episodes)

	Type of Day	
Type of Routine for Episode	**Typical**	**Atypical**
Mealtime	29 (26%)	27 (20%)
Children's Bedtime	11 (10%)	8 (6%)
Leisure time	26 (23%)	25 (19%)
Leaving or returning home	17 (15%)	20 (15%)
Schoolwork time	5 (4%)	1 (1%)
Other routine	21 (19%)	23 (17%)
Not part of a routine	4 (4%)	31 (23%)

These routines were based on other time-use studies of homelife [76]. The survey did not include personal care routine, to minimize the intrusion on subjects' privacy, but we had many reports of showering and dressing. Subjects also listed other routines, such as shopping, yard work, or "Saturday" activities. Over 60% of the episodes included multiple activities, about the same percentage of multi-tasking found by other home time-use studies [76].

In other time-use studies, people often feel they are reporting on a day which was atypical (40%) [76]. These participants reported 50% of the days surveyed were atypical (13 of 25 participants), and 12 days were typical. The sample days occurred at the end of the school year (which may *not* be typical), so a somewhat larger percentage of atypical days is expected. Special events and activities were cited twelve times to describe why days were atypical, including trips to school, swim practice, and car repairs. Out of 113 episodes on the 12 "typical" days, only 4 (4%) were not part of a routine. On the "different" days, there were 31 (23%) of the total 135 episodes not in a routine. Clearly, routines are pervasive, and provide near coverage of waking hours on a "typical" day.

4.4.2 DayRM Routines: Descriptive Statistics of Routines and Availability

Participants were asked about availability relative to routines in two different parts of the survey: for each episode and as a general preference. For each episode, participants indicated their availability and whether the episode was part of a specific routine, or not (for the descriptive summary across all participants see Table 8). The routines were: mealtime,

children's bedtime, leaving or returning home, schoolwork time, leisure time, other routine, not part of a routine. During mealtime routines participants were inconsistent in their reported availability. They were available for interruption in 35 of the 56 (63%) mealtime routine episodes. Across all participants' leisure routines, 42 out of the 51 (82%) leisure episodes were reported as *available*. Leisure routines appear to be consistently with positive availability status. In contrast, children's bedtime routines were negatively correlated to availability, only available in 6 out of 19 (32%) bedtime episodes. These are not statistically significant figures, but provide an initial, descriptive basis for the consistency of the relationship between the routines of interest and availability.

Table 8: Routines and Availability (across participants, episodes reported as available within a particular routine)

	Reported Availability	
Routine	**By Episode**	**Percentage**
Mealtime	35 of 56	63%
Children's Bedtime	6 of 19	32%
Leisure time	42 of 51	82%
Leaving/returning	15 of 37	41%
Schoolwork time	3 of 6	50%
Other routine	23 of 44	52%
Not part of routine	17 of 35	49%

In the open-ended questions in the final part of the survey, participants were asked to indicate their *general availability* during each of these same routines. These questions were designed to probe the participant's overall notion of their availability with respect to each of the specific routines. They followed the specific responses for each episode and were meant to reflect the *general* availability policy towards each routine. For leisure, 95% of the participants were generally available (19 out of 20 participant responses), which is consistent with the 82% of leisure episodes actually reported as available. Children's bedtime is also consistent, but consistently unavailable. Only 20% of the participants are generally available (4 out of 20 responses), and only 32% of bedtime episodes were reported as available. Mealtime routines were not consistently correlated with availability. During an actual mealtime routine, subjects reported they were available in 63% of those episodes (35

out of 56). However, only 20% of these same participants (4 out of 20) portray themselves as generally available during mealtime routines. This interest contrast is one example where actual behavior within a specific daily situation may be quite different from one's preferences or intentions. Leisure is positively correlated to availability, children's bedtime routine is a negative predictor, and mealtimes need further investigation.

4.4.3 DayRM Routines: Predicting Routines

In keeping with research both at home [56] and in the office [36, 22], this study is interested in whether or not one could use measurable variables—location and talking—to predict availability at any given moment. However, the study hypothesized that one might be able to more accurately predict routines, which could provide people with a more nuanced understanding of how to determine availability on an individual or household level. Ultimately, this research is interested in determining a set of externally measurable variables that help predict whether or not the household is in a "routine," and whether or not this prediction is more accurate than the prediction of availability. To examine these questions, four separate hierarchical logistic regression analyses were conducted—one for availability and three for significant household routines: mealtime, children's bedtime, and leisure. These routines are of particular interest as meals and children's bedtime are part of the parental boundary activities [62] and leisure is often associated with availability, see ESM Factors (Chapter 3). This analysis was used because statistical regression analysis specifically asks questions about the ability of predicting an outcome based on a set of variables. Logistic regression simply refers to the fact that the dependent variable in all of these analyses was binary. Statistical analysis was used to identify those features which are most predictive of the particular routine.

Because each survey asked participants to indicate their current routine (if any) and their availability, the analysis was able to use reported information about the household state to attempt to predict these answers. To obtain a binary availability variable, researchers coded as *available* both:

> Yes, I could be available for a few seconds to a minute

Yes, I could be available for (estimate minutes) or longer

The following were coded as *unavailable*:

No, it would be difficult or awkward to be interrupted

No, I would prefer not to be interrupted

Similarly, for each routine of interest,whether or not the episode was in this particular routine was coded as "1" and otherwise as "0". There was one binary variable for each routine and "not in a routine", thus every episode had one and only one of the routine variables set on ("1").

The data analysis was divided into two steps. In the first step, variables representing location of each member of the household were entered, which researchers believe could be accurately captured from soon-to-be available sensor technology. For example, this step included variables such as participant is in kitchen, child in family room, spouse in office. The second step of the analysis included twenty-three activity variables that describe a broad range of home activities and which could be reliably computed from a combination of sensors in the near future. For example, in step two the analysis entered eating, conversation, reading, paying bills, watching TV, and doing laundry. While one can easily determine whether the TV is turned on, it is not as certain as to when someone is or is not watching the TV. This data is self-report, and as such is only as accurate as the provider's memory. Recalling one's location and general activities during a self-defined segment of time does not rely upon recall of items and actions external to the provider. However, the accuracy of the analysis is dependent upon the reliability of these reported locations and activities.

For each step, hierarchical logistic regression produces a linear equation for predicting the dependent variable from the (many) independent variables. Summary results of this statistical model are listed in Table 9. By running each data point independently through this equation, one can determine how accurate the model is. In other words, if the resulting equation only predicts a subject's actual routine half of the time, then one would say that the equation is only 50% accurate.

Results indicate that a statistically significant model can be built to predict individual

Table 9: Statistically Significant Model Accuracy for Three Routines

Model to Predict:	Baseline Measure	Location (Step 1)	Activities (Step 2)
Mealtime (n=56)	77%	89%	94%
Bedtime (n=19)	92%	96%	97%
Leisure (n=51)	80%	85%	90%

routines with relatively high accuracy, as shown in Table 9 [1]. Based on the first step of each of these regression analyses (i.e., using readily measurable variables), the statistical model is able to predict mealtime with 89% accuracy, bedtime with 96% accuracy, and leisure with 85% accuracy. When the second step is included in each analysis (i.e., less easily measurable variables), the accuracy increases to for each routine; mealtime reaches 94%, bedtime 97% [2], and leisure 90%. The variables of each step are summarized in Section 4.2.2. The first step variables appear in the actual survey questions 3, 4, and 5 shown in Figure 21 in Appendix B. The variables of the second step are appear in survey question 7 shown in Figure 21 in Appendix B. To place these predictive values in perspective, the baseline column shows the percentage of correct predictions when the most common response is always given, also called a majority classifier. Mealtime routine prediction accuracy improved from 77% to 89% and 94%, in each step. The bedtime baseline is high, due to the small number of bedtime episodes (19); simply guessing *not* in bedtime is correct 92% of the time (230 out of 249 episodes). The small number of bedtime episodes does not provide much change in the accuracy prediction.

Since routines provide nearly complete coverage of episodes in home life (85% of any day), it is important to understand whether each routine can be positively identified rather just predicting *not* in the routine. If models using sensors can accurately recognize each routine, then the day could be described with some confidence as a sequence of routines. To determine how well the model created from the DayRM Routines data would perform, one can examine the matrix of 'self-reported data", the self-reported routine for each episode, vs. "predicted", whether the model would predict the specified routine or not for that episode.

[1] $\triangle R^2$ was significant at $\alpha < 0.05$ for steps 1 and 2, for each routine.

[2] Due to the small number of bedtime routines relative to the large number of factors used, the second step of bedtime routine used only a subset of factors most likely to relate to bedtime.

For example, look at the matrix for mealtime routine predictions, shown in Table 10. In the mealtime matrix, the first row shows the 193 episodes reported **not** in mealtime (189 + 4 = 193); the model correctly predicted 189 as not mealtime, but had *false positives* for 4 episodes. The model is 98% accurate at predicting *not* in a mealtime episode. Similarly, the second row shows those 56 episodes which were reported as in mealtime routine (11 + 45 = 56). The model correctly predicted 45 episodes as in mealtime, but *missed* predicting 11 mealtime episodes. This shows the mealtime routine predictor is only 80% accurate in identifying mealtime routine. While the overall model accuracy is 94%, it was correctly identifying mealtime only 80% of the time.

Table 10: Mealtime Model Prediction Accuracy, includes location and activity variables (predicting per episode)

	Predicted by Model, Step 2		
Self-Reported	**Not Mealtime**	**Mealtime**	**% Correct**
Not Mealtime	189	4	98%
Mealtime	11	45	80%
Overall %			94%

The corresponding matrix of self-reported vs. predicted routines is provided, for each routine in Tables 10, 11, and 12. Bedtime routine is only accurately predicted in 68% of the bedtime episodes (13 out 19 bedtime episodes), which is not quite as good as the 75% overall accuracy desired. On the other hand, 99% of the episodes not in bedtime (227 out of 230 not bedtime episodes), were correctly predicted. Since, children's bedtime is negatively correlated to availability, knowing when *not* in bedtime routine, is useful in determining when to interrupt. The leisure routines have a similar profile of prediction to children's bedtime routine, much more accurate at predicting *not* in leisure, than in leisure. 190 out of 198 episodes not in leisure were accurately predicted (96%); 35 out of 51 leisure routines were correctly predicted (69% correct). However, since leisure is positively correlated to availability, the lower accuracy of positive identification implies the model may be less useful when dealing with leisure routines.

Table 11: Child's Bedtime Model Prediction Accuracy, including only location variables (predicting per episode)

	Predicted by Model, Step 1		
Self-Reported	**Not Bedtime**	**Bedtime**	**% Correct**
Not Bedtime	227	3	99%
Bedtime	6	13	68%
Overall %			96%

Table 12: Leisure Model Prediction Accuracy, including location and activity variables (predicting per episode)

	Predicted by Model, Step 2		
Self-Reported	**Not Leisure**	**Leisure**	**% Correct**
Not Leisure	190	8	96%
Leisure	16	35	69%
Overall %			90%

4.4.4 DayRM Routines: Day Reconstruction Data Validity

This study applied the Day Reconstruction Method, a hybrid diary method, that has been successfully applied in other fields [43], but is not generally used in HCI or CSCW research. This study was purposely designed to mirror the data survey of the prior ESM Factors study of home availability using the experience sampling method, see Chapter 3. The DayRM survey, part III recovering the day's episodes, was as close to the data items collected in the prior ESM Factors study as possible; both asked who was with the participant, their room location, and provided nearly identical activity checklists. Finally, the availability questions were very closely worded and conditioned on close family and on the same purpose for the interruption: talk about an important task and talk for social interactions. Based on the first step of the regression analysis (i.e., using readily measurable variables of location), the model is able to predict availability with 72% accuracy, which is on the same order as results from other studies in both the home (see Chapter 3) and the office [22].The DayRM data produced a model that has 76% overall accuracy in predicting availability (as shown in Table 13, the similar data items in the prior ESM Factors study had 78% availability prediction. The similar model accuracies from nearly identical survey questions provides one validity check for this data.

Table 13: Model Accuracy for Availability

Model to Predict:	Baseline Measure	Location (Step 1)	Activities (Step 2)
Availability (n=141)	57%	72%	76%

4.5 DayRM Role of Routines: Relevancy of Routines

Although it is interesting to see that measurable variables allow one to predict routines with high accuracy, these regression analyses included everything and the kitchen sink (almost literally!) as independent variables. To develop more parsimonious models of home life, research need to provide a deeper analysis of the relevancy of routines to availability and shared awareness. This study has explored the features of routines in the home, hoping to harness the power of routines in availability determination and to bridge sociological descriptions of routines into the dynamic environmental indicators of home routines. This study focuses on three ways routines are a valuable conceptualization of availability: appropriate abstraction level, temporally segmenting activity, and transition functions of routines.

4.5.1 DayRM Routines: Routines as Availability Cues

Does knowledge of a household's routine provide cues into their availability? Of the three routines explored, leisure time is the most consistently predictive, participants reported being available in 42 out of 51 leisure episodes (82%). However, leisure is the most difficult to identify, with only 35 out of 51 correctly predicted (60%). Leisure routines are predicted through some of the same activities seen in prior sampling studies, including TV (p=.001, B=4.057), email (p=.022, B=3.501), and managing personal information (p=.110, B=3.498) [3]. Surprisingly, leisure time is also predicted by several activities more often associated with "work": laundry (p=.006, B=4.021), managing personal information (p=.110, B=3.498), and written communication (p=.012, B=6.524). Listening to music was negatively correlated to leisure routine (p=.105, B=-5.406). In this case, an activity that is usually associated with leisure is actually predicting when *not* in leisure routine.

[3]Values are from this exploratory study, using loose measures of significance.

The variety of activities predicting leisure is also seen in the breadth of leisure activities recorded—an average of 2.7 activities/episode, with every one of the 23 different activities occurring at least once. The large number of activities per leisure episode suggests that leisure may also be a time to handle routine housekeeping tasks, adding complexity to predicting leisure and its correlation to availability.

The child's bedtime routine episodes are negatively correlated to availability, participants reported being available in just 6 out of 19 bedtime episodes (32%). This data also shows some evidence that parents working full-time out of the home are most often unavailable during bedtime routine. Our homes with infants were somewhat less-available during the bedtime routine than families with only elementary age children.

In general, mealtime routine is not a consistent availability predictor. Although participants actually reported they were available in 45 of the 56 mealtime episodes (63%), they spoke of generally not being available during mealtime. In Part IV of the survey, where participants were asked to reflect on their general inclination to be available or not for each of the routines presented for each episode, only 4 out of 20 respondents (20%) claimed they would be available during mealtime routine. There is a discrepancy between availability within a real situation, and perceived availability policy or preference. The households in this study were more likely to be available during week-end mealtime (73%, available in 19 of 26 episodes) than during the weekday mealtime routines (53%, 16 or 30 episodes). When the family was having a typical day their mealtime availability was 52% (15 of 29 episodes), but when the reported day was unusual, availability increased to 74% (20 of 27 mealtime episodes), perhaps in compensation for the differences in the day. When we look at the effect of age of the youngest child in the household, the trend is to be less available during mealtime routine as the youngest child is more mature. This may reflect increased social interactions among family at mealtime routines as the children develop. Although recognizing mealtime routine is not sufficient for understanding availability in the home, adding knowledge of household specific preferences and whether it is a typical day for the family increases the correlation.

4.5.2 DayRM Routines: Routines as Appropriate Abstraction

Shared awareness and availability information has also been of interest, not just between homes, but in the workplace as impromptu face-to-face meetings are complemented by phone calls, email and instant messaging to collaborate. The information shared can be a single bit of information, such as an instant messenger "I'm available", or a shared media space, with synchronous video and/or audio streams. There is a tension between providing enough information to enable the person to determine the appropriate communication interaction and to protect the privacy of the provider, for instance blurring images when video conferencing from home [60]. Routines are meaningful within the social context of interaction, naturally encapsulating details of the situation. Because routines derive meaning from the common understanding of what is and is not a particular routine, they are an abstract representation of on going interactions. This is consistent with the findings of Dabbish and Kraut, in which team members were able to better manage interruptions and enhance task performance when an abstract representation of information was provided, rather than detailed representations [12]. Routines hold just such potential: they have an everyday usage that abstracts away distracting details, but provides enough insight into the mentality of those engaged in the routine.

Routines, in addition to providing an appropriate amount of insight to availability between locations, are also excellent candidates for computational perception. The DayRM Routines models using potential sensors of location (step 1) and activities, like eating, talking, doing laundry, (step 2), show particular routines can be correctly identified with moderate accuracy. From the perspective of routines, the life of another household appears as a sequence of episodes. Those outside the home or office, use the knowledge of routine as enacted in that home or workplace to enhance their determination of availability. Providing only knowledge of the routine protects the user from being overwhelmed with too many details that make it difficult to quickly assess the situation. Routines, provide more context than an availability status, while respecting the privacy and etiquette of the household.

4.5.3 DayRM Routines: Temporally Segmenting Routines

Some of the "messiness" of routines arises from the gap in how the routine name is used in everyday settings, and one's internalized associations with a specific routine. This gap was evident in the participants' perception of mealtime as "not available", but in practice they were available in 45 of the 56 mealtime episodes (63%). How does one account for the disparity between their intention and the actual practice? This study looked at the qualitative data describing one specific mealtime routine, dinnertime. Participants were asked to list three indicators or activities that dinner was starting and then three to signal the end of dinnertime. The responses were location and person-centric. For instance, to start the meal, the most frequently mentioned factor (13 times) was:

> *"Everyone is seated at the table"*

Food preparation, time of day, and setting the table were also important:

> *"cooking buzzer goes off"*
>
> *"it's around 6:30 (+-10 minutes)"*
>
> *"we set the table"*

The end of dinner includes table clearing, cleaning-up, and transitioning to attend to other activities, from one survey:

> *"Children finished eating and asked to be excused"*
>
> *"We take off from the table"*
>
> *"Shower time/homework begins"*

These markers of the beginning and end of dinner time are quite consistent compared to the diversity of activities found in the overall mealtime episodes, 3.5 different activities per mealtime episode.

The participant description of dinner is characterized by a coming together in a specific location at a relatively fixed time. The ending has family members moving about the room clearing and cleaning the table and moving to other rooms and activities. This study demonstrates that dinner mealtime routine is conceptualized as three sequential segments—food

preparation, eating, clean-up. Just as this research explored the details of the dinnertime routine, future research may explore the divisions within other routines. These findings imply that determining temporal and functional segments within mealtime routine will be predictable from sensor data and may be better correlated to availability than the more generic "mealtime routine."

4.5.4 DayRM Routines: Boundary and Transition Work of Routines

The boundary-making nature of routines both opens and closes windows of availability [62]. Participants often used mealtime and bedtime routines as markers, and most went further to specify a window of opportunity "after dinner and before bedtime," but in six cases this excluded children's bedtime. As one succinctly portrayed policy:

> *(good time) "between dinner and bedtime"*
> *(not good) "mornings and evening meal"*

Even in this homogeneous population of families with young children, it is difficult to find a generic "safe time" to call, respecting household policies and preferences. Many of these windows of availability are opening and closing relative to the children's bedtime routine, after which it is not socially acceptable to call. When is the window of opportunity between meal clean-up and children's bedtime routine for another household? With just knowledge of certain "boundary-making" household routines, a close family member would at least know when a call is likely to be welcomed and may be given the attention they desire.

In addition to bounding, routines help transition from one frame of mind to another, such as dinner to children's bedtime routine. This movement between mindsets is similar to Gonzalez and Mark's finding that office workers cope with interruptions by continually refreshing their overview of all "working spheres", units of activity and collaborators, and strategizing how to transition from one to another [27]. In the example of ending dinnertime in the prior section, dinner ends with the beginning of homework and personal bathing. Time of day was rarely used to indicate bedtime routine. The bedtime routine is instead defined by the family in terms of personal interaction, activities, and locations (bed and bath). There is an overall lessening of activity, talking and lights are turned off. But the

most prominent characteristic was the intimate and comforting parent-child interactions at the bedside, mentioned sixteen times in surveys. Since time of day was not used as a marker of bedtime routine, the recognition of the routine would provide information those outside the household would not otherwise have, about the transition within the household. Recognizing children's bedtime will clearly mark a time when parents are not available, but one that is not well-defined by time.

4.6 DayRM Role of Routines: Discussion

This research has shown that a combination of sensors detecting room location and more complex, less reliable sensor measures of activities predict mealtime and leisure routines relatively accurately. Friends and family members already have some knowledge of the household availability preferences. Sharing relevant information about current household routines may provide just enough information to the caller, thus managing interruptions. Conceptualizing awareness in terms of routines, rather than availability status, may also apply to those who work from home and to office situations.

4.6.1 DayRM Routines: Routines and Availability Awareness

This study highlights two benefits of routines to between home awareness: routines are dynamic indicators of homelife and routine information carries richer meaning than availability alone. This research confirms the findings of other studies of routines and begins to explore the empirical prediction of particular routines, based on implicitly gathered information about the everyday home activities. Routines in the home are both dynamic and tightly integrated into the social organization of homelife. Crabtree and Rodden's *ecological habitat* both organizes the home and reveals the invisible routines within [10]. Taylor and Swan explore how lists in the domestic environment are integrated into home life and then serve as the visible, social organizers of the household [87].

It is this local production of a routine woven into the social relations of home that makes it difficult for an outsider to *know* enough about another household's routines. The participant responses reveal many ways knowledge of routine would help determine availability:

(good time) "Lunchtime in general though I don't think they really know."

(not good) "I don't think they know. My routine varies daily a lot."

This person's *good time* for a call is described by routine, as well as when *not* to call, but this information is not *usually* visible to others. Leisure and mealtime can be predicted relatively accurately from simple, implicit sensing in the home environment, making "visible" certain aspects of home organization and social interactions.

Just as knowledge of the current routine could help the potential caller determine best times for the other household, knowing when a household is "off-routine" enables better timing of between-home conversations. If one's routine is different, then other's assumptions on their availability may be adjusted. In this study, when the family was having a typical day their mealtime availability was 52% (15 of 29 episodes), but when the day was deemed unusual, availability increased to 74% (20 of 27 episodes) during mealtime. Availability is conditioned by who is interrupting:

"I am always available to my immediate family [living in the house] except when I'm on the telephone or paying bills. I do not answer the phone to people outside of those living in my house when working with my kids on school work or while we are eating a meal or snack."

The perceived intimacy of one's social interactions corresponds to the access afforded, even differentiating between *close* family and friends.

4.6.2 DayRM Routines: Routines and Perception Technology

A key to predicting routines is accurate and reliable sensing of both a person's location, their interactions, and activities. Simple sensors can only provide part of this information. While there are technologies on the horizon to detect the room location of someone in the home, one may want to focus on sensing and perception techniques that recognize those activities significant for routines. Researchers may want to focus sensing and perception techniques on factors significant to the rooms of interest for particular routines and their activities. With the mealtime routine the kitchen and dining room are of interest, as is food

preparation, especially around the stove, and clean-up. The teeth brushing, bathing and dressing activities marking bedtime may be recognized using approaches that infer activities of daily living for the elderly [72]. In the child's bedroom, perception would be directed to detecting reading and conversation around the child's bed. The ending of bedtime routine is characterized by parent-child interaction around the bed and a lessening of motor-movement activity, talking, and light level. The boundary-work of routines [62] implies perception technology should look for the beginning and ending markers of particular routines.

Knowledge of whether or not a particular routine has already been completed is more significant than the momentary assessment of current routine. If dinnertime is completed and the child's bedtime is not yet started, then many households are available. Romero and Mateas are developing a perception system that synchronizes the input of multiple sensing devices to define features over a "social space" and time could directly identify the mealtime routine in the kitchen[78]. This study emphasizes the prediction of family routines, either indirectly using discrete location and activity recognition in locations of particular interest or the identification of specific routine boundaries by patterns in social spaces of the home.

4.6.3 DayRM Routines: Learning Household Routines

Routines appear to be especially useful when coupled with some knowledge of family preferences or daily norms specific to the household. A critical factor will be establishing a default system with initial values approximating routines and policies. Routines are readily described in narrative by the family, but not so easily learned, just because they are richly contextual. For instance, *mealtime* is commonly used to refer to any "routine" food preparation, eating, or clean-up activities. Yet these participants describe the start of *mealtime* as when the family members gather to eat; while some mentioned food was now ready to eat, none marked mealtime start with food preparation. Part of the learning process of routines will need to include finer grain *routines*, that encapsulate the local organization and social interactions. This study shows mealtime routine as composed of three sequential "routines": food preparation, eating, clean-up. Each of these phases differ in the acceptability of an interruption and the resources one has to handle an interruption. Leisure is also

partitioned, not so much temporally, but more by the activity level and number of people involved. The appropriate segmenting of everyday routines may provide better correlation with availability. This requires further research. In addition, systems will need to learn the variety of mealtime routines, like having dinner delivered, rather than "prepared in the home". There is also the learning as the household changes, in response to school terms and extracurricular activities, or in the maturing of the children and the corresponding social interaction changes. Any system that will be useful in recognizing routines will need to learn to evolve its model of any particular routine.

4.7 DayRM Role of Routines: Summary

This research offers main contributions from the results of the DayRM Routines study that add to understanding how to predict routines and how to use routines to support inter-home awareness. The Day Reconstruction Method was used to gather time-use data on home routines and availability, with results matching the prior ESM Factors study and office simulation studies. The approach of this research has been to gather data in real situations that simple sensors could detect. Since sensor deployment can be costly and disruptive, especially in the home, the statistical models can inform the selection and placement of sensors. Second, mealtime and leisure routines can be accurately predicted from fairly simple sensed phenomena, such as, detecting room location, talking and changes in activity. Third, this work has also provided a richer description of the factors that predict and effect each of these routines. Finally, ES^3M Using Factors study portrays the relevance of routines in availability assessment between households.

CHAPTER V

ES^3M USING FACTORS FOR PREDICTIONS: EFFECT OF CONTEXT ON AVAILABILITY PREDICTION

When family members and friends call one another, each expects the caller to respect their activity patterns and only call at appropriate times [46]. Do they really know the schedule and preferences of the other person? In these close relationships, one often provides access, even when it is not a *good time* to call [98]. From the caller's perspective, interrupting at inappropriate moments is socially awkward and may impair the fluidity of the conversation. Would callers make more accurate assessments of availability if they had access to some context about the remote conversation partner?

The prior ESM Factors study identified candidate sensing that provides moderately accurate predictions of availability, see Chapter 3. While this research found potential environmental indicators of availability in the home, there is no assurance that this information is either useful or usable. This study looks at these home awareness challenges:

> *Are friends and family already* good enough *at finding appropriate times to call?*
>
> *Does shared contextual data help others determine whether or not an individual is available?*
>
> *Is one type of data more useful for predicting availability?*

This chapter discusses the study designed to answer these questions. The investigation compares availability predictions made with only knowledge of the generic day of the week and time of day as compared to each of three context conditions: routines (e.g. mealtime), activities and location (e.g. watching TV with children in living room), and the combination of both routines and activities. Although people expect family and friends to know when to call, either about an urgent matter or social chatting, this study found people are no better than random guessing in their predictions. When any situation information, such

as routine, room location, or activity is added, then the accuracy of availability prediction improves. Detailed activity, location and presence information appears to provide the best overall prediction accuracy, but is not statistically different from just routine context or combining routines and activities. While shared context is useful to improve availability prediction, it is not clear precisely what form such information should take to preserve the social balance between caller and recipient and the security and privacy concerns of the provider. There are many tensions in sharing situation information, such as preserving the social balance between caller and recipient in the conversation.

5.1 ES^3M Using Factors for Predictions: Method and Participants

The goal of this study is to provide an accurate assessment of how well people are able to predict good times to interrupt others, and whether shared context from the other home improves these predictions. First, the accuracy of current availability prediction will be established, using only tacit knowledge, time of day and day of the week. Then tacit knowledge will be supplemented with additional activity and location information and availability prediction accuracy will be measured again. These two predictions can be compared to determine whether shared context is useful, that is, does it improve accuracy. These prediction figures provide quantitative answers to the questions above and serve as motivation for the development of prototypes inspired by DayRM Routines and CDA Shared Awareness, in Chapter 4 and Chapter 6.

5.1.1 ES^3M Using Factors: Study and Instruments

This study used a multi-step hybrid method to achieve balance between the control needed for gathering empirical data, while maintaining the richness of *in situ* data. It is difficult to envision how an observer might determine that an interrupting phone call was *not made*, as there is usually no observable action to mark one's decision to *not* call. When researchers ask participants to note internal decisions in a diary, the results are subject to distortions from lack of recall and *post hoc* rationalization. Even if the subject had a perfect memory, it is very difficult to imagine how a researcher might determine the availability of the potential

recipient at the times when a call was not made. Would it be appropriate to ask the subject to interrupt with apologies and ask if this is a good time or not? To overcome these data collection problems, this study uses a multi-step approach:

1. Sample a person's availability at specific moments and the corresponding context using ESM, similar to ESM Factors study, in Chapter 3
2. Simulate home life situations using the ESM samples of moments in time
3. Survey potential callers using the simulated situations, constructing pairs of questions using the same day and time, but adding context in the second of the pair in the survey

The data of interest is the accuracy of availability prediction by family and friends. To obtain such a measure, the first step is to gather *in situ* samples of home life and the availability of the individual at that time. Second, home life situations for a time of day and day of the week are simulated using these acquired samples. Then, friends and family members are surveyed to assess their accuracy at predicting the other's availability; first with only time of day provided, then with additional situation information added. This multi-step approach is referred to as the Experience Sampling-Simulation-Survey Method, or ES^3M Using Factors, for short.

5.1.1.1 ES^3M Using Factors: Stage 1 of Study

In stage one, each participant is given a small personal digital assistant (PDA) to carry with them during their home life for three days. At random intervals, the PDA interrupted the user with an alarm, and presented a brief survey to complete. The interruptions were scheduled to occur randomly once within each 30-minute interval. The survey consisted of ten questions, modeled on those used in the prior ESM Factors study, in Chapter 3, and could be answered by an experienced participant in less than one minute. The survey asked participants questions in the following general categories:

- "Are you alone or with others right now?"
- "Where are you?"

- "What are you doing right now?"
- "How would you feel about someone interrupting you right now?"

The question responses were designed to provide fine-grained responses to these four general questions. For example, when location response was "home," the next question requested the room. There were questions to cover the four categories of activities, derived from Venkatesh's technology use within the home [91]: communication, food related, household tasks, and leisure. Within each of these there were four to five specific activities and "other", where any combination or none could be selected, as fit the current activity context. The complete survey is in Appendix D, Section D.1. Two questions determined availability to another adult family member:

1. Would this be a good time for an adult family member to get your help with an important question requiring your full attention for a minute or two?
2. Would this be a good time for an adult family member to catch up on social news, activities and events with you?

For the first, some examples of "important questions" are: making plans and resolving scheduling conflicts, asking for help or advice, and timely reminders. All participants completed the ESM survey for at least three days, and some continued completing surveys until the PDA was physically collected.

The software and hardware set-up and training of participants were identical to those used in ESM Factors, and described in Section 3.1.2. If a survey was not answered within a specified time frame, then a "missed survey" was recorded at that date and time. Each question also had a timeout interval. This insured the data was recorded close to the time of the alarm and not recalled later. Each participant was offered a token reward of five dollars per day, maximum of twenty dollars paid at the post-study interview. They were also paid $2 for each family or friend that completed the availability survey constructed from these samples, as described below in Section 5.1.1.3.

5.1.1.2 ES^{3}M Using Factors: Intermediate Stage, Survey Construction

The initial stage provided situation data and corresponding availability status for use in constructing a survey. Each ESM sample provided self-reported availability for two purposes: (1) urgent task and (2) social talk. The sample also provided the corresponding set of context: household routine, room location, activities and who is in the room. These samples of actual experiences would provide the person's "correct" availability status (a.k.a. *ground truth*) relative to day, time and other environmental factors. Family members and friends of the person providing the sample would be asked whether or not the provider was available, first for an urgent task and second to talk, see Figure 4. By comparing their availability prediction to the self-reported availability status (ground truth), one can the accuracy of predicting when to interrupt.

Motivated by results from the previous DayRM Routines and CDA Shared Awareness studies, this research was interested in different granularities of context that might communicate availability to others. The hypothesis was that additional situation information would improve the accuracy of predictions by family and friends using only tacit knowledge about the same time and day of the week. The study compared how well a potential caller's predictions matched the self-reported availability: (1) in the control situation and (2) when provided one of three experimental information sets. The predictive accuracy was compared to one of three conditions: (1) household routines, like mealtime, (2) detailed presence, location and activity information, watching TV with children in family room and (3) both routine and detailed context. The control condition models the current situation where the only context available is the current day and time, although this may differ across time zones for the caller vs. the recipient.

A within-subjects experimental design controlled for individual differences in availability assessment. Each participant in the last stage of the investigation is asked to assess availability in both the control condition, knowing only day of the week and time of day, and the experimental condition, where additional real sampled situation data is provided for that same day and time. Repeated-measures control for effects of variance in the survey subjects. It does not control for the effect of variance between the seven providers of sample

Step:	Introduction	Consent	Your Info	Survey Situation 4b of 12	End

Survey Situation 4b of 12	Georgia Burdell Home Information Wednesday, 2:47 p. m.
	Schoolwork Time

ANSWER THE FOLLOWING QUESTIONS BASED ON Georgia Burdell's INFORMATION

1. Would this be a good time for her/him to answer an important question for you that requires full attention for a minute or two?
   (Some examples of 'Important questions' are: making plans and resolving scheduling conflicts, asking for help or advice, and timely reminders.)

   - ○ No, they would not be available
   - ○ No, they would prefer not to talk
   - ○ Yes, they could be available for a minute or two
   - ○ Yes, they could be available for several minutes or more

2. Would this be a good time to catch up on social news, activities, and events?

   - ○ No, they would not be available
   - ○ No, they would prefer not to talk
   - ○ Yes, they could be available for a minute or two
   - ○ Yes, they could be available for several minutes or more

Proceed **To Situation 5 of 12**

Figure 4: On-Line Survey Data, With Additional Routine information, note progress cues at top and bottom

survey data.

Pilots showed that twelve situations were reasonable to expect a participant to answer and would provide four pairs of responses for each of the three conditions. Each participant would predict availability twice for twelve situations: first with time only and next with additional context. The availability assessment was actually two questions, dependent upon the purpose of the interruption: urgent task or social talk. For each participant, there are 48 predictions made: 12 situation samples * 2 conditions (day vs added context) * 2 reasons for interruption (urgent and talk).

A balanced Latin square design controlled for order effects. For each of the seven providers, the experimental condition (type of context) was varied to balance the sequence and order of the conditions. With only seven surveys, a completely counterbalanced design was not possible. Within each survey pair, the control situation (day and time) was always first, as in real-life calling situations, where one is usually aware of time and day. The experimental condition was always presented second, adding the context to the time and day.

For each of the seven ESM providers a unique twelve situation survey was constructed, using the pre-defined ordering of context data. The sample provider was asked to take their own survey. Providers could veto any content they were not comfortable sharing, and they realized the time commitment when inviting their family to take the survey. The effects of context on self-predictions of the providers was also assessed. Four of the seven providers completed their survey during a follow-up interview.

5.1.1.3 ES^{3}M Using Factors: Stage 3, On-Line Availability Survey

In the final stage, potential callers completed an availability prediction survey based on actual home life situation samples. The survey was available on-line, enabling remote participants to access it. All participants used the on-line version at their convenience. The survey consisted of four parts:

1. Introduction and Consent Form

2. Log-in (to protect provider's home life data)

3. Demographic questions about the potential caller

4. Availability Assessment for Actual Situations (twelve pairs of time vs context data)

Details of each section are shown in Appendix D, Section D.2. In addition to the convenience, the computer-presented survey allowed the researchers to require responses when appropriate. For instance, providing demographic data was optional, but the availability survey required both questions to be completed before proceeding to the next situation. The introduction page provided some context for the study in layman's terms, see Figure 38 in Appendix D. A simple log-in protected the provider, insuring only those who were invited would be able to access the situation data for a specific person, see Figure 39. This study was only interested in responses from those who normally call the provider, not random individuals. To personalize the survey, all questions used the name of the particular sample provider; this also reminded the survey participant to respond relevant to that person. In addition to demographics on the users, they were asked open-ended questions about how they know when it is a good time to call or visit this person, and when not to call, see Figures 41,42,43,44. The availability survey portion began with an introduction and an example, explaining that the same two questions would be asked for each situation, see Figures 45 and 46. Then the twelve situations were presented, control condition followed by experimental condition, for examples see Figures 47, 48, 4, 50, and 51 in Appendix D. The contextual data was always presented in text, the time and day as well as the routine and activity details. Since one screen of text appears very similar to another, we provided multiple cues at both the top and the bottom of the screen to show progress through the survey and how much farther to the end, see Figure 4. To emphasize that the situation had changed between question pairs, we displayed a different image for each sample. Images of homes and graphic designs were selected, excluding images of people and activities that might imply availability status. The on-line delivery of the availability survey may have lessened the potential for providing "socially acceptable" responses as opposed to the participant's actual response, as the researcher was not physically present.

5.1.2 ES^3M Using Factors: Subjects

There were two pools of participants: sample providers and their friends and family who took their availability survey. Seven parents of young children were recruited to participate in the ESM portion of the study, five females and two males. Parents from youth activities in the community who were acquainted with the investigators were invited to participate. These participants became co-investigators, by enlisting the volunteers for their availability survey. It was important to have a trusting relationship to facilitate the recruitment of the final survey volunteers. There was an eighth ESM participant who did not have time to issue the invitations; that ESM data was not used in any of this analysis. The seven sample providers were married, their ages were in the 35-44 year range, all were well-educated, with either college or graduate degrees. Each had two or three children, ranging in age from one year up to eleven years of age. They had a wide range of occupations, two homemakers, teacher, consultant, research engineer, IT manager and CPA. Each enlisted family members, friends and neighbors to take the availability survey constructed from their situation data recorded on the PDA.

Thirty-six participants completed the survey on-line for the specific friend or family member. The average number of associates that took a given provider's survey was five, ranging from as few as three to as many as seven friends and family. At least fifty persons were asked to take the on-line availability survey (as reported by the seven providers), and thirty-six participated. (The providers did not inform the research team of all those invited to take the survey.)

The friends and family were similar in most respects to the sample providers. Thirty were females and six males; thirty-two married and one-single. Note that in the demographics portion of the survey, participants were not required to answer the questions, so the total responses vary by question. Twenty-five were in the 35-44 years old age bracket, four younger and seven in older brackets, including three in the "55+" bracket (parents and parent-in-law). They were well-educated with college and graduate degrees held by thirty-three. Their occupations ranged over: homemakers, teachers, librarians, engineers, IT professionals, architect, and medical workers. The users are evenly split between family

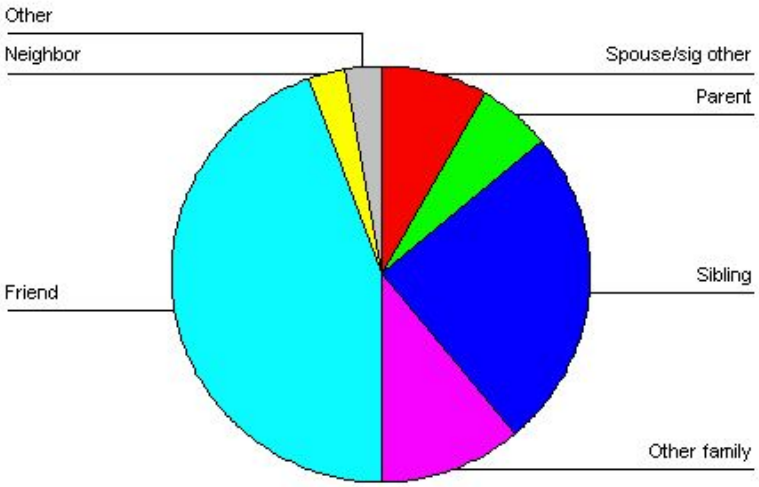

Figure 5: Relationship of Friends and Family to Provider

members (spouse, parent, sibling and other family) and non-related (friends, neighbors and others), as shown in Figure 5. The users were geographically distributed, but the two largest groups were in the same neighborhood and more than one hundred miles away, as depicted in Figure 6. The context-user participants described themselves as middle of the road in terms of technology awareness and adoption. In the home, they used both land-line phones and mobiles, answering machines and caller ID, with nearly half also using fax. When they wanted to contact their friend or family member, they phoned or emailed.

5.2 ES^3M Using Factors for Predictions: Results

The ES^3M Using Factors study showed people are generally no better than random guessing (50% accuracy) at predicting whether someone is available, when using just day of the week, time of day and implicit knowledge of daily life rhythms. However, when provided specific situation information about the other person, then the predictions improve to over 60% correct. There was no statistically significant difference between the context conditions: routines, detailed activities, both routine and activity information. Providing more detailed situation information does not always improve the predictive accuracy. Using routines, a more abstract representation of activity, appears to provide statistically equivalent accuracy,

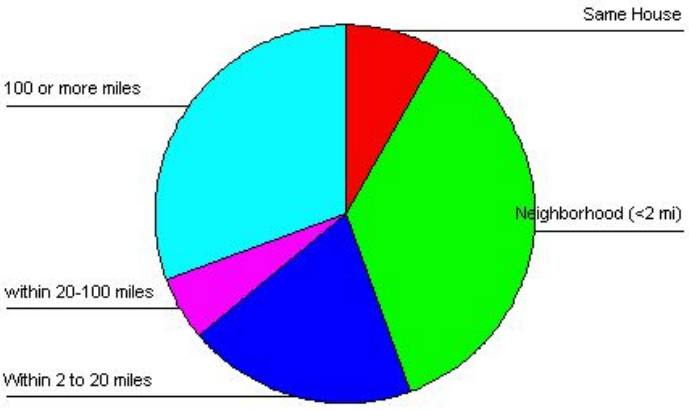

Figure 6: Distance of Friends and Family Members Homes from Provider's Home

while potentially respecting the social interaction protocols and desire for privacy at home.

5.2.1 ES^3M Using Factors: Friends and Family On-Line Survey Results

This study is interested in determining whether family and friends make more accurate availability predictions when situation context is shared. Thirty-six volunteers completed the on-line availability survey of twelve situations from the home life of the provider, a friend or family member. All participants completed the twelve paired samples, providing 432 pairs of responses (12 situations * 36 participants). The text questions were identical for all samples, only the text description of situation information changed. The context conditions were presented in text only, to avoid any bias due to interpretation of images or icons. However, to emphasize the change from one of the twelve situations to the next, each sample was associated with a different graphic image; the same for the control condition and the context condition for a specific sample. Pilot studies showed that progress through numbered situations was not sufficient to cue participants to notice the change in situation, but the change of image was sufficient. After the study, some providers reported that some users looked at the images as context about the situation, even though they were purposely selected to not imply availability or activity context.

Table 14: Availability Samples Correctly Predicted by Friends and Family (out of 432 questions)

Urgent Talk			Social Talk	
Day & Time	**Any Added Context**		**Day & Time**	**Any Added Context**
50% (216)	59% (253)		50% (217)	63% (271)

The first question of interest is how accurate are people at predicting other's availability from information at hand: day of the week, time of day, and implicit knowledge of the other's home rhythms and preferences? Recall, there were two availability questions for each situation: talk about an urgent task and talk about social activities. Out of the 432 samples, participants' predictions for availability only matched *ground truth*, the self-reported availability of providers, in half of the cases. When friends and family were presented with just the generic day of the week (not a particular date) and the time of day, only 50% (216) of the talk for urgent task predictions matched and only 50% (217) of the social talk responses. While people are expected to learn the life patterns of others to call at appropriate times [46], this data shows people are only able to correctly predict availability in half of the situations. Statistically, this is equivalent to flipping a coin to determining whether this is a good time to call. However, when looking at the accuracy of availability prediction for those same situations, but in the paired condition with some textual representation of the current context at the other's home, then the accuracy improved to 59% (253) for talk about an urgent task and and 63% (271) for social talk. These figures are for all three context conditions and simply show there is an improvement, but does not indicate statistical significance. The correct predictions contrasting day and time vs. all other context conditions are summarized in Table 14. At this point, the data shows that friends and family are not very accurate at knowing other's availability, but they improve with more explicit knowledge of the current situation.

The next step is to examine whether this improvement in prediction accuracy is significant for each of the three context conditions: routines, activities and both routines and activities. Differences between the pairs of predictions were examined over the aggregate on-line survey data of the 36 friends and family members. The McNemar non-parametric

test was used to determine whether or not the binary availability prediction was unchanged (null hypothesis). This statistical analysis was chosen because it focuses on the changes from one sample response to another. In this case, the null hypothesis is that the addition of context information would have no effect on the accuracy of availability prediction. Family and friends would be equally likely to make the same availability prediction in both conditions. The variable of interest, availability prediction, was binary. It answered the question, did the predicted availability response match the self-reported availability status for that situation sample? The availability prediction variable was coded as a value of one when the user-prediction matched the self-reported ESM survey availability and zero otherwise. For example, if the self-report was "not available" and the predicted was "available", then the prediction accuracy variable would be coded as a zero (not matching). The interesting cases occur when the predictions between conditions differed. Each context condition vs. day and time was examined for each of the two availability conditions (urgent talk and social talk) for significance.

Changes in predictions between the time and day condition and the added context condition, the two cells in each table where the two responses differ, were examined for significance. For instance, looking at Table 15 show shows predictive accuracies between day/time and shared context of current household routine. With shared routines, both conditions predicted availability for social talk correctly in 61 samples and both were incorrect in 43 samples, see Table 15. The cell with 31 indicates those samples that were correctly predicted when routine information was provided, but were not correct with only day information. On the other hand, one sees 9 samples that were correctly predicted with only day information, but were not correctly predicted with additional routine data. Only these two cells of the table in which there is a change in the prediction between conditions are used to determine the chi-square distribution and significance. In this case, adding routine data significantly increases the prediction of availability for social talk ($p = .001$), but is only moderately significant for urgent task talk availability ($p = .144$). The results for each condition are shown in Tables 15 (Routines), 16 (Activities), and 17 (Routines and Activities). From Table 16, one can see that providing specific activities, room location, and who

is in the room with the person significantly increases prediction accuracy for both purposes, urgent task talk (p=.040) and social talk (p=.005). In the third condition, providing the detailed activities, location, presence and the routine, only the urgent task talk availability prediction is significantly changed (p=.080). Shared contextual information increases availability prediction accuracy, but it depends upon the type of information shared and the purpose of the interruption.

Table 15: Availability Prediction Differences with added Routine Context

	After Adding Routines Prediction Accuracy				
Day & Time	**Urgent Talk**			**Social Talk**	
Accuracy	**Not Correct**	**Correct**		**Not Correct**	**Correct**
Not Correct	50	24		43	31
Correct	14	56		9	61
Chi-Sq (sig.)	**2.132 (.144)**			**11.025 (.001)**	

Table 16: Availability Prediction Differences with added Activities, Location and Presence Context

	After Adding Activities Prediction Accuracy				
Day & Time	**Urgent Talk**			**Social Talk**	
Accuracy	**Not Correct**	**Correct**		**Not Correct**	**Correct**
Not Correct	47	27		39	33
Correct	13	57		13	59
Chi-Sq (sig.)	**4.225 (.040)**			**7.848 (.005)**	

Table 17: Availability Prediction Differences with added Routines AND Activities, Location and Presence Context

	After Adding Routines & Activities Prediction Accuracy				
Day & Time	**Urgent Talk**			**Social Talk**	
Accuracy	**Not Correct**	**Correct**		**Not Correct**	**Correct**
Not Correct	38	30		40	29
Correct	17	59		17	58
Chi-Sq (sig.)	**3.064 (.080)**			**2.630 (.105)**	

Since all three conditions improved predictions for at least one type of interruption, the next step was to look at whether there was a significant difference between the predictive accuracy of the three types of context examined: routines, activities, and both. An analysis of variance was used to test the null hypothesis that the three conditions are equal. No significant difference was found between the means of the three context conditions. There

may be some difference, but it is not revealed by this data. The responses were also examined by provider (rather than context condition), where there were large variations between the seven groups of friends and family in prediction accuracy. The variance between the three context conditions may be relatively small compared to the differences between the seven survey provider groups. This data does not differentiate between those who are more predictable in their availability and the friends and family who may be socially closer and thus better predictors. This study did not provide sufficient data availability predictions for any single provider to determine the effect of reliability and social closeness. However, as discussed in the next section 5.2.2, the sample providers self-prediction accuracy varies widely; the large variation among provider availability may overwhelm the smaller variation between context condition effects. While context improves availability prediction, this study does not reveal any statistically significant difference between the three types of context examined.

5.2.2 ES^3M Using Factors: Sample Providers Results

While not the primary focus of this study, the researchers also looked at provider's availability across the twelve survey sample pairs. In the interruption for urgent task talk, providers were available in 57% of the situations, ranging from available in only 17% of the situations up to 83%. For interruptions for talk about social events, they were available somewhat less, 45% overall, ranging from available in 17% of the situations to 67%. This individual variation in availability is consistent with ESM Factorsresults reported in Chapter 3. The availability profile of each provider is shown in Table 18.

Researchers also looked at how accurately each provider was able to predict their own availability when taking their individual availability survey. When given only the generic day of the week and time of potential interruption (e.g. Wednesday, 5:05 p.m.), providers were correct in 61% of the situations (51 out of 84 correct) for the urgent talk that would require their attention for several minutes. In the case of availability for social talk, given only generic day and time, the providers were correct in only 52% of the situations (just 44 out of 82 samples). However, when they were provided the situational context they

Table 18: Availability Profile of Each Provider for Urgent and Social Talk

	Urgent Talk	**Social Talk**
Provider ID	**(out of 12)**	**(out of 12)**
1	83% (10)	50% (6)
2	50% (6)	50% (6)
3	83% (10)	67% (8)
4	42% (5)	42% (5)
5	17% (2)	17% (2)
6	67% (8)	58% (7)
7	58% (7)	33% (4)
Average (StdDev)	57% (3)	45% (2)

had recorded in response to the ESM survey, then overall accuracies rose to 74% and 71%, respectively. In general, those that benefit the most from the additional context had the lowest accuracies when provided only day and time; those that were the least reliable at predicting with only day and time, improved the most with any added situation information. Some individuals are also much better at predicting their availability for urgent talk than for social talk, see provider IDs 1, 3, and 6. The accuracies for each provider are included in Table 19. The sample providers vary a great deal in their availability and their accuracy at predicting their own availability. The large variation between provider availability profiles and reliability at self-prediction may overwhelm the variation between the three context conditions effects for family and friends. A future study may control for variation between providers by using more samples over a longer period of time, rather than a dozen samples from several providers. These providers vary in both their tendency toward availability and in their accuracy of self-prediction.

While the goal of this study is to determine how accurately others can predict availability, there was also an opportunity to explore the tensions and concerns of sharing context from the provider's perspective. Four of the providers did a think-aloud as they reviewed their on-line survey, sharing their thoughts about how they were determining their availability. When only generic day and time were provided, the participants often tried to recall their specific schedule and activities, since they knew the specific date for this *generic* situation:

"Wednesday at 5, I'm generally getting dinner ready." (typical)

Table 19: Availability Prediction Accuracy by Provider for Urgent Talk and Social Talk Purposes, (out of 12)

	Urgent Talk Prediction			Social Talk Prediction	
Provider ID	**Time of Day**	**Plus Context**		**Time of Day**	**Plus Context**
1	83% (10)	83% (10)		50% (6)	58% (7)
2	58% (7)	58% (7)		67% (8)	67% (8)
3	83% (10)	83% (10)		58% (7)	75% (9)
4	50% (6)	75% (9)		50% (6)	75% (9)
5	42% (5)	58% (7)		42% (5)	58% (7)
6	42% (5)	92% (11)		42% (5)	75% (9)
7	67% (8)	67% (8)		58% (7)	83% (10)
Overall Accuracy	61%	74%		52%	70%

"I think we're watching [special event on TV]..." (specific)

They talked about a particular day and time as being "normal", in a routine, or as "generally available." Two participants made specific remarks about providing too much detail and sharing activities that were out of the normal for them, when looking at the added context situations. In addition, security and social judgment concerns were also mentioned. Some envisioned home technology that could detect and share context such as the PDA self-report information, and felt they would want some way to secure the data or to obscure their location with fake data. In other instances, the participants felt that the detailed activity opened the door to others to judge whether they were available, based on the caller's value system, rather than the recipient's:

"Watching TV, ahm..., not important to me, so must be available. I prefer [just sharing] availability status."

5.3 ES^3M Using Factors for Predictions: Discussion

Through the qualitative data in interviews and questionnaires and statistical analysis, several interesting aspects of availability prediction are evident. Although, friends and family are expected to call at appropriate times, people are not very good at determining those times. Sharing current situational context appears to improve this prediction. However, it is not clear exactly what level of detail or amount of information is correlated to predictive

accuracy. As discussed in the following sections, from this study context seems to be more helpful in particular situations and purposes, such as when the recipient is not in their routine, and for callers who live farther away.

5.3.1 ES^3M Using Factors: Does Context Matter?

We expect our friends and family to know when we are likely to be available, to determine when to call [46]. In response to the survey questions, "(1) What are your notions of when is a good time to call? and (2) When is it not a good time?", almost all participants cited time of day and days of the week, 33 and 32 participants, respectively. In one participant's words:

> *"I pretty much [k]new [provider]'s routine with [his/her] children when considering the answers to these questions."*

In contrast, the particular provider, for the survey cited above, when responding to his/her own survey described their home life patterns, while thinking aloud:

> *"We're so random. [We] may go out with friends, depending on the weather and .... [Our] schedules are more rigid in the week, more flexible on the week-end. ... [During the week] Usually only time for dinner, playtime, snack. Fit bath time in there, somewhere.."*

While the relative felt they '*knew* this schedule, even the provider described their home patterns as flexible to random. This reciprocal belief that we know others' patterns and they know our schedule is not accurate when predicting availability.

This perception of knowing the other's patterns was cited again and again, yet, in this survey, participants using day and time alone, were no better than random guessing when determining actual times of availability. Some of this misconception about how well people judge *best times* is biased by the social construction of interruption, in particular the notion of accessibility to those who are close to us [98]. In response to the survey question, "Is there other knowledge about the provider that you considered, but were not shown?", one participant:

As [provider's sibling], I am assuming [provider] always makes a minute or two to talk to me; Also, I do not talk to [provider] or [their spouse] all the time, so when I call, they tend to take my calls and chat for a minute. I also sort of know their schedule so I know when the best/worst times to call are. [Provider] is too nice and will answer the phone just to say hi. It's helpful because when I call I know that [provider] will answer if [he/she] is home.

Neither the caller nor the recipient talk about learning better times to interrupt, since they responded to the call it must be "ok." One's social interactions work to strengthen their relationships, but are not meant to *teach* others about their lifestyle rhythms. It is not surprising to find that in reality, one's interruptions, while carefully timed in many cases, are still missing the preferred state half of the time.

While friends and family are mistaken in their knowledge of schedules, they are sincere in their efforts to use context. One relative after completing the survey sent this in an email to the research study email listed on the log-in screen:

"I know [provider] would appreciate phone calls at convenient times, especially with young children. ... Let me know the results so I can use your info to build a better relationship with my [relative]!!"

In response to when not to call, seventeen participants talked about knowing details about their routines and using that to gauge when to call. Thus in the survey responses where the simulated situation context was provided, accuracy of predictions increased to 59% and 63% of the time accurate. This is not as accurate as a human observer of a scene, who can claim over 70% accuracy [22], but it is better and statistically attributable to the additional context provided. Future research might explore which type of information increases accuracy and how it might be determined.

5.3.2 ES^3M Using Factors: What Context Matters?

Based on this survey data analysis, there is an improvement in availability prediction with additional situation information, but no difference in predictive power between the three

context conditions: routines, activities and providing both. More information is not necessarily better, as the dual condition was only significant for the urgent talk interruption, and activities alone were significant predictors for both interruption types. The textual representation of the information may have been distracting or the additional information may lead to uncertainty. These findings are consistent with Dabbish and Kraut, who found that team members were able to better manage interruptions and enhance task performance when an abstract representation of information was provided, rather than detailed representations [12].

Since predictive power does not appear to be different among the types of context shared, then other factors such as respect for privacy, ensuring security, and portraying a socially appropriate *face* can be used in determining the appropriate context to share. As noted above, providing detailed activity was statistically significant at improving predictions for urgent and social talking interruptions, while routines were only significant for social talk, and the combined condition only for urgent talk. There was no difference, however, between the average prediction accuracy of the three context conditions. This implies that more abstract representations of situational activity may provide sufficient information to the human determining availability. Several providers talked about others not needing to see "those details", such as the situation information of eating when they are just drinking water or they felt that room location was mis-leading about the activities at that time in that room. There was some preference to display a computed availability status, instead of the detailed context, as one provider responded to a detailed activity context situation:

> *"Do not tell people I am eating. People do not need to know that I'm having a snack of water. Instead just 'Available time'."*

Part of this tension is in providing more than is needed, but it also changes the balance of responsibility. With more information, the caller is held accountable to use it. There may be disparities in values, so the caller may decide the person *should* be available, since they are just watching TV, but this happens to be the one show they never want to miss. One caller acknowledges a known time to not call, due to the '*value* of one television series to

their family member:

> *[Not good time]"During [name of weekly TV program] (Wed @ 9 - 10)!"*

Presenting household routine information presents a compromise between detailed activity and availability status. In open-ended responses, seventeen participants used routines as a way to determine when not to call and "by nine" when specifying good times. There is also concern for the representation of the person and their accessibility to the outside world:

> *"Maybe should only say 'eating meal' – that should be enough. Laundry and housekeeping .. not needed for others."*

These sentiments are similar to those expressed by the homemakers in CDA Shared Awareness (discussed in Chapter 6), with respect to showing a socially acceptable face of the household. The information shared needs to express the etiquette and politeness of the persons providing the context, respecting the privacy and security concerns of the household.

5.3.3 ES^3M Using Factors: When Does Context Matter?

Are there situations when context has more of an effect than others? For instance, there was a difference in the effect of information about routines for social talk availability prediction, but not on urgent task interruptions. As mentioned above, routines were the second most dominant way participants distinguished when someone was available. This study also looked at the predictions according to whether the situation was part of a particular routine, "other" routine, or not in a routine. As shown in Table 20, reported availability varied with the routine of the household, and was different according to the purpose of the interruption. For instance mealtime routine is more interruptible for urgent task talk than social talk, but leisure time is more available for social than urgent talk. For urgent talk interruptions during the routines that involve children, e.g. their bedtime and schoolwork, additional context improves the prediction, as is the case when not in a routine (see Figure 7). In the social talk interruptions, the bedtime and schoolwork routine improve the most with context, while mealtimes and leisure are not (see Figure 8).

This research also looked at the relationship to the provider and the geographic distance between homes in relative to the benefits of context. There were two parents of sample

Table 20: Reported Availability by Routine (Each cell is the % available reported for all samples of that routine for that type interruption.)

	Available by Purpose	
Type of Routine	**Urgent Talk**	**Social Talk**
Mealtime	45%	23%
Children's Bedtime	20%	0%
Schoolwork time	43%	42%
Leisure time	63%	86%
Other routine	65%	72%
Not part of a routine	35%	23%

providers and one parent-in-law (other relationship) who took the survey. While this is a very small sample, it is interesting that with only day and time information, the *mothers* were correct in 63% of the urgent talk questions and 67% of the social talk interruptions. With context the mothers increased urgent to 67%, but decreased slightly on talk to 58% correct. This effect did not generalize to the nine siblings in the survey. However, the one parent-in-law was very low in accuracy and only improved to 33% and 50% correct. In CDA Shared Awareness study (see Chapter 6), the participants claimed a shared or learned availability expectation from their parents, and this finding is consistent with those participants. The three spouses were not as accurate as the mothers, but did not benefit in accuracy gains as those from outside the home. As expected, those living one hundred or more miles away improved from about 50% to 61% and 65% correct. More surprising, those living two to twenty miles away achieved the highest accuracy, slightly better than those in the neighborhood (within two miles of provider). Some people will benefit more from the additional context, including those who live farther away, friends, and family members.

5.4 ES^3M Using Factors : Contributions and Summary

This study investigated the need for context-aware communication to increase the accuracy of availability prediction, for either talk about an urgent task or for social talk. First, there is a need for shared context as people expect family and friends to call at "convenient" times, but this survey found that friends and family are only accurate in half of their predictions based on implicit knowledge, day, and time. However, added context information can

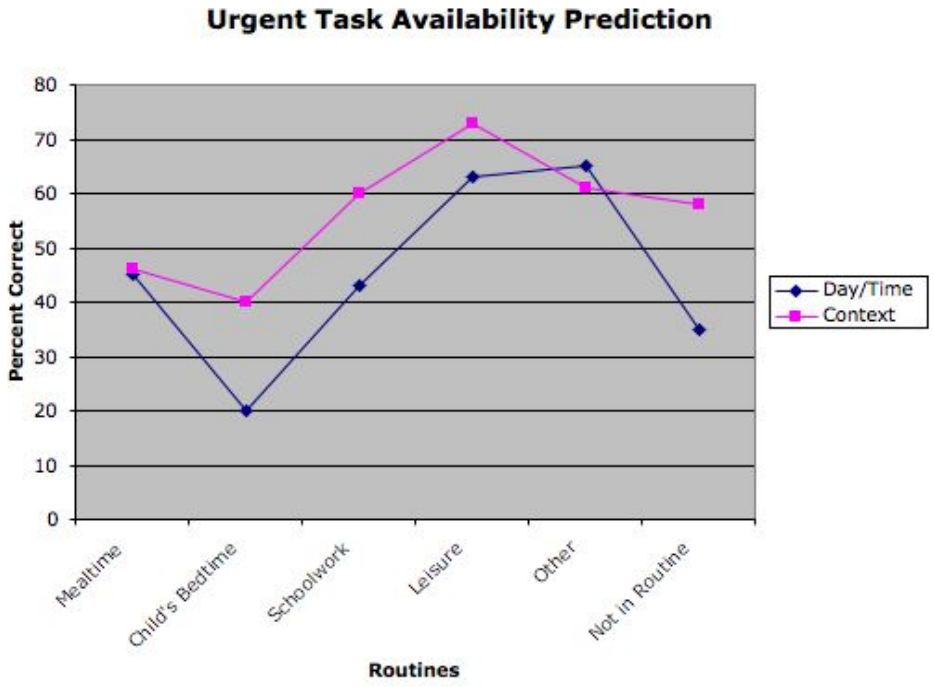

Figure 7: Urgent Task Availability Prediction by Routine

Portrays time/day only and added context condition.

increase availability prediction accuracy. What is not clear is the amount and type of information to share or the cost vs. improvement benefit. Detailed activity, location and presence information appears best overall, but is not significantly different from routines or combining routines and activities. Providers, however, were concerned with providing "too much" information, where the caller's judgment of their availability may reflect different values than their own. While shared context is useful, it is not clear precisely what form such information should take to preserve the social balance between caller and recipient and the security and privacy concerns of the provider. This study shows callers can improve their predictions of when to call when provided situational context, and suggests that abstract representations of either routines or explicit availability may be both preferred by providers and also be sufficient.

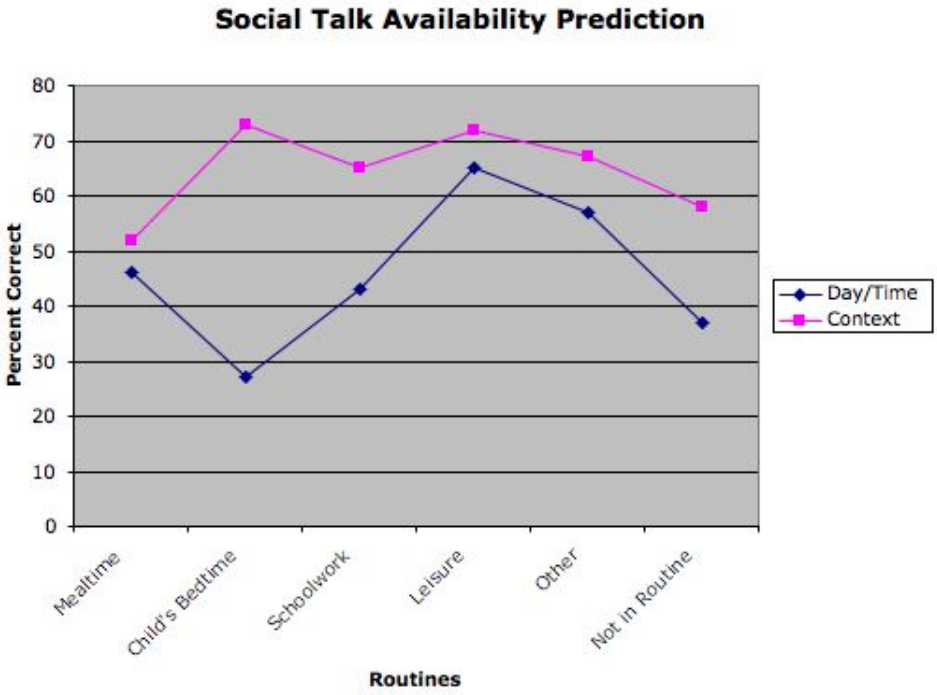

Figure 8: Social Talk Availability Prediction by Routine

Portrays time/day only and added context condition.

CHAPTER VI

SHARING AWARENESS FOR AVAILABILITY

Our home is outfitted with technology to do more for us than ever before — increasing entertainment choices and making it easier to prepare a meal. The washing machine even "communicates directly" to the dryer to insure the most efficient dry cycle is used [16]. Computing can help save energy resources, handle housekeeping tasks, and enhance our entertainment experiences. But what services are offered in the home to provide the person initiating a conversation salient cues to another person's availability for conversation? One can envision an instant messenger service designed for the home, to utilize this proliferation of smart appliances and services — implicitly determining availability to share with a select group of family and friends. Desktop IM in the workplace supports flexible and expressive communication, enabling a potential conversant to connect and manage communication, rather than just exchange information [58]. Is such a service feasible within homelife, where the "work" is not productivity-oriented, but relationship-oriented? In the home, this status is determined factors such as activity in the kitchen and whether two or more household members are in the family room with the TV turned on (see ESM Factors study, Chapter 3), rather than keyboard and mouse interaction. Challenging the feasibility of an availability service for the home are the following questions:

Does a service portraying availability for conversation fit into home life?

Where would it be used, and by whom?

6.1 Cooperative Design Sharing Awareness: Potential of Shared Awareness and Availability Prediction

An instant messenger designed for home-to-home conversation with implicit availability detection and sharing is in some ways akin to current telephone call screening practices.

Rather than block incoming calls, how can one share appropriate information to "invite" the caller at times when the household is "available?" Would knowing the room location of family members or whether they are eating dinner help the initiator to make better predictions of availability? Determining what data to use and where to gather it to support an awareness application is especially difficult in the home, where activity is not centered around a single technology or desktop computer [49]. Availability is further nuanced by the consideration of person and purpose. Social closeness between individuals is the most important factor determining when one is accessible [98]. But, the intended purpose of the interruption is also a factor in whether one is actually available or not. For instance, when the caller is the child's school or the doctor's office, the expected purpose of the call and/or person calling affect one's availability. If availability indicators exist within the home, then how would household members want the information represented and with whom would they share it?

The prior ESM Factors study identified candidate sensing that provides moderately accurate predictions of availability, Chapter 3. While there appear to be potential environmental indicators of availability in the home, there is no assurance that this information is either useful or usable. This study explores this second challenge of home awareness:

> *How do household members respond as providers and consumers of shared awareness data?*

6.2 Cooperative Design Sharing Awareness: Study of Home Availability Services

To evaluate how the availability service may be useful in the home, a Cooperative Design Activity (CDA) was used to explore:

1. What information would household members reveal to close family and friends outside this home?

2. Would the information vary according to whom they would reveal it?

3. Where would such information be used in the home and in what form factor?

To investigate a shared-availability service for the home, the study used a hybrid method, combining aspects of diary studies, focus groups and contextual design. Since there are very few prior technologies to inform the design of home availability services, it was desirable to have the participants help direct the investigation at this exploratory stage. The participants were enlisted as co-designers, scaffolding the process with pre-printed stickers of home life activities and availability status that were prominent in the prior ESM Factors study. In addition to providing explicit design materials, our participants were also asked to recall and record the context of two specific activities from their prior day. The diaries and self-designed displays provided the basis for the focus group discussion concerning how and when such information would be useful. In the absence of experience with technology for such a service, this activity provided a concrete interface for discussing and interacting with the issues of concern in sharing specific situation data.

This study assessed female homemaker attitudes about sharing information concerning specific activities of their prior day. The nine participants created paper displays using pre-printed activity and availability stickers to show what they would share. The groups discussed not only what they would show, but why they included and excluded specific types of information. The researchers also explored who in the social network participant would share the display with and how they would use this information in their own home.

The design activity was limited to visual displays, excluding audio interaction. While there are many situations where audio interfaces are preferred, the noisy home environment is not well-suited to an audio-only interaction mode. I was also more interested in determining what would be shared, with whom, and what amount of detail would be appropriate. The paper design provided a concrete starting point for the discussion that was also easily shared around the table with other participants.

Concrete activities from the participant's own life during a recent day were used as a scenario for the design activity. The research focused on mealtime and leisure activities, based on the ESM study, discussed in Chapter 3. In the prior study, mealtimes were frequently mentioned in interviews and several leisure activities were statistically significant predictors of availability: watching TV or movies and playing games. These routines were

used in the current study design activity as both were common to most families and were activities participants seemed open to discussing.

6.2.1 CDA Shared Awareness: Participants

Nine mothers of young children were recruited for the study. The participants either worked part-time during the child's school days or not at all. The average age for participants was 42. They had two children on the average with age variance from 3 to 10 (mean age = 6). They were all Caucasians with college degrees. All had landline phones, cell phones and answering machines. Most had caller ID service. Email was used by all, while IM was not used. These participants have a moderate level of experience with technology, but are not early adopters of technology.

6.2.2 CDA Shared Awareness: Method

The Cooperative Design Activity (CDA) was a sequence of several different activities, summarized below. The detailed procedure and protocol is in Appendix C.

1. Each participant constructs a mini-diary of their prior day leisure and meal times.
2. Individuals design a display of information that shows their availability to close family and friends during one of the leisure activities in the diary.
3. Group discussion of what information items to include for leisure, what not to share, and why or why not.
4. Individuals design a second display of information that shows their availability to close family and friends during mealtime
5. Group discussion of what information items to include for mealtime, what not to share, and why or why not.
6. Individual shows with whom to share the info display.
7. Group discusses how to use this information within their own home.

Figure 9: Pre-printed Stickers used for participant Screen Design, each activity was represented in three forms: text, graphics, and abstract symbols

Participants first constructed a mini-diary of leisure activities and meal times from the prior day. They were asked to select one leisure activity as a source for their first design activity, then used a mealtime episode for the subsequent design. The participants were provided various materials to use in the design activity, such as pre-printed stickers, markers, pens and blank stickers. The pre-defined stickers conveyed information regarding availability, activities in the home, locations, people and time. These pre-printed home activities correspond to the types of information that technology can detect or compute from sensed data and that were frequently selected in the prior home availability sampling study. As shown in Figure 9, each activity was represented in three forms: as text, graphics, and abstract symbols. The stickers were in black and white to remove potential color bias. However, blank color stickers and markers were also offered to add colors and customize information. For each episode, the homemakers were asked to visually portray what they would reveal about themselves to close family or friends outside the household:

> *What would you have liked them to see about your situation to determine whether this would be a good time to get your help with an activity or task you would want to give your full attention?*

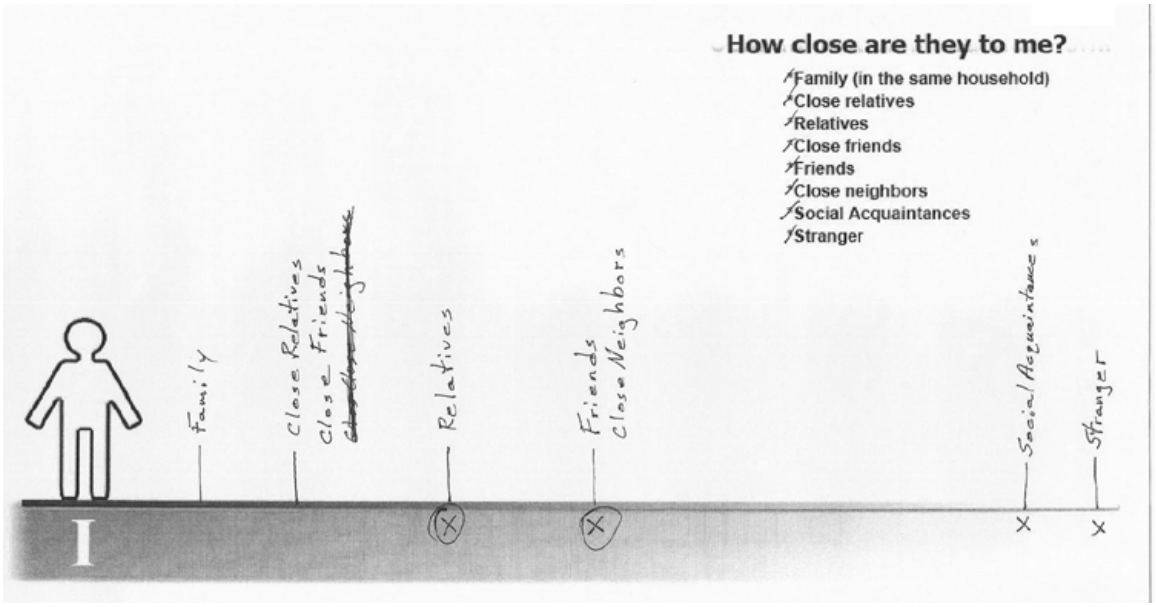

Figure 10: Interaction Form used by one participant to indicate with whom they would share the availability info and their relative social closeness.

This situated their availability with respect to attention required and an interpersonal closeness. Participants individually designed their display, then discussed what they would or would not include in the shared information. All the designs are included in Section C.2 of Appendix C. The discussion helped them understand the balance of benefits and concerns current technology afforded when sharing home activities.

In the next phase of the cooperative design activity, each participant identified those with whom they would share this display. Participants had been asked to only consider close friends and family members as people who would be using this information. Figure 10 shows the tool used to probe the wider social circle. The interaction form provided a conceptual line of social closeness starting with oneself. Participants first placed each of the eight designated groups on the line in the order of how close they are to themselves. Next, they were asked to place an "X" mark on any group with whom they would not share the information they had designed. The social network was grouped into eight categories: family within household, close relatives, relatives, close friends, friends, close neighbors, neighbors, social acquaintances and strangers. We defined "close" as comfort level in communication, not as physical proximity or next of kin.

The final phase of the Cooperative Design Activity shifted the focus of participants to the physical and tangible aspects of the design, and to being a consumer, rather than producer of availability information. The groups were provided several artifacts for the home that one could envision as a digital display, including various sized picture frames and wall calendars. The calendars and larger frames were presented as wall mounted and smaller frames as semi-mobile displays; cellphones and PDA handheld devices as portable options. The discussion embraced size, location, and accessibility of the envisioned application.

6.3 Cooperative Design Sharing Awareness: Results

The Cooperative Design Activity (CDA) showed homemakers would reveal availability status, but are less willing to share details of specific activities. However, when several people were engaged in the homelife activity, they more often included some information about the actual activity on the display for shared data. Eating dinner would be shared, but reading a book alone would only be shown as *not available*. The later discussion portion of the CDA showed this simplicity of shared information may have a relationship to the social groups to whom they would reveal it.

6.3.1 Revealing Availability Information

There was a distinction between leisure and dinnertime activities in the type of information they would disclose. They were more willing to show details for dinnertime than for leisure activities. The study highlighted the role of social protocol and socially acceptable information levels, as well.

The leisure activities these homemakers used for the design activity were viewed as "personal time," not as time with others, and they were reluctant to interrupt others or to be interrupted during this time. This is in contrast to the prior ESM Factors study where several leisure activities were positive predictors of availability (Chapter 3). The homemakers explained their unavailability in several ways:

> *"This is time with my children, or this is my personal time, or maybe you know what, I don't want [to] communicate with anybody. I don't want anybody to know that I am*

reading this trash all by myself."

"There are time zones when I am just sitting just myself and don't feel like getting up and walking up to the telephone. It's not that I am not available. It's just that I don't want to be bothered."

Moreover, participants were less willing to share any other information besides the binary availability status about their leisure activities. The primary reason for not wanting to reveal detailed information such as activities was the judgmental value of leisure time, as these two described it:

"I don't want to put people in the situation where they have to make judgment about whether my not being available is the right thing or the wrong thing to do."

"I will not tell people that I am doing a leisure activity because it is rude to tell people I am reading and do not want to answer your call."

Some included estimated time for activity duration. Some participants questioned the feasibility of time estimation for their leisure activities because, as homemakers, their schedules are not fixed and, hence unpredictable. They also did not want to be responsible for being unavailable when they should be according to the time estimation.

Dinnertime displays showed much contrast to leisure time in terms of revealing availability. Dinnertime was expected to be mixed between available and not available status. But the displays consistently portray not available (9 out of 9 displays). Most were comfortable showing that they were unavailable because it was their dinnertime. Displays explicitly showed "dinner time" label and often included detailed activities, such as dining table, family eating, or another food related icon as well as textual descriptions. Other inclusions were estimated time to finish or customized voice/text messages saying, *"Eating dinner. Call back in 30 minutes."* The distinction between leisure and dinner time is clear in the screen design shown in Figure 11. Here, the participant chose to reveal only availability

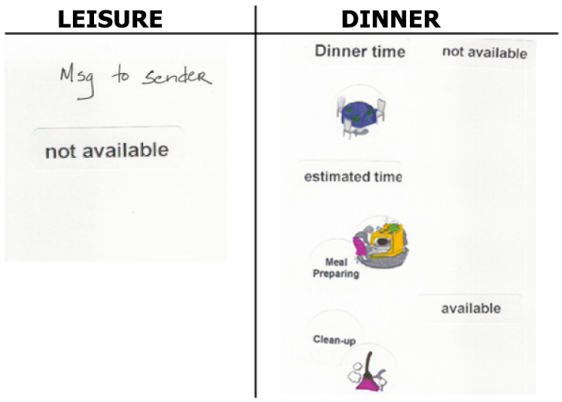

Figure 11: Screen Design from one participant, describing what to include in her ideal display for both the leisure and dinner time. Interesting contrast shown between minimal availability status for leisure time versus iconic and descriptive display for dinnertime.

status for leisure activity, but would display mealtime routine, detailed activity, availability status, and estimated time for dinnertime routines. There was no explicit attempt to explain why the participant would be willing to reveal more for dinnertime. One might assume it is because dinnertime is a shared practice in every household that creates similar expectation toward the routine. The duration for eating dinner was similar across households, with a small range from 25 minutes to 40 minutes. Also, dinnertime is viewed as a household activity rather than an individual activity, and includes more than just eating. They described mealtime as a shared activity with family, and the routine being a time of interaction and conversation. The discussion revealed different mealtime responses to interrupting phone calls. While all participants were unavailable during mealtime, they related numerous stories of when it was expedient to take the call. The anecdotes ranged from checking caller ID but not answering, muting the ring tones and then forgetting to check voice messages, picking up the phone with much regret to their action.

> *"I hate being called during dinner and I hate being called while putting them (kids) to bed. I tend to answer the phone, and then I was like 'Why did I do that?' Cause then you've gotta say ..."*

While the participants would only reveal a binary representation of their availability in their initial designs, during the discussion they talked about revealing somewhat more

information about family routines and activities. However, there is an undercurrent of not providing any more information than is socially acceptable in the situation. This study begins to reveal some of the nuances to sharing information for inter-home communication and the ways in which technology is expected to accommodate existing practices.

6.3.2 Sharing Availability

The CDA study shows consistency in the home-based social network. As seen in Table 21, the family received the highest level of sharing. This is consistent with studies looking at privacy and location information, where the family receives a high level of detailed information, but office colleagues and friends generally receive less information [66, 69]. *Close* relatives and friends consistently formed another group across participants. Strangers were set apart by almost all.

Table 21: Sharing Availability Information with Others

	Availability Info	
	Shared with	**Not Shared with**
Family (in home)	8	1
Close Relatives	7	2
Close Friends	7	2
Close Neighbors	6	3
Relatives	4	4
Friends	4	5
Acquaintances	3	6
Strangers	1	8

Subjects were comfortable with a notion of displaying availability information to certain close social network members, or no information at all to other groups. Many viewed availability information as a supplementary agent that helps others make a decision about when to interrupt. While the researchers did not probe these social interactions in the discussion, two possibilities may explain why the shared availability display is binary:

1. Share with those close family and friends to provide better info on when to find a good time, and enhance the quality of communication.

2. Value accessibility to one's close family and friend, want them to always see an *available* indicator.

However, there was one participant who indicated the opposite: withhold availability information from family and close relatives, but provide it to all other groups. The note on the interaction form specified: "I would answer the phone for these folks." The fear of missing calls or contact with a family member may pose an adoption hurdle to such an availability service, overcoming the benefits of "filtering effects." Another participant also expressed her concern of providing an additional layer of availability information if it would block her channel to the adult world. The concern is well expressed in the following comment:

> *"Well I think, the difference for us as Mom is all of us are predominantly staying homes [sic]. We have more contacts with our kids during the day and limited time with adults. So we really crave for that kind of interaction. It's nice to have our interaction and have adult time. .... I can see people who are business oriented, all day long on the phone, or interacting all day long who want to streamline what they want to receive and what not. ... They want [to] use their time off work as efficiently as they can. And this would streamline that."*

Whom they are willing to share availability information with depends upon the benefit envisioned. If the negative social effects may be costly, then shared awareness will not be revealed to those people. For persons who value the benefit of "streamlining" their interactions during time at home, then the sharing may be quite different. This study had assumed there would be some desire to share availability information, but the studies discussed in prior chapters had only looked at the feasibility of determining such status, not how the information would be used across households. This needs further study to determine variations across a broader population.

6.3.3 Home Use of Availability Services

After exploring the concept and potential content of the availability service, the design discussion group was redirected to focus on how and where they might use this service. In the first part of the CDA, the participants were asked to design and discuss as the *producer* of the availability information. The *producer* was the household member whose activity, location, and availability status would be detected and shared to another home. However,

at this point in the study, the subjects were directed to switch roles to that of the *consumer*. They imagined using such an availability service in their home, to determine whether or not it was a good time to contact a particular close family member or friend. It is important to understand how people envision the physical location(s) and tangible form of the service because it largely influences the affordance and constraints of service design. Picture frames in a variety of sizes, wall calendars, personal digital assistants (PDAs), and cellphones were provided as options for the service and accompanying display, as described in Section 6.2.2. Among the artifacts supplied, the participants preferred smaller displays with widespread accessibility in the home, similar to the dispersion of technology found in ethnographic studies of domestic routines [49, 11]. The compact size refers to both screen size and the overall footprint of the device displaying availability data. The participants preferred the smallest picture frame or portable handheld devices, rather than the larger "tablet" sized frames. There was no preference between wall-mounted, counter top, and mobile:

> *"I have a feeling it's in the kitchen, but the footprint of the whole device isn't taking up too much counter space."*

They did express interest in being able to take the service to different rooms within the home, as well as outside the home, similar to their use of a cell phone:

> *"Given how much I'm on the go ... having something actually tied into my cell phone would be powerful."*

Most participants envisioned this service to be an extension of their answering machine or caller ID machine:

> *"At a minimum, if it was something that could be part of the phone."*

In the cooperative design discussion, participants spoke of a device "per floor" of the home, to access the service wherever they envisioned using it — as they initiate a phone call, as a subtle indicator of incoming calls, as feedback for out-going status of this household:

> *"I wouldn't necessarily need to carry [it] around with me, but something that I could visually see, you know, to check like an answering machine, except my answering*

machine is only in one area, and so it would be nice to have it, you know, upstairs and downstairs."

While time-constrained, the discussion of the form factor suggests development of a compact device that is about the size of telephone/answering machine combination, which also has a portable component. The participants used the telephone as their initial design prototype, but the size of the mobile handset constrains the display size to much smaller than the preferred.

6.3.4 User Perceptions of Home Availability Services

This study investigated the type of information people are willing to share, to whom they will reveal it, and how they envision using this service in their home. Prior studies, discussed in Chapter 3 and 4, found indicators in the home that correlate to availability and that technology can detect or compute. Yet, researchers have not answered an essential question, before pursuing actual design: Do people want to use it? Initially, participants saw no reason to share availability information. Later, in the discussion specific incidents came to light, where having this extra information would have been useful. While the homemakers are only one segment of the household, they are heavy users of communication services and it is important to understand their perceived use and need of such a service.

At the outset of each design and discussion session, the participants did not perceive a need for new services to negotiate best times to call others or to lessen interruptions at home. They were very satisfied with their appropriation of the current technology, such as caller ID and the answering machine, to handle any communication annoyances:

"Wouldn't just not answering the phone pretty much tell people that you are not available?"

Furthermore, they did not see how others would need more explicit availability information:

"I already know what I need to know about those I contact and I don't think I'd want to share about myself. I know their routines, like dinner and bedtime. I learn them over the years and they know about us."

There was also a concern that technology would lessen the personal touch in their audio communication. While they appreciated and used email, caller ID and answering machines, they did not want to lose the free-flowing individuality of their interactions:

> *'Happened to ... my generation, things like voice mail and the fax machine and the cell phone, that instantaneous interaction, or instantaneous response."*

They voiced tension in technology leading to a more formal communication atmosphere and creating undesired expectations, rather than enhancing the conversations they already valued.

Technology was viewed as too unreliable to portray their availability, and would in fact mislead those outside the home. Participants were skeptical about how technology can accurately grasp their moment-to-moment changing routines:

> *"..it's hard to say I have a schedule ... except for ... like a dinner time hour. And we just answer the phone. I mean... it usually doesn't bother me I guess."*

The consequences of sharing inaccurate availability information were very undesirable. They felt responsible for being available, when that was the shared status, even if it was not correct. They also did not want to miss any communication due to the accidental display of "not available". Most were routine examples, such as always answering for their child's school or other instances of their parent role, but in one case the extreme commitment they act upon in all of their family caregiver roles was shared:

> *"I've just gone through with [my parent] being sick and passing away, and I felt like I had to be available morning through the night. Because I never knew if it was hospital, if it was doctor's office or if it was whomever. But I made myself available, but I did not feel myself as glued as if I couldn't take a shower."*

They liked having full control as to whether to answer or ignore the call without providing a reason. They did not want the burden of having to update their availability status, yet at the same time, they were uncomfortable with technology that would implicitly determine their availability. There were many examples of taking interruptions at dinnertime,

even though they were all *not available*, but they found it useful to handle this particular interruption during dinner. In practice, they were conditionally available, but they did not want to disclose that availability.

On the other hand, participants saw more benefits when positioning themselves as the consumer of availability information, rather than as the producer. The anecdotes involve not interrupting"family time," like dinner or putting kids to bed time:

> *"We used to eat around seven. And that's when a lot of people have already eaten. So at six o'clock, I am like, 'Oh I need to call someone, and do they already eat or do they eat later?'... So it's kind of like between six and nine, you know, people are either eating and putting kids to bed, but if you just needed to call and say, 'Hey, I am gonna get to you tomorrow.' If that's all for your conversation, you don't wanna call during their dinner time."*

Knowing such information will help them act within the realm of social appropriateness, and also opened the door to discussing reciprocating such information. There is a window of evening time bounded by dinner and children's bedtime, when people do not want to be interrupted and likewise hesitate to interrupt other households:

> *"Once dinner gets going, if during school year, we are trying to get kids in bed, we are really trying to have them asleep by eight o'clock ... you've gotta have that group going, dinner and dadadadadada [meaning etc.]."*

One interesting contrast between the consumer and producer stance was the sharing of location information. When designing a display in the CDA Shared Awareness study, most participants were reticent about revealing where they were located. As a consumer, however, they talked about the benefit of knowing someone's location in determining their availability:

> *"...my grandmother, because she lives by herself. ...You know if she was in the house, if she was fine, or maybe she was out of the house in the garden, she could show me that that was what she was doing."*

Knowing whether someone is at home, not at home (but in town), or traveling out of town were the three "places" that would indicate whether or not they were available. One participant particularly saw the usefulness of this service as an unobtrusive monitoring device for her aging parents, stating that the changes in location information would give her an indication that her parents were well, similar to findings of Rowan and Mynatt in the long-term field trial of the Digital Family Portrait [79]. While the participants initially saw little need for shared availability information, the discussion revealed how they would use such information. They may eventually disclose more information, if it were reliable and accurate.

6.4 Cooperative Design Sharing Awareness: Design Implications

The Cooperative Design Activity (CDA) supported the goal of exploring how a shared availability service might fit into everyday home life by probing real situations through participatory design. The user-generated diaries, pre-printed stickers, and designs served as probes to evoke user discussion situated in actual home life experiences. This hybrid method both grounded potential users in familiar situations from their own lives and prompted them to reveal and discuss what they would and would not be willing to share outside the home. While this study was interested in information representation preferences shown in the designs, researchers were also considering the larger issues of how participants envisioned using such information. The design implications reflect not just the individual paper displays, but also the rich discussion surrounding the artifact creation and their context of use. The design activity and discussion revealed three types of design implications: shared awareness information features; user requirements for home use; and challenges to adoption across homes.

6.4.1 Awareness Information Sharing Implications

One goal of the CDA was to explore the types of information people would be willing to share about their home life. The participants incorporated minimal information and used only a few of the pre-printed stickers that conveyed availability status and activities in the

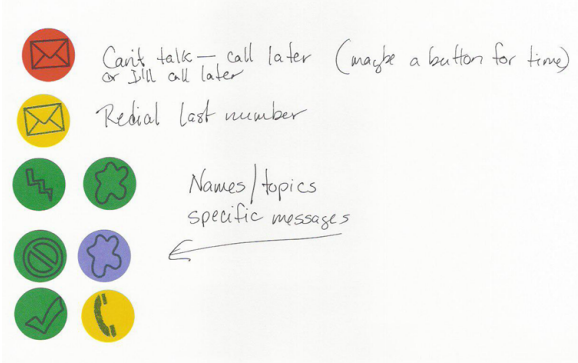

Figure 12: Individualized Messages for Availability

Personalized and sociably acceptable messages used more activity icons and color.

home in their designs, for an example look back at Figure 9 in Section 6.2.2. Participants preferred binary availability status rather than a conditional probability (e.g. 75% likely available) or interpreted value (e.g. not available while reading). Showing the activity would only be desired when the activity itself implies the appropriate social justification as to why they are/are not available. There was no preference for any particular style of graphical representation of activity; a picture of people eating dinner around a table or a simple icon of dish and silverware, were treated the same, as long as they clearly match the routine (dinner) or the activity (eating).

The original individual visual designs were mostly text, with sparse use of color for information. However, those displays that were designed *ad hoc* during the discussion, used colors and icons to portray meaning at a glance. Participants envisioned the availability data as a visual replacement of their voice-mail greetings, for quick at-a-glance message review. However, they wanted the service to reflect the personality of the household rather than merely passing off information, similar to Goffman's notion of the "role which one presents" to the outside world [26]. For instance, instead of showing *"Not available, next available in 30 minutes,"* they wanted it personalized to reflect a socially acceptable message, *"Sorry. We are eating dinner. Please call back in 30 minutes."* They specifically designed for individual, user-defined messages appropriate to the household, shown in figure 12. The CDA study provides a basis for future designs to investigate how to portray the household with appropriate manners, while not sharing too much information.

6.4.2 Awareness System Requirements

The cooperative discussion highlighted requirements that impact the design of a shared awareness system. Ease of use and accessibility were dominant themes when considering adoption within one's home. Information should fit on a small, handheld display that is portable, fitting into the household routine of moving from room-to-room, finding a quiet enough place to communicate and concentrate on other tasks. For these reasons, the homemakers were concerned that their availability status would not accurately reflect the environmental constraints on their attention.

Some of the same reasons driving the need for mobile availability services also point to the integration of multiple communication channels. To overcome the noisy or busy home environment, alternative media, such as email and text-messages were used. For instance, one participant relates how a peripheral email arrival cue alerted her to her sister's late-night conversation availability:

> *"My sister wanted to call me at 11 o'clock and she emailed at 11 o'clock. I heard the beep on the computer or whatever and I called her because I knew she was up. Because she just sent me an email."*

In this incident, availability was signaled via email, an appropriate alternate media channel, for the more intrusive "phone ring."

Another system requirement is the need to provide an accurate and robust identification of family or friends initiating calls, independent of the device used. Participants want to share different information depending on who is initiating communication. The current caller ID system detects the phone number and displays the name registered for that number. Participants were concerned their family members would not receive the necessary information if identified as a stranger when using different phones. The identification mechanism should provide more accurate identity, than simply matching registered phone numbers.

6.4.3 Groupware Design Challenges

In some respects the challenges encountered in designing home availability services are those identified by Grudin for groupware applications [29], but we also found design constraints of personalization and portability that are more unique to domestic life. The overall design concept of an availability service to support inter-home communication suffered from five design challenges of groupware [29]:

1. Not a fair balance of benefit vs. effort
2. Requires "critical mass" of users to be functionally useful
3. Insensitivity to existing social practices
4. Handling the real activities, not the "ideal" version
5. Supporting the infrequent, but critical, activities seamlessly

The design challenges of balancing benefit vs. effort and achieving "critical mass" to be useful are inter-related. Users did not initially perceive the value of such a service in their home, as discussed in Section 6.3.4. They envisioned themselves explicitly setting the shared information indicators, or at least checking their feedback for accuracy. The researchers could have provided visionary videos or more detailed explanations as to how specific sensing technology may accurately and reliably detect sufficient information in their home environment to reasonably set an availability status, determine location, or recognize activity. The CDA participants saw no gain in sharing availability data, as current telephony already handled their phone call coordination well enough. They also felt this *extra* information placed additional decision-making on the potential caller, a balance the producers would rather not change. There is no obvious gain to sharing home life information, a critical component for adoption of a useful group service.

The challenge to incorporate support for the infrequent, yet critical activities into the routine service interaction was evident in the incidents when they would use availability information. Often the motivation for sharing data bits were the unusual circumstances, when the *extra* information would indeed be very useful. The shared availability was most

often viewed as useful at infrequent times, yet the service needs to be incorporated into the individual's communication interface during routine access.

Designers may need to consider how to mitigate these concerns, perhaps by looking to prior technology acceptance in the home. The telephone is an interesting example of an "office" technology integrating into the household. Safety and business were most often cited as reasons for acquiring a phone, but telephones were actually used to support a variety of existing social practices [20]. Similarly, presence technology may be installed in the home for security reasons and could be adopted to provide availability information. While availability information may enter the home for one purpose, it may be integrated into the household as the shared data is used to support communication protocols of the family. These challenges concern adoption from the user perception of trade-offs and usefulness, both in support of everyday communication and also those *out-of-the-ordinary* needs.

Two other groupware design challenges were cited in the CDA study: sensitivity to social practices and handling real vs. ideal activities [29]. One example of the former is the potential disruption to the expected conversation flow and the relationship building that occurs in between-home interaction [32]:

> *"I just don't think I want anybody to know what my activities are until I am having it. That's the part of conversing in a conversation. 'Oh you were out playing at the park that's great blablabla.' And that kinda keeps the conversation."*

The CDA study used a phone call as a proxy for interruption, in the negative sense. In the design discussion it was clear that these subjects did not view a phone call as an activity to avoid or to re-schedule. Instead, phone calls were *welcomed* interruptions of another adult in their day of caregiving and household activities, recall this line from the longer quote in Section 6.3.2: *"It's nice to have our interaction and have adult time."* If not actually a *lifeline* to other adults, then a phone call was a welcomed connection with another adult, rather than an interruption or more child talk. Designing to share availability status would need to account for these social needs and uses of the system, while fulfilling the less frequent needs to actually enable finding times to communicate.

The last groupware design challenge the CDA study revealed was handling the range of behaviors that comprise the "normal" home routine. As discussed in Section 6.3.1, during mealtime all participants advertised "not available," but in practice they actually respond to the phone during dinner, under some conditions. There is a tension designing for the desired vs. expedient availability, similar to Goffman's notion of the "role or self which one presents" to the world. This discrepancy between observed behavior and desired household policy is often related to designing for the actual activity vs. the ideal day. Discerning these real life exceptions and why they are different, is difficult for an outside observer, but easily explained by the family *in situ*.

While the researchers saw these groupware challenges in the design activity, the discussion was also marked by two additional challenges: the need to personalize and to provide services where needed, as needed. The purpose of home-based communication service is not data transfer, instead it serves as the "face" or social representation of the family, as office displays were succinctly critiqued by one of the participants:

> *"It's informational, but it's not personal."*

Any message is expected to provide a sense of the social culture of the home and the good manners of the family; the *not available* status message was replaced with *"Eating dinner. Call us back in 20 minutes."* The ability to retrieve such a message was desired wherever one was located in the home, thus the need for pervasive services. One would tend to appropriate the familiar cell phone and tether these services to it, except that they "park" the cell phones in one location at home and use the portable handset landlines, coupled with other services. There is the challenge of integrating the indvidual family messages into the social protocol of the service and to providing a pervasive service in an easy-to-use form factor.

6.5 Cooperative Design Sharing Awareness: Summary

This study has explored user perceptions of shared availability information, contingent upon who would use it and how it would be deployed within one's home. This research has identified design requirements and adoption hurdles for shared awareness services between homes

of family and close friends. It has also revealed particular types of availability information that are appropriate for sharing with specific members of one's social network. Smart appliances and network-enabled entertainment components are just two cases of computational sensing entering our homelife. While the original purpose may be for the "business" of providing cleaner clothes, more efficient energy use, or on-demand entertainment, this information may also provide cues to the routines of homelife. Either gathered and displayed for people, or enhanced by computational learning or perception, this proliferation of information may be re-purposed to determine when to issue timely reminders for best times to call a friend or to take a medication.

This study examined dual challenges in developing between home, context-aware communication services. The research focused on two *"feasibility endpoints"* concerning availability services in the home: determining what awareness information providers are willing to share and how such information may be useful in the home. In the Cooperative Design Activity, one sees many of the same design challenges found in office groupware development [29], and others that are uniquely important to home-based groupware. First, the level of detail to be shared appears correlated to the routine; for example, more details are appropriate for mealtime, than for leisure times. The interaction needs to be available throughout the home, either compact and portable to go with the family member around the house, or integrated with other services at various room locations. Accuracy and reliability of the shared information is important, along with device-independent caller identification. While not unique to the home, the desire to personalize and present a socially acceptable availability status to their close family and friends is extremely important. Closely related to providing personally meaningful messages, is the desire to support not just the expected home routines, but those unusual days when sharing information can be most useful. While the motivation was in shared awareness, these findings provide a basis for other homelife services, such as coordinating schedules through family calendars and to-do lists, issuing timely reminders from these schedules and lists, that do not interfere with existing conversation or other family activities.

CHAPTER VII

CONTRIBUTIONS AND FUTURE WORK

The goal of this work was to help people determine mutually appropriate times to initiate conversation between homes. The thesis proposed:

- *The natural activities of home life may be sampled as a set of environmental factors which then serve as an indicator for family availability. These external factors will be effective for identifying household routines of availability and useful in determining when to initiate conversation across homes* in Section 1.3.

Several sampling studies were used to investigate the environmental factors of the home *in situ* and simulate potential sensing technology.

7.1 Summary of Results

This research focused on the sampling of everyday activities in actual family life to determine a set of predictors for routine activities and their correlation to availability for inter-home conversation between friends and family. The interruption of a phone call from a *close* family member or friend served as the common mechanism to determine availability for two purposes: (1) handling talk about an urgent task and (2) social talk about daily events. These studies addressed four broad, inter-related questions:

- Are there environmental factors of the home that correlate to availability and how reliable are they?
- How do families define their availability for between home conversation?
- What guidelines can we provide for the design of context-aware digital household artifacts to share with those outside the home?
- How would families benefit from the use of communication interfaces reflecting these environmental cues for availability?

The findings are summarized for each of research challenges in the following sections.

7.1.1 Environmental Factors to Predict Availability

These sampling studies of actual family life revealed a number of promising factors correlating to availability, including some room locations and activities. As discussed in ESM Factors (Chapter 3), the kitchen is an area of multiple and frequent activities, and a prime location for sensing aimed at activity recognition. ESM Factor Finderanalysis indicates that interruption in the kitchen is more acceptable than other rooms in the house. Interruption is particularly bad in someone else's (presumably a child's) bedroom, as shown both in ESM Factors and DayRM Routines (Chapters 3 and 4). These same studies show availability in the kitchen is also dependent upon personal preferences and particular activities, such as eating vs. cleaning up. Engaging in face-to-face conversation indicates one is less available for interruption, independent of the room (see Section 3.3.2). Leisure activities, including TV, movies, and game playing, are significantly correlated to availability (see Section 3.3.2 and 4.5.1). Other indicators that appeared promising include change of activities and detecting household routines, such as dinner and children's bedtime (see Section 3.4.4). Household routines define home life, both in their ubiquity and their abstraction of details [10]. Routines were found to be another *feature* of home life that are correlated with environmental factors and may be useful availability indicators (see Section 4.6.1). The results of these studies indicate there are environmental factors in home life that can be sensed, either in real-time or over some time span, which correlate to self-reported availability.

7.1.2 Defining Availability in Home Life

A characterization of availability within home life is important to support family-specific needs and to aid designers and developers of context-aware communication services. This research found three defining characteristics of the interrupted household (see Section 3.5.2): policies held, social closeness, and attention available. This framework guided the design of DayRM Routines and CDA Shared Awareness studies, where participants expressed their notions of "availability" along the first two aspects: preferences and social closeness.

Often one's everyday activities are so routine, that it is difficult to make the invisible, yet important features, visible to technologists. Providing a framework of salient characteristics enabled the investigators to design probes explicitly exploring people's perceptions of their availability.

The ESM Factors study of home life and availability found people talk about availability relative to routines—patterns of activities characterizing home life. In the follow-up DayRM Routines study (see Chapter 4), home life was described in the context of a routine over 85% of the day. Using relatively easily sensed location information, statistical modeling showed mealtime, children's bedtime and leisure routines may be predicted with moderate accuracy; the accuracy improved, when simulations of more complex sensing of activities were added. Leisure was correlated to availability, but individuals were not available during children's bedtime routine. Mealtime was not a consistent availability indicator, but appeared to require temporal, activity segmentation to provide accurate enough information for the person to determine availability. This research highlighted three ways routines are valuable to understanding availability:

- Routines abstract away distracting details, yet provide insight;
- Routines segment home life temporally and functionally
- Routines mark boundaries and aid transitions from one availability mode to another.

7.1.3 Context-Aware Communication Design Guidelines

One goal of this research is to provide design guidelines for household services that share context and enhance communication with friends and family outside the home. The guidelines discussed below are:

1. Provide for individual differences at initial start-up and as family life evolves
2. Provide situation context to augment implicit knowledge
3. Balance context shared with sensitivity to social protocols and accountability
4. Portray the social *face of the home*, not just information

These impact the design of services for between home communication and sharing context. These guidelines influence sensor selection, placement, and the inference required to make sense of sensor data, as well as the determination of what context to share with whom.

These studies have found context-mediated communication requirements are highly individual. This impacts the sensing use, where to install, what to detect, learning initial preferences, and inferring changes over time relative to seasonal and maturation changes. There are factors to availability that will need to be adapted to the individual household, such as recognizing transitions between availability states: changing rooms, preparing to leave home, or cleaning-up after a meal (Sections 3.4.1, 3.4.4). A critical factor will be establishing a default system with initial values approximating routines and policies. The initial process of learning routines will include *finer-grain routines*, that encapsulate the organization and social interactions of the particular family home (Section 4.5.4). There is also learning as the household changes, in response to school terms and extracurricular activities, or in the maturing of the children and the corresponding social interaction changes (Section 4.5.1). Any system that will be useful in recognizing availability will also evolve its model of any particular predictive routine.

Context-aware communication services in the home should provide current situation information to augment the tacit knowledge of friends and family. The ES^3M Using Factors study revealed that although friends and family believe they have sufficient knowledge of others' household activities to determine availability, in fact they are not accurate predictors of *best times* to call (Section 5.2.1). However, when provided specific situation information about the other person, then the predictions improve to over 60% correct. The CDA Shared Awareness study showed people would reveal their availability status, but are less willing to share details of specific activities (Section 6.3.4). Sharing relevant information about current household routines may provide *just enough* information to enable the caller to better manage interruptions (Section 5.2.1, 6.3.4). The DayRM Routines study highlighted two benefits of using routines to conceptualize between home awareness: (1) routines are dynamic indicators of home life and (2) routine information carries richer meaning than availability alone (Section 4.5.1, 4.5.2). Furthermore the boundary-work of routines [62]

implies knowing whether or not a particular routine has already been completed may be more significant than the momentary assessment of current routine (Section 4.5.4). In these busy family households, children's bedtime was not accurately marked by time of day, yet knowing "children's bedtime routine" has already happened during the evening signals a transition in the parent's activities, attention, and availability. Providing current situation information improves the determination of *best times* to interrupt friends and family members.

The benefit of sharing context with others must also be balanced with respect to its effect on the social protocol and accountability of conversation. The type and amount of information to share is dependent upon "social" factors—within and outside the home. In CDA Shared Awareness study, when several people were engaged in an activity, they were more willing to include some information about the actual activity in shared data (Section 6.3.1). For instance, *eating dinner* is an activity that would be shared with others and would include details, including the people, eating, table, and *not available*. However, reading a book alone would only be shown as *not available*, with no additional activity information shared with those outside the home. Family members and close friends would receive more information than those who are more socially distant (Section 6.3.2). The ES^3M Using Factors study tried to remove aesthetic considerations of graphical representations of availability information, but users still consistently look for meaning in the colors and images, both as providers and users of the information (Section 5.2.1).

Context-aware home communication services portray the social *face of the home*, not just information aimed at more efficient interactions. Participants in the CDA Shared Awareness study felt technology would bring a more formal communication atmosphere and potentially create undesired expectations, rather than enhancing the conversations they already valued (Section 6.3.2). Some homemakers liked having full control as to whether to answer or ignore the call without providing a reason, relying on "plausible deniability". On the other hand, participants saw more benefits when positioning themselves as the consumer of availability information, rather than as the provider; in particular not interrupting *family time*, like dinner or getting children ready for bed. One interesting contrast between the

consumer and producer stance was the sharing of location information (Section 6.3.1). When designing a display in the CDA Shared Awareness study, most participants were reticent about revealing where they were located. As a consumer, however, they talked about the benefit of knowing someone's location in determining their availability. Knowing whether someone is at home, not at home (but in town), or traveling out of town were the three "places" of interest (Section 6.3.4).

In some respects the challenges encountered in designing home availability services are those identified by Grudin for groupware applications [29], but this research also found design constraints of personalization and portability that are more unique to domestic life. The CDA Shared Awareness participants saw no gain in sharing availability data, as current telephony already handled their phone call coordination well enough (Section 6.3.4). They also felt this *extra* information placed additional decision-making on the potential caller, a balance the providers would rather not change (Section 6.3.4). Thus, there is no obvious benefit to sharing home life information, one critical component for adoption of a group service. Home-based communication service is not simply data sharing, instead it serves as the "face" or social representation of the family. Any message is expected to provide a sense of the good manners of the family and the social culture of the home (Section 6.4.1). To be useful, the interaction needs to be available throughout the home, either compact and portable to go with the family member around the house, or integrated with other services at various room locations (Section 6.3.3). Accuracy and reliability of the shared information is important, along with device independent caller identification (Section 6.3.4). While not unique to the home, the desire to personalize and present a socially acceptable availability status to their close family and friends is extremely important.

7.1.4 Use and Usefulness of Shared Context

The sampling studies establish the feasibility of determining availability in the home, and the companion challenge is to determine whether such information was needed and if so, how could it be used. The participants in the CDA Shared Awareness study were satisfied with their appropriation of the current technology, such as caller ID and the answering

machine, to manage incoming communication and used their implicit knowledge of others' home life patterns to call at *convenient* times (see Chapter 6). This research, however, shows that people are no better than random guessing, when determining availability of those in another home (Section 5.2.1). The ES^3M Using Factors study (see Chapter 5) found added context information can increase availability prediction accuracy. What is not clear is the amount and type of information to share. Detailed activity, location and presence information appear best overall, but are not significantly different from routines or combining routines and detailed activities (Section 5.2.1). Context may be more helpful in particular situations, such as when the recipient is not in their routine (Section 4.6.1). For example in DayRM Routines , when the family was having a typical day their mealtime availability was 52% (15 of 29 episodes), but when the day was deemed unusual, availability increased to 74% (20 of 27 episodes) during mealtime. In ES^3M Using Factors , context was more helpful for callers who live farther away. Those living one hundred or more miles away improved from about 50% to 61% and 65% correct (Section 5.3.3). More surprising, those living two to twenty miles away achieved the highest accuracy, slightly better than those in the neighborhood, within two miles of provider (Section 5.3.3). While shared context is useful, it is not clear precisely what form such information should take to preserve the social balance between caller and recipient and the security and privacy concerns of the the provider. The ES^3M Using Factors study shows callers can improve their predictions of when to call with context (from 50% accuracy to better than 60% accurate), and suggests that abstract representations of either routines or explicit availability may be preferred by providers and be sufficient.

7.2 Implications for Design of Home Availability Services

This research has explored dual challenges in developing between home, context-aware communication services. The work focused on two "endpoints" to providing situation aware services in the home: determining what can be sensed that correlates to availability and designing the interface to display the availability information. These formative studies of

home life availability highlight three areas in providing computer support for the collaborative labor of home life. Personal preferences toward availability are significantly different, between individuals and in response to the same situation. In home life, rhythms and routines appear to have more complex definitions, than comparable patterns of activities in office work. Finally, balancing privacy desired with one's shared availability, is an on-going tension in the social construction of home life and its boundaries.

7.2.1 Personalization: Individual Differences Matter

While it may not seem surprising to report that individual differences play an important role in determining patterns of availability, its impact on home services cannot be ignored or minimized. The implication is that any home availability service must be designed to both learn the particulars of the home and to adapt as family life evolves. Each of the studies portray varying individual inclinations toward availability and differences relative to leisure activities, in general. In the ESM Factors study, participants were distributed across a range of available 80% of the time to a low of only 40% of the samples. Not only were some subjects more inclined to interruption than others, individuals tended to treat some similar situations differently. For example, while some individuals are available while reading, others indicated that this is a terrible time for interruption. In CDA Shared Awareness, the leisure activities these homemakers used for the design activity were viewed as "personal time", not as time with others, and they were very reluctant to interrupt others and to be interrupted during this time. This is in contrast to the prior ESM Factors and DayRM Routines studies where several leisure activities were positive predictors of availability. These individual and household specific patterns form a lens for those outside the home to understand acceptable interruption times and coordinate shared activities. Learning individual patterns of availability is one research challenge for home services.

7.2.2 Activity Recognition: Rhythms and Routines

In home settings, people describe their time in terms of routines and patterns. However, there is a mismatch between how individuals talk about their activities and what one is able to measure with sensors. These research subjects talked about "putting the children

to bed", "having dinner", and "getting ready for soccer practice" (Chapter 3 and 6). The potential sensors of the studies, however, could only capture information such as location and sound level. In the DayRM Routines study, which asked individuals to identify routines and activities, there is evidence that routines often correlate to individual availability, but extrapolating routines from potential sensor data is difficult. Regression algorithms accurately predicted activities from the potential sensor data, but this is likely a statistical artifact resulting from the low frequency of certain routines in the data. For example, if a routine only occurs 5% of the time, one can predict with 95% accuracy whether or not the person is in this routine if you simply guess that one is never in this routine. However, it is more useful to know when someone is in the routine than when they are not. The gap between what is sensed and activities recognized is a challenge to the recognition of routines, and leisure time in particular (Chapter 4).

This leads to the question, why hasn't this mismatch between activities and sensors affected availability research in office settings? In research on interruption in the workplace, James Fogarty and his colleagues have been relatively successful at building models that use the input from various sensors to accurately determine availability [21]. Unlike the home, however, office settings are relatively constrained; individuals tend to remain in only one room. In fact, research on interruption in office settings typically ignores individuals who are not in their own offices. Furthermore, there are only a handful of devices that are important signals of availability (e.g., computer use [35], telephone use[22], status of the office door[36].

Activities in the home setting, however, are not nearly as constrained. Individuals routinely move between multiple bedrooms, the kitchen, and various living areas. Each room has its own set of devices, which may not be easily instrumentable (e.g., books and newspapers) and may support more than one activity. For example, the kitchen table may be used for family dinners, children's homework, or paying bills, each of which have different norms of availability. Home life is characterized by multiple, simultaneous activities [86]. In DayRM Routines , leisure time was just such a "busy" routine, with a breadth of activities both predicting leisure and on average three different activities occurring within any single

leisure time (Section 4.5.1). Leisure times often include household tasks, such as laundry and bill paying, with more typical leisure activities, like watching TV and listening to music (Section 4.5.1). As if that were not challenging enough, individual attitudes toward availability vary across and within households. For example, one household may define dinnertime as a time of no interruptions whereas another family may consider interruptions perfectly acceptable during dinner (Chapter 3, 6). Likewise, certain household activities, like putting children to bed, may involve one parent, but not the other (Chapter 3).

For these reasons, using sensors to directly predict interruption of leisure is challenging, at best. Based on these studies, there is reason to believe that learning algorithms could predict individual availability in home life times relatively accurately if these algorithms had information about the current activity, including location. One research challenge is to be able to accurately determine activities given sensor data. From these studies, recognizing when the family is eating, would correlate highly to *not* available and is a socially acceptable situation to share. Determining when the eating portion of mealtime is completed would also be important to both availability prediction and also timely reminders, such as medication to be taken on a *full stomach*. In the child's bedroom, sensing would be directed to detecting reading and conversation around the child's bed to determine bedtime routine and *not* available. The ending of bedtime routine is characterized by parent-child interaction around the bed and a lessening of motor-movement activity, talking, and light level; detecting this transition would signal a change of availability status. Determining the start of dinner or children's bedtime is useful in defining the "windows of availability" (Chapter 4). Using discrete location and activity recognition in locations of particular interest or the identification of specific routine boundaries by patterns in social areas within the home is useful. Mateas and Romero are developing such a perception system that synchronizes the input of multiple sensing devices to define features over a "social space" and over time that could directly identify the mealtime routine in the kitchen and the children's bedtime [78].

7.2.3 Privacy: The Social Construction of Interruption

These studies suggest that individuals in home environments tend toward availability. One of the most important criteria for being a "good" parent, child, sibling, or friend is to be always accessible [98]. More significantly, social closeness between the individuals is the most important factor determining when one is accessible [98]. This suggests that social contexts play an important role for determining receptivity to interruption.

Social construction of parenting roles also plays a role in one's accessibility. In a two-parent household, how much a person is directly responsible for care of a child affects availability. When in secondary parenting role, there is almost no impact on mentally switching roles for availability [62]. Parents' availability is also affected by how much attention they believe a child needs. When a parent provides more care, either as primary or from their view of the child's needs, there is less accessibility, due to the mental cost of this commitment to the child [62]. The sensing of the parental role may be as direct as co-location, but may not be that straightforward Chapter 3). Again, there are many factors, including child's age, physical space of the home, and activities of the child and parent. The varying roles of parent within home life may provide availability cues through visible actions or as household rituals identified, by family or technology.

The CDA Shared Awareness study highlighted the social role of shared information to portray the household availability accurately and politely. In home life, communication is relational, not focused on tasks and data; as one of our participants pointed out when critiquing availability prototypes , *"It's informational, but it's not personal."* A phone call served as the example interruption, but in the negative sense. In the CDA Shared Awareness discussion it was clear those subjects did not view a phone call as an activity to avoid or to re-schedule (Chapter 6). Instead, phone calls were *welcomed* interruptions of another adult in their day of care giving and household activities.

Another reason to shun disclosure of detailed activity and location information, by participants of CDA Shared Awareness , was the judgmental attitude of others towards leisure time activities (Chapter 6. Disclosing home life details would only be preferred if the activity also implies the appropriate social justification as to why they are or are

not available (Section 6.3.1). Providing additional information changes the social protocol balance: denying the provider "plausible deniability" and adding accountability to the caller. Further research is needed into the social construction of home life interruption so that designers may better understand how to design appropriately flexible technologies for dealing with the challenges of interruption.

7.2.4 Evaluation in Natural Settings

The context-aware communication prototyped in the Family Intercom [57] inspired the quest to determine how such context might be generated. Are there other methods that will help determine the actual sensing to install in the home? Installing a variety of sensing, even in the Aware Home, requires a great many resources–time, equipment, computation, data analysis, and participants' time. Instead,a feasibility study with user-centric focus was used to identify appropriate computational sensing goals. In the absence of a prototype with sensor data for concrete user interactions, data was gathered from real home settings. A sequential mixed methods approach was employed, using the findings from one method to explain and focus the next step in the research. For instance, the ESM Factors first gathered quantitative data in the PDA survey, but the steps and features of the statistical analysis were informed by the semi-structured qualitative interview data. Others may find this sequence of methods helpful in determining feasibility of other innovative technologies for the home or in other novel environments.

Sampling techniques were chosen to collect the *in situ* data in the home, as an observer may not be appropriate or able to gather the data of interest. A variety of diary and sampling studies were implemented to support both longitudinal data collection and broad populations. By carefully selecting the sampling approach to provide the appropriate type of data, this research was able to investigate very narrow questions (Does context improve availability prediction?) as well as broad explorations (Are there any features in the home environment to predict availability?). It is often difficult to observe infrequently occurring events, but broad sampling in DayRM Routines provided time-use data for an entire day, thus capturing many singleton events, like children's bedtime that happen only once a day.

The data gathered by these methods was the type expected and the high participation level of subjects in these diary studies was also encouraging. Careful planning to minimize inconvenience to the participants has enabled them as co-investigators to provide access to users of potential shared-context, in ES^3M Using Factors. These sequential, multi-step sampling studies appear to be a viable approach to developing a concrete situation to gain informed user feedback, especially in the absence of existing technology.

7.3 Future Work

While these results show the potential of availability prediction in the home, this research does not address how such services would be used. These studies have begun to evaluate between home awareness prototypes that provide minimal information in a variety of personable and socially respectful modes. To design for the home, implies learning the "face" of the household and how to express this role appropriately to the external world. Through multiple prototypes, one can explore the appropriate granularity of context to share (status, location, activity, routine), graphical representation (text, icon, both), and the aesthetics of the form factor.

Since these participants were uncomfortable sharing awareness information, studying how availability prediction may enhance interruption management at the recipient's home may be more appropriate. Rather than disclose context for outsiders to use, instead consider incorporating availability of the individual or family into existing incoming call management systems. For instance, if the family is eating dinner and the "phone answering service" is aware of that activity plus the preference for no interruptions during mealtime, then the answering service could automatically direct the call to a polite "dinnertime" notice and record a message, rather than allow the phone to ring for the full count prior to rolling over to message mode. Using context locally, where gathered, to manage interruptions is consistent with existing technology, but provides a means to observe concrete user interaction to availability prediction from environmental features. One could envision the "answering service" providing alternative media for messages; similar to email arrival signaling a family member is awake and available for a phone call (switching to media with a more disruptive

alert). There are also situations where sharing across homes is acceptable. For instance, these participants had specific caregiver roles in relationship to parents and friends that live alone, where knowing their location or activities would be useful. However, for everyday use, tethering availability status to the appropriate management of incoming calls, fits with existing practices to provide actual use at home.

By incorporating availability information into current practices, one would be able to study the evolving use over time. There are two benefits from the use of actual availability status: determine reliability and establish usability criteria. When the availability status changes the management strategy, the in-home user should have some feedback as to this change, either visual or audio. Thus, the provider may help "tune" the system. If the predictions are not reliable, then the user will over-ride. User interaction can help evaluate sensor reliability and the feasibility of computational models. If the availability detection and/or computation is reliable, then user interaction can inform development of suitable usability criteria. Does the service provide appropriate feedback to portray availability and the appropriate management of incoming calls? Does it reveal enough about the underlying model, for the user to understand the responses, both automatic and user initiated? Longitudinal use and observation of prototype availability service would provide reliability and usability metrics.

Other areas to study are adoption practices and the evolving use of new communication technologies. For instance, VOIP use is relatively new, especially in the home, but provides a service platform for availability services. How do people currently determine when to call using VOIP? How does it differ from making a cell phone call? When and why are alternative communication channels chosen? Other media channels may also be useful, such as instant messengers on cell phones. The mobility of the service fits with home life where people move about from room to room. How does the asynchronous nature of IM fit into the busy home? These studies found a desire to "delay interruption", either for a few moments when transitioning between activities or a longer time to finish watching a movie. Observing the use of mobile IM and VOIP technologies adopted for home use would enable exploration of how family members manage interruption at home.

7.4 Conclusion

This research contributes to the growing interest in two home communication, in particular the feasibility of availability prediction and the shared used of this situation information. The natural activities of home life were sampled to determine those environmental factors which then serve as an indicator for family availability. These external factors were found to be effective for identifying household routines of availability and useful in determining when to initiate conversation across homes. In ESM Factors and DayRM Routines studies, statistical models revealed that both availability status and household routines can be predicted from fairly simple sensed phenomena, e.g. room location, conversation, and eating. This work has implications for perception research in the home, both in the selection and placement of sensing, as well as in the appropriate inference to provide *usable* information from the technology. This work also established a need for shared context, to improve the prediction accuracy of friends and family when determining when to call. From outside the home, people are no better than random guessing when determing *best* times to interrupt. However, as shown in ES^3M Using Factors study additional situation knowledge improves the accuracy of the predictions. But, there is a further challenge in determining the appropriate representation of shared availability knowledge. From CDA Shared Awareness study, it is apparent that sharing situational information outside the home changes the existing balance in conversational protocol, in ways that may actually disrupt the social interaction. Knowing too much precludes the recipient's *plausible deniability* as well as the the basis for conversation, sharing the current happenings. In a larger sense, the design of home services must also attend to the desire of the household members to personalize and present a socially acceptable availability status to their close family and friends. This work contributes on two *"feasibility endpoints"* concerning availability services in the home: determining what awareness information providers are willing to share and how such information may be useful between homes.

APPENDIX A

ESM FACTORS : SURVEY QUESTIONS AND RESULTS

The ESM survey was composed as a series of memos on the PDA, using keywords to control the flow of questions and selection options. The "%Type" or "%t" tag specifies the type of question that will be used; the parameter "list" creates a listbox, where only one choice may be selected from those displayed. We also used "checkboxes" allowing multiple selections, "text" for comments, and "slider" to select time from range of 1 to 60 minutes. The questions are presented in sequential order, unless a "%next" or "%n" tag is used. This tag specifies which question should be presented next, the parameter is the question id number; this tag may be applied to all responses for the question or to individual response choices.

The first question listed below has question id "10" and displays: "Right now I am ....". The four responses are shown as a "list", where only one may be selected. If the person selects "by myself", then the next question is "30" asking about location. However, if the selection is "with one other person", then the next question is "15". At question "15", the user identifies the other person, then the user is directed to question "30" concerning location.

More details on the question set-up are available with the iESP on-line documentation, Intel Experience Sampling Program, iESP, http://seattleweb.intel-research.net/projects/ESM/.

10. Right now I am ...%Type list

- by myself %n 30
- with one other person %n 15
- with 2 or more persons %n 20

15. The other person is ... %n 30

- my significant other/spouse

- my child
- another family member
- a friend
- other

20. The other person(s) is ...%type c %n 30

- my significant other/spouse
- my child(ren)
- other family member(s)
- friend(s)
- other(s)

30. My location is at ...

- Home %n 33
- Work %n 35
- a Store %n 37
- a Recreation Site %n 40
- in a Car %n 42
- Other location %n 60

33. At Home in the ...%n 60

- living room
- dining room
- family room/den

- kitchen
- my bedroom
- others bedroom
- bathroom
- office
- patio
- yard
- garage
- other

35. At Work in the ... %n 60

- Office
- Other

37. At this store ...

- grocery %n 60
- Other

40. Recreation or entertainment site %n 60

- Park
- Movie
- other

42. In a Car ...%n 60

- driving

- as passenger

60. My current COMMUNICATION activities include ... %t c %n 70

- Face-to-face conversation
- Telephone call
- Chat or Instant Messenger
- Email
- Written Correspondence
- Other

70. My current activities involving FOOD include ... %t c %n 80

- Eating
- Food preparation
- Food Clean-up
- Planning Meals
- Other

80. My current HOUSEHOLD TASKS and Activities include ... %t c %n 90

- Laundry or housecleaning
- Shopping
- Managing Finances
- Personal/family info
- My job or education
- Other

90. My current LEISURE activities include ... %t c %n 150

- Watching TV or Movie
- Reading
- Game playing
- Sleeping or Napping
- Family Gathering item Other

150. I participate in this activity at times that are ...%n 210

- intentionally planned
- anticipated, but variable
- unusual, but not surprising
- unexpected or even startling

210. Would this be a good time for an adult family member to get your help with an activity or task they consider urgent? %n 230

- No, not at all %n 220
- Not now, maybe in a few minutes %n 212
- Yes, for just a moment
- Yes, for however long

212. About how many minutes until you would be available? %t s %n 220
Presented a "slider" from 1 to 60 minutes.

220. My most important reason for NOT being available is ...%t c %n 240

- The person needing help
- Their task or its urgency

- My location
- My activity
- Other

230. My most important reason for being available is ...%t c %n 240

- The person needing help
- Their task or its urgency
- My location
- My activity
- Other

240. Would this be a good time for an adult family member to catch up on today's events with you? %n 260

- No, not at all %n 250
- Not now, maybe in a few minutes %n 242
- Yes, for just a moment
- Yes, for however long

242. About how many minutes until you would be available? %t s %n 250
Presented a "slider" from 1 to 60 minutes.

250. My most important reason for NOT being available is ...%t c %n 300

- The person wanting to talk
- Just chatting can wait
- My location
- My activity

- Other

300. OPTIONAL ... Enter any comments about your current location and activity or explanations of your responses here ... %t t

APPENDIX B

DAYRM ROUTINES : SURVEY INSTRUMENT

B.1 DayRM Routines : Part I

There is a two page demographic survey in part I of DayRM Routines, see Figures 13 and 14.

B.2 DayRM Routines : Part II

Divider Sheet for Part II of DayRM Routines, see Figure 15.

B.2.1 DayRM Routines : Diary and Instructions

Instructions for completion of Prior Day Diary for Part II of DayRM Routines, see Figure 16.

Prior Day Diary for Part II of DayRM Routines, see Figure 17.

B.3 DayRM Routines : Packet III

Participants were instructed to begin packet 3 after completing packet 2. Packets 3 and 4 were in a sealed envelope.

Summary of Prior Day, Part III of DayRM Routines, see Figure 18.

Instructions for completing survey for each episode of prior day, Part III of DayRM Routines, see Figure 19.

Instructions for constructing the interruption from a recalled situation, Part III of DayRM Routines, see Figure 20.

Context Information Prior Day per Episode, Part III of DayRM Routines, see Figure 21.

Availability and Routines Questions, Part III of DayRM Routines, see Figure 22.

Change in Location/Activity for One Episode, Part III of DayRM Routines, see Figure 23.

B.3.1 DayRM Routines : Packet IV Overall Availability

Indicators for Mealtime and Children's Bedtime Routines Questions, Part IV of DayRM Routines , see Figure 24.

Overall Availability and Routines Questions, Part IV of DayRM Routines, see Figure 25.

General good and bad times for interruptions, Part IV of DayRM Routines, see Figure 26.

Participant Information

1. **Name** _____

2. **Gender** ___M ___F **Race** ___ Black ___Caucasian ___Asian ___Other

3. **Marital Status** _____Single ____ Married _____ Other

4. **Your Age (in years)** ___ 18-22 ___ 23-29 ___ 30-39 ___ 40-49
   ___ 50-59 ___ 60-69 ___ 70 or older

5. **Occupation** _____
   ____ Student _____ Retired
   Normal Days and Hours of work _____
   (example: M,W,F 7 am – 3 pm and T,Th 4 pm –midnight)
   Where do you work? ___ Office ___ At Home (explain) Travel to different sites
   Other _____

6. **Education completed** ____ High School ____ Post-HS Training
   ____ College degree ____ Graduate degree

7. **What kind of communication devices are used in your home?**

Device Description	In Home Yes	No	Who uses this?	Where is this located in your home?
Telephone				
My Cell Phone				
Other Cell Phone				
Walkie-Talkies				
Baby Monitor				
Answering Machine				
Caller ID				
Short Message Service (SMS)				
Fax				
Other				
Computer-based communication tools in your home				
Email				
IM				
News Groups				
Other				

Figure 13: Participant Demographic Information, page 1 of 2

Household, Family and Friends

Household Membership

List each person living in your home in the table below, including yourself first.

	First Name or Alias	Gender	Age*	Relationship to participant	Occupation
1	Self (participant)			self	
2					
3					
4					
5					
6					
7					
8					

*Age in years for child and best approximation for adults.

Family and Close Friends

List family and friends with whom you communicate "regularly" and/or with whom you have a "close" personal relationship. For example, your child attending college in another city may not call or email you daily, but you have a close relationship.

	First Name or Alias	Gender	Age*	Relationship to participant
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				

*Age in years for child and best approximation for adults.

Figure 14: Participant Household and Communication Network, page 2 of 2

Packet 2 of 4

You may keep this diary of your prior day's activities

Figure 15: Packet 2 Divider Sheet

Yesterday's Home Life Times

We would like to learn what you did and how you felt **yesterday during your home life times**. *Home life* times may be spent either at home or outside the house, but do not include when you are engaged in work-related activities. Not all days are the same – some are better, some are worse and others are pretty typical. Here we are only asking you about times when you were involved in **home-related activities from yesterday.**

Because people find it difficult to remember exactly what they did and experienced, we ask you to first recall when you were in "home-related" times yesterday. Then, you will write a diary of those times. Think of your day as a continuous series of scenes of episodes in a film. Give each episode a brief name that will help you remember it and write down the approximate times at which each episode began and ended. The episodes people identify usually last between 15 minutes and 2 hours. The end of an episode might be going to a different location, finishing one activity and starting another, or a change in the people with whom you are chatting. For instance, "Evening dinner time with family" from 6:00 pm to 7:30pm may actually be three episodes or scenes:

Episode Name	Start/End Times	**Activities**
Preparing Dinner	6:00 – 6:30 pm	preparing dinner, helping with homework, setting table, chatting, feed dog
Eating Dinner	6:30 - 7:10 pm	eating dinner, family conversation, planning/scheduling
After Dinner Clean-up	7:10 – 7:30 pm	clean-up activities, walk dog, more homework, chatting

The activities within an episode or scene may actually overlap or occur at the same time. In the example above, someone may be chatting and preparing dinner at the same time, which may overlap with homework help and feeding the dog.

There is space on the diary page to enter 15 episodes, although you may not need that many, depending on your home life day. It is not necessary to fill up all the lines in the table – use the breakdown of the day that makes the most sense to you and best captures what you did and how you felt. Additional sheets are available, if you have more than 15 episodes, or you may enter the additional episodes on the back. You will not include times when you were *"at work"*, whether you work at home or outside the home. You should determine whether your time commuting to and from work is spent on work or home-related activities.

Try to remember each episode in detail, and write a few words that will remind you of exactly what was happening. Also, try to remember how you felt and what your mood was like during each episode. What you write only has to make sense to you, and to help you remember what happened when you are answering the questions in Packets 3 and 4.

> *This diary (packet #2) is only for you, to help you remember and describe what happened during your home life portion of yesterday. It is yours to keep, so your notes are strictly personal and confidential. You do not need to turn it in. Nobody will read what you jot down about your day.*

Figure 16: Packet 2 Instructions for Diary of Prior Day Espisodes

Part 2 - Home Life Yesterday

Episode	What happened? Episode Name	Begin Time	End Time	Notes to yourself What did you feel?
Example	Preparing Lunch	11:30 am	11:55am	Cooking food, set table, chatting in kitchen – Rushed & hungry
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Remember, what you write in your diary will not be seen by anybody else.
Packet 2 is yours to keep if you wish –
you don't have to turn it in with the rest of your questionnaire.

Figure 17: Packet 2 Diary of Prior Day Espisodes

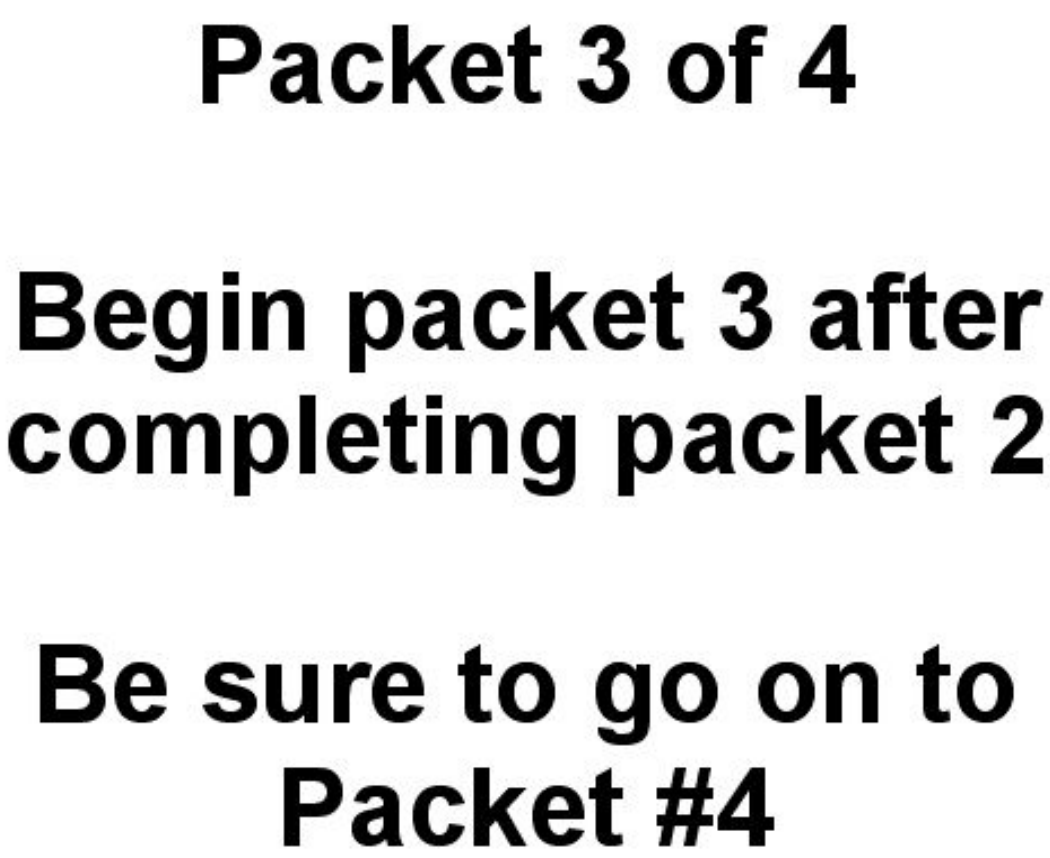

Figure 18: Packet 3 Divider

Part 3
What were you doing in your home life yesterday?

Now, we would like to learn in more detail how you spend your time in home-related activities and when you are available for a phone call from a close relative or friend. **For each episode, there are several questions about what happened and how available you were to someone outside the home. Please use the notes on your diary pages as often as you need them. You do not need to turn in packet 2, the diary pages.** You will turn in packets 3 and 4 for researchers to read your responses about activities in your home.

Before we proceed please look back at your diary pages for your home life.

1. To begin, please circle the day of the week that **YESTERDAY** was:

   Monday Tuesday Wednesday Thursday Friday Saturday Sunday

2. How many episodes did you record for your home life? _____

   What time segments were covered by these episodes?

   (May be single or multiple segments with a time gap between.)For instance, you may have a home life segment in the morning (7-8:30 am) and another in the afternoon/evening (4:30-11:00 pm), where each segment has several episodes or scenes.

Start of Home Life	End Time of Home Life

3. Was yesterday a typical day for your family? ____ YES _____ NO

   What was **different** or what made it **typical**?

   _____

   _____

   _____

   _____

   _____

Figure 19: Packet 3 Instructions

Part 3 (continued)
What were you doing in your home life yesterday?

4. **Recalled Interruption**

Recall a time when a family member from outside your household wanted to get your help with an activity or question **they considered important enough to interrupt you**. This does **not** need to be from yesterday. This request may have been made via a phone call or they may have stopped by your home in-person.

Who was making the request? _____

What was the activity or task? _____

_____

_____

One of the questions asked for each episode is:

"Would this have been a good time for an adult family member to get your help with an activity or task requiring your full attention?"

When you encounter this question, **think about the recalled interruption situation above when responding**.

Now, look back at your diary for yesterday.
Please complete one sheet for each episode or scene in your home life diary!

Please answer the questions for every episode you recorded, beginning with the first episode. Use one sheet per episode. To make it easier to keep track, we will ask you to write down the number of the episode. For example, the first episode was number 1, the second episode was 2, and so on.

It is very important that we get information about all of the episodes you experienced in your home life yesterday, so please be sure to answer the questions for all of your home life episodes, including the first and last episode of the home life day, then you can go on to Packet 4.

Figure 20: Packet 3 Instructions for Recalled Interruption

Home Life Episode

When did this episode begin and end (e.g. 3:20 pm)? Please try to remember the times as precisely as you can.

1. This is episode number ____, which began at _____ and ended at _____.

2. How did you determine the start of an episode? (Rank any that apply, 1=most important.)
   ___ people involved
   ___ activity change
   ___ room change
   ___ time or schedule
   ___ other _____

3. Where were you? ____ At home or _____ (if not at home, go to #6)
   If you were at home, in which location?
   ___ kitchen
   ___ my bedroom
   ___ family or living room
   ___ child's bedroom
   ___ dining room
   ___ other at home

4. If you were at home, in general, who was in the room with you? ___ by myself OR
   ___ spouse/significant other
   ___ my child(ren) How many? _____
   ___ others _____ How many? _____

5. If at home, who else is at home? ___ by myself OR indicate others' locations below.

	Kitchen	Family/ Living Room	Dining Room	Parent Bedroom	Child's Bedroom	Other at Home
Spouse						
Children						
Others						

6. Circle the number best describing your interaction with other people during this episode.

0%	50%	100%
no interaction	occasionally interacting	continual talk/interaction

7. **What were you doing? (please check all that apply)**
   ___ eating meal/snack
   ___ telephone
   ___ preparing meal/snack
   ___ email, on-line chat, or IM
   ___ cleaning after meal/snack
   ___ written communication
   ___ planning meals
   ___ work-related activity
   ___ other food related
   ___ sleeping or napping
   ___ laundry or housecleaning
   ___ watching TV or movie
   ___ yardwork
   ___ reading
   ___ shopping
   ___ games (video, board, card)
   ___ managing money
   ___ listening to music
   ___ bill payment
   ___ educational/school related
   ___ managing personal records
   ___ planning/scheduling
   ___ face-to-face conversation
   ___ other activities _____

Figure 21: Packet 3 Context Information for Prior Day for each Episode

Use the recalled recent interruption from a family member to answer questions #8 & #9.

8. a. Would this have been a good time for an adult family member outside your home to **get your help with an activity or task you would want to give your full attention**?

___ No, it would be difficult or awkward to be interrupted
___ No, I would prefer not to be interrupted
___ Yes, I could be available for a few seconds to a minute
___ Yes, I could be available for ____ minutes or longer (estimate minutes)

b. When thinking about your availability response #8a above, what factor was most important? Use 1= most important, 2 = next most important, leave blank any that do not apply.

___ The person needing your attention _____
___ Their activity or task _____
___ Your activity _____
___ Your location _____
___ Other _____

9. a. Would this be a good time for an adult family member outside the home to **catch up on the family events and activities**?

___ No, it would be difficult or awkward to be interrupted
___ No, I would prefer not to be interrupted
___ Yes, I could be available for a few seconds to a minute
___ Yes, I could be available for ____ minutes or longer (estimate minutes)

b. When thinking about your availability response #9a above, what factor was most important? Use 1= most important, 2 = next most important, leave blank any that do not apply.

___ The person needing your attention _____
___ Their activity or task _____
___ Your activity _____
___ Your location _____
___ Other _____

10. This episode is part of your normal routine during …

___ Mealtime
___ Children's Bedtime
___ Leaving or returning home
___ Schoolwork time
___ Leisure time
___ Other routine _____
___ Not part of a routine

Figure 22: Packet 3 Availability and Routines Questions

Changing Location and Activity between Home Life Episodes

Select the first episode where you changed rooms and activity, from the previous episode.

These are episodes number _____ and _____.

Beginning in _____ location and the next episode moving to _____.

Ending activity of **first** episode _____

Beginning activity of **next** episode _____

Recall the time transitioning from the first episode into the next episode to answer the following. Use the recalled recent interruption from a family member to answer questions #1 & #2.

1. a. Would this have been a good time for an adult family member outside your home to **get your help with an activity or task you would want to give your full attention**?
   ___ No, it would be difficult or awkward to be interrupted
   ___ No, I would prefer not to be interrupted
   ___ Yes, I could be available for a few seconds to a minute
   ___ Yes, I could be available for ____ minutes or longer (estimate minutes)
   b. When thinking about your availability response #1a above, what factor was most important? Use 1= most important, 2 = next most important, leave blank any that do not apply.
   ___ The person needing your attention _____
   ___ Their activity or task _____
   ___ Your activity _____
   ___ Your location _____
   ___ Other _____

2. a. Would this be a good time for an adult family member outside the home to catch up on the family events and activities?
   ___ No, it would be difficult or awkward to be interrupted
   ___ No, I would prefer not to be interrupted
   ___ Yes, I could be available for a few seconds to a minute
   ___ Yes, I could be available for ____ minutes or longer (estimate minutes)
   b. When thinking about your availability response #2a above, what factor was most important? Use 1= most important, 2 = next most important, leave blank any that do not apply.
   ___ The person needing your attention _____
   ___ Their activity or task _____
   ___ Your activity _____
   ___ Your location _____
   ___ Other _____

3. This episode is part of our normal routine
   ___ at Mealtime
   ___ Children's Bedtime
   ___ Leaving or returning home
   ___ Schoolwork time
   ___ Leisure time

4. Describe the change in episodes (continue on back, if needed) _____

   _____

Figure 23: Packet 3 Change in Location/Activity for One Episode

Part 4 – Availability and Interruptions

1. From yesterday, list three indicators that **dinner time has started** in your household?

   a) _____

   _____

   b) _____

   _____

   c) _____

   _____

2. From yesterday, list three indicators that **dinner time is ending** in your household?

   a) _____

   _____

   b) _____

   _____

   c) _____

   _____

3. From yesterday, list three indicators that **children's bedtime routine is starting** in your household?

   a) _____

   _____

   b) _____

   _____

   c) _____

   _____

Figure 24: Packet 4 Dinner and Bedtime Routines Questions

4. From yesterday, list three indicators that **children's bedtime routine is ending** in your household?

a) _____

_____

b) _____

_____

c) _____

_____

Family Availability

Now that you've taken stock of your family availability for yesterday, we would like to find out about how you really feel about availability during your home life. The following questions (#5 to #9) ask about general reflections on your availability during home-related activities. We are interested in your belief over many days, not just your availability for yesterday.

5. Indicate for each activity whether you are **generally available (+) or not (-)** for the majority of the time the activity lasts:

___ eating meal/snack
___ preparing meal/snack
___ cleaning after meal/snack
___ planning meals
___ other food related
___ laundry or housecleaning
___ yardwork
___ shopping
___ managing money
___ bill payment
___ managing personal records
___ face-to-face conversation
___ Others _____
___ telephone
___ email, on-line chat, or IM
___ written communication
___ work-related activity
___ sleeping or napping
___ watching TV or movie
___ reading
___ games (video, board, card)
___ listening to music
___ educational/school related
___ planning/scheduling

6. For each routine, indicate whether you would be available (+) or not (-) for the majority of the time the routine lasts:

___ Mealtime
___ Children's Bedtime
___ Leaving or returning home
___ Schoolwork time
___ Leisure time
___ Other _____

Figure 25: Packet 4 Overall Availability and Routines Questions

7. In general, what do you think **your household members believe to be a good time to call you or your family?**

8. In general, what do you think **your household members believe is NOT a good time to call you or your family?**

9. Anything else you want to say about your family and their availability? _____

THANK YOU!

Figure 26: Packet 4 Good and Bad Times to Interrupt

APPENDIX C

CDA SHARED AWARENESS : STUDY PROTOCOL AND DATA

C.1 CDA Shared Awareness : Procedure and Protocol

Design of Home Availability Services

Cooperative Design Discussion Overview Guide

(Total Session Time: less than 2 hours, providing breaks as needed)

I. Introduction and Consent (15 minutes)

Briefly review purpose of study and obtain informed consent from each participant.

- Review guidelines for group, provide concrete example of situations we are investigating, and schedule for cooperative design session
- Consent form explanations and signing.
- Start recording group video and audio.

Introductions - Name and one example of when it is "a good time" to be interrupted during homelife.

II. Cooperative Design Scenario (20 minutes)

1. Each participant will complete a brief description of a leisure time episode from their prior afternoon or evening - who, where, when, what were you doing, availability status.
2. Then image your best friend, from outside your immediate household is trying to speak with you, what information do you want them to have about you and your household?

3. Using the paper prototype display provided, show the information you would share, including how you would represent the data. Participants will use the pre-printed sheets of "context information" data stickers we provide with varying levels of detail and different visual representation forms. For example, availability may be a toggle (yes/no), a probability (10

4. After the members design their individual availability service, then discuss why each choose particular info and its representation. Why are those pieces of information included in this display? Why were some data items not selected?

III. Cooperative Design Scenario Alternative Activity (10 minutes)

1. Now, consider your dinnertime routine from yesterday. Jot down the specifics about it on the sheet provided.

2. Design a paper prototype display for this situation from a new set of prototype materials or make alterations to the availability display reflecting leisure.

3. Discussion What did you change about the display to show dinner vs. leisure activity? Why?

IV. Plausible Deniability (10 minutes)

1. What are some activities you do not want shared - no sticker needed? We have provided many representations of a dozen or more activities, that might be sensed via home-based technology. But, homes are places of privacy and closed doors. For example, married couples do not usually broadcast their private times together , no matter what time of day or what the activity. What are situations that you would not want technology to detect or to share?

V. Prototype Changes for Different Recipients (20 minutes)

1. To whom would you show each of these prototypes, showing leisure and dinner time routine?

2. Provide a "Where are these people?" paper, where each participant can indicate those persons to who they would share each display. The distance the stick figure is away from the "me" figure is proportionate to the "closeness" of communication interactions. Closer placement is more familiar, farther away is more formal.

3. Who would you not want to see this? Draw a figure for these persons on the communication interaction form. How might you change this prototype display to share a revised version with this other family member or friend?

VI. Design Alternatives Form Factors (25 minutes)

1. Now consider how you might use this type of display as a consumer of data shared by others. Imagine you will preview this availability info from another household while you are engaged in the leisure activity you recalled from yesterday Where will this display be located in your home? We provide several "mock" prototypes of wearable/mobile size, personal/tablet size, and wall-mount size and examples of how they may fit into home use.

2. Where would you want to see this info? Whose availability info would you want to see? Use a blank "Where are these people?" ruler, and draw named "Xs" to indicate each and how close your interactions are. How many do you have?

3. How will you manage to see all of these person's data? When would you want to see it? How would you want to interact with the data that is how would you find the person or family whom you were interested in interrupting? What are the advantages of your choice? Are there any features that are not desirable?

4. If you were moving around, carrying this service on your cellphone or PDA, what would you want to see on this size device? Provide the appropriate form factors and time re-think in this situation.

VII. Wrap-up and Availability Experiences (10 minutes)

1. Now that we have talked about the details of how you both share and use availability information, do you have anything to add from your prior comments?

2. Overall, do you think your sharing of availability info would be more beneficial or harmful? How?

3. Any final thoughts about technology services to enhance communication between persons with existing close communication interactions?

C.2 CDA Shared Awareness : Participant Designs

C.2.1 Group 1 Participant Designs

For the first Cooperative Design Activity focus group, the paper designs are shown below. For each participant, both the dinnertime and leisure time displays are show in the same figure.

C.2.2 Group 2 Participant Designs

For the second Cooperative Design Activity focus group, the paper designs are shown below. For each participant, both the dinnertime and leisure time displays are show in the same figure.

Figure 27: Group 1 Participant 1 Design. Notice only text, no activity detail provided.

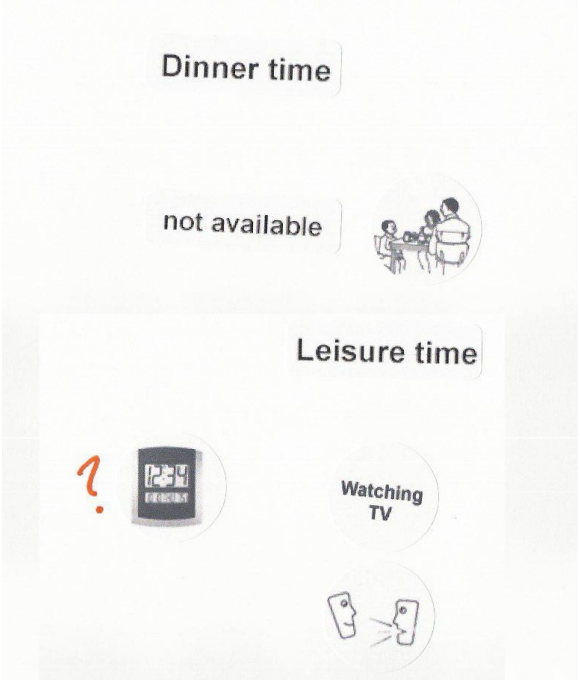

Figure 28: Group 1 Participant 2 Design. Dinner shows activity. Leisure provides multiple activities, watching TV and conversation, as well as time until available, but no availability status.

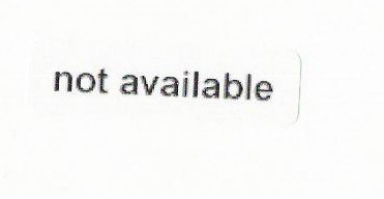

Figure 29: Group 1 Participant 3 Design. Only one design for both leisure and dinner time, just the status: not available.

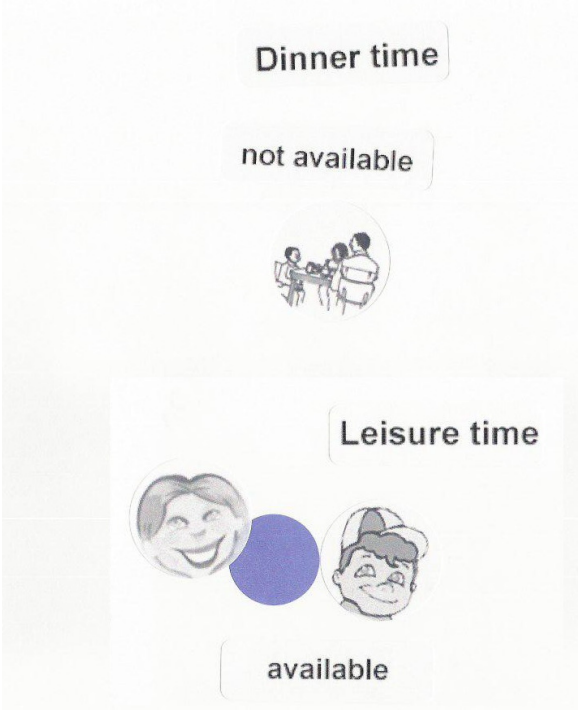

Figure 30: Group 1 Participant 4 Design. This design has more detail and use of color. But, it does not share the activity at leisure, just the participants and status is available.

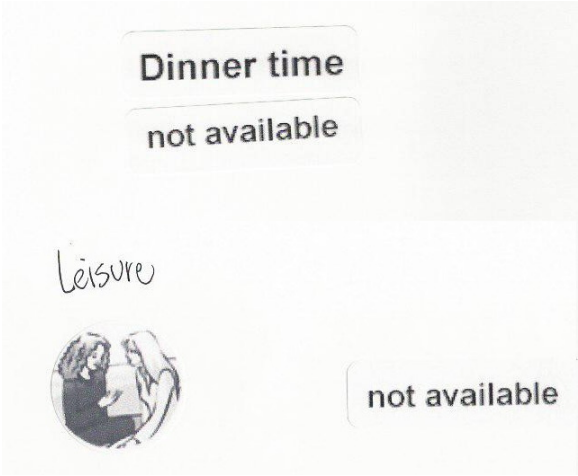

Figure 31: Group 2 Participant 1 Design. This design shows more detail for the leisure activity, than dinner time. However, the leisure is a social activity, talking with a friend.

Figure 32: Group 2 Participant 2 Design. Dinnertime on the left shows activity and location, but not status. Leisure on right only shows availability status.

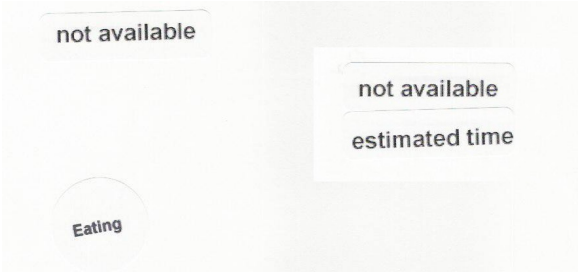

Figure 33: Group 2 Participant 3 Design. Dinnertime display shows activity eating and not available, but leisure only shows status and estimated time until available.

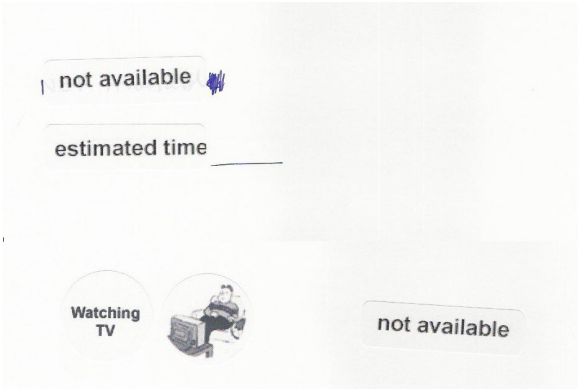

Figure 34: Group 2 Participant 4 Design. For dinner, just shows not available and estimated time until available. Below, the leisure display shows the activity, watching TV, in both text and icon, along with status.

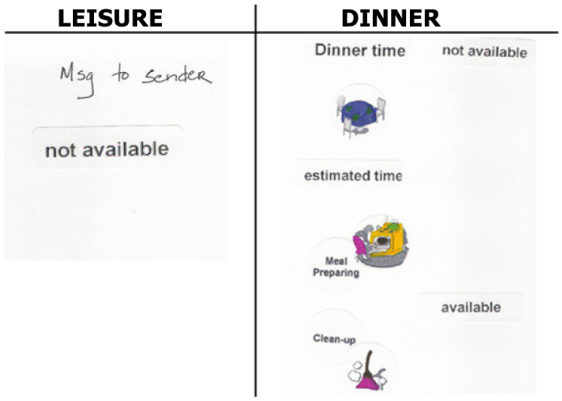

Figure 35: Group 2 Participant 5 Design. This design shows more detail for dinner time, including several phases of dinnertime and the corresponding availability status for each. For leisure, just the status.

APPENDIX D

ES^3M USING FACTORS : SURVEY INSTRUMENTS

D.1 ES^3M Using Factors : PDA-based Survey Instrument Gathering Samples

The ESM survey was composed as a series of memos on the PDA, using keywords to control the flow of questions and selection options, also see the ESM Factors ESM description in Appendix A. The questions are referenced by an identification number, appearing first in the memo, where | is the field divider. Then comes the question text, presentation type, and next question number. The responses are also delineated by | and may include a conditional to branch to the specified question, when this response is selected. For example,

> *10| Right now I am ...%Type list|by myself %n 30|with one other person %n 15|with 2 or more persons %n 20*

This is question number 10, and displays: Right now I am .... The possible responses are shown as a "list", only one may be selected. Depending on which response is selected, the user is taken to a more detailed question to describe who is in the same room. More details on the question set-up are available with the iESP on-line documentation, Intel Experience Sampling Program, iESP, http://seattleweb.intel-research.net/projects/ESM/.

Each survey question, response choices, and type of presentation are shown Figures 36 and 37.

D.2 ES^3M Using Factors : On-Line Availability Survey Instrument

10|Right now I am ...%Type list|by myself %n 30|with one other person %n 15|with 2 or more persons %n 20
15|The other person is ... %n 30|my significant other/spouse|my child|another family member|a friend|other

150|This is part of my normal routine during ...%n 210|Mealtime|Children's Bedtime|Leisure time|Schoolwork time|Other routine|Not in a routine

20|The other person(s) is ...%type c %n 30|my significant other/spouse|my child(ren)|other family member(s) |friend(s)|other(s)

210|Would this be a good time for an adult family member to get your help with an important question requiring your full attention for a minute or two? %n 230|No, not at all %n 220|Not now, I prefer not to talk%n 212|Yes, for just a minute or two|Yes, for several minutes

212|About how many minutes until you would be available? %t s %n 220|1 min.|60 min.

220|My most important reason for NOT being available is ...%t c %n 240|The person needing help|Their task or its urgency|My location|My activity|Other

230|My most important reason for being available is ...%t c %n 240|The person needing help|Their task or its urgency|My location|My activity|Other

240|Would this be a good time for an adult family member to catch up on social news, activities and events with you? %n 260|No, not at all %n 250|Not now, I prefer not to talk%n 242|Yes, for just a minute or two|Yes, for several minutes

242|About how many minutes until you would be available? %t s %n 250|1 min.|60 min.

250|My most important reason for NOT being available is ...%t c %n 300|The person wanting to talk|Just chatting can wait|My location|My activity|Other

260|My most important reason for being available is ...%t c %n 300|The person wanting to talk|Just catching up is important|My location|My activity|Other

30|My location is at ... |Home %n 33|Work %n 35|a Store %n 37|a Recreation Site %n 40|in a Car %n 42|Other location %n 60

300|OPTIONAL ... Enter any comments about your current location and activity or explanations of your responses here ... %t t

Figure 36: ESM Availability Survey

33|At Home in the ...%n 60|living room|dining room|family room/den|kitchen|my bedroom|others bedroom|bathroom|office|patio|yard|garage|other

35|At Work in the ... %n 60|Office|Other

37|At this store ...|grocery %n 60|Other

40|Recreation or entertainment site %n 60|Park|Movie|other

42|In a Car ...%n 60|driving|as passenger

60|My current COMMUNICATION activities include ... %t c %n 70|Face-to-face conversation|Telephone call|Chat or Instant Messenger|Email|Written Correspondence|Other

70|My current activities involving FOOD include ... %t c %n 80|Eating meal/snack|Preparing meal/snack|Food Clean-up|Planning Meals|Other

80|My current HOUSEHOLD TASKS and Activities include ... %t c %n 90|Laundry or housecleaning|Shopping|Managing Finances|Personal/family info|My job or education|Other

90|My current LEISURE activities include ... %t c %n 150|Watching TV or Movie|Reading|Game playing|Sleeping or Napping|Listening to Music|Other

Figure 37: ESM Availability Survey, page 2

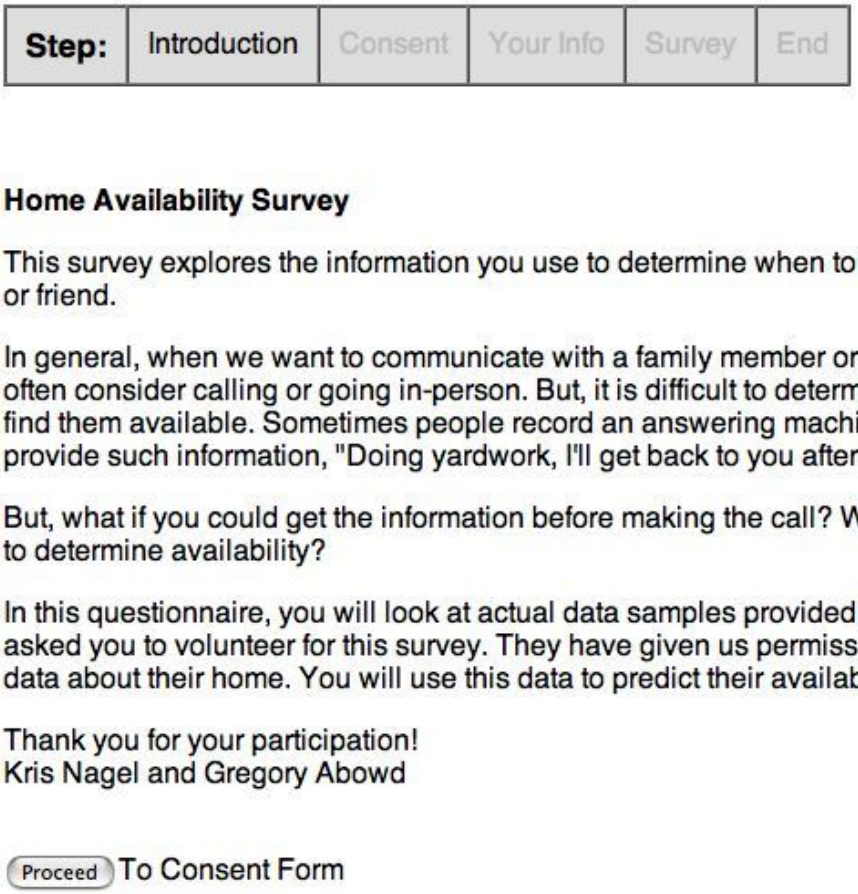

Figure 38: Introduction to On-Line Availability Survey

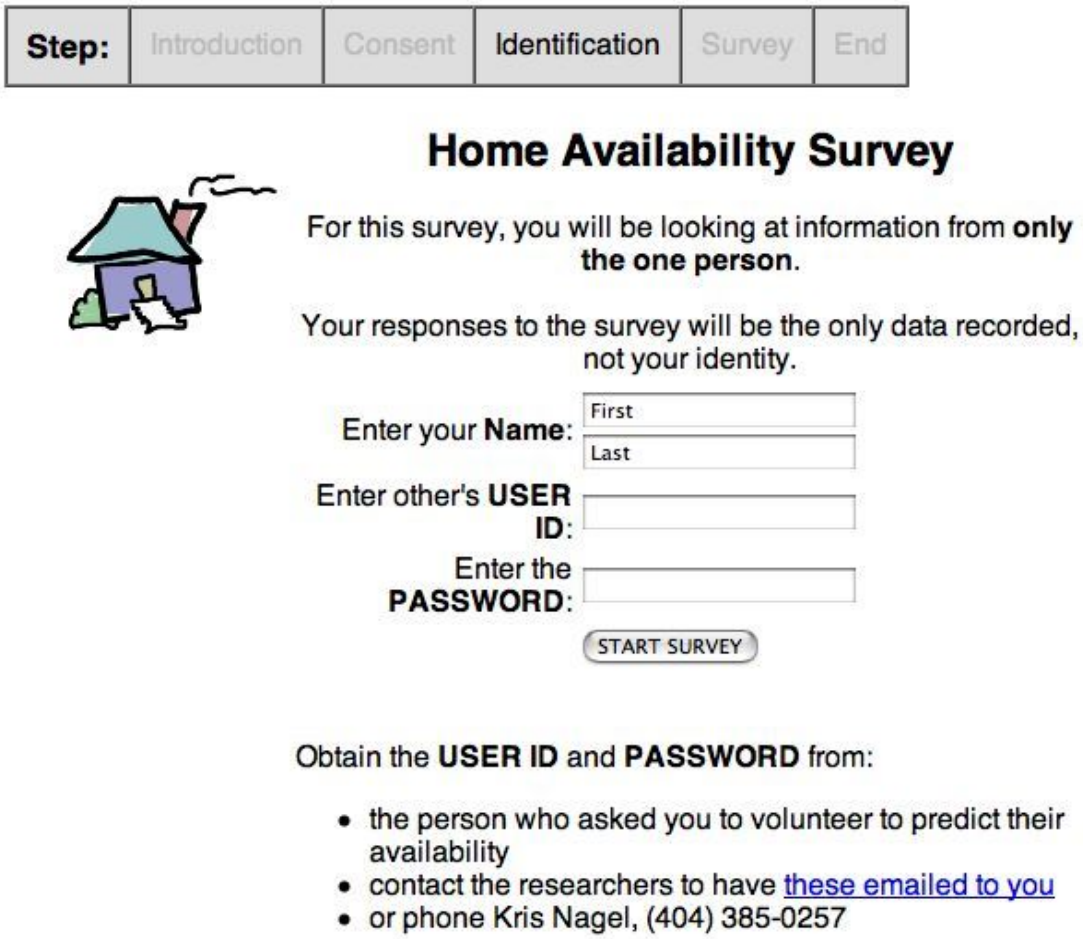

Figure 39: Log-in to On-Line Availability Survey

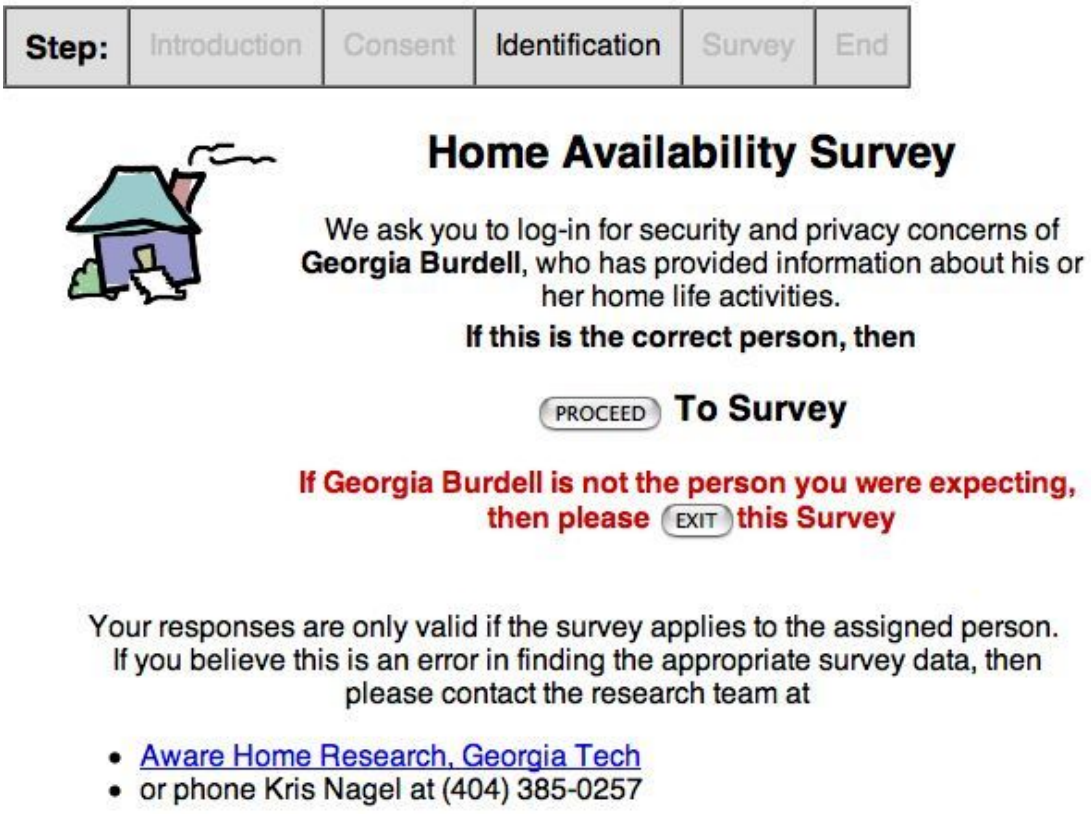

Figure 40: Confirmation of Provider Identity for On-Line Availability Survey Data

Step:	Introduction	Consent	Your Info, Page 1 of 3	Survey	End

Demographics

To begin, we ask for some information about you. Please note, all fields are optional.

1. Gender:

   ○ Female
   ○ Male

2. Marital Status:

   ○ Married
   ○ Single
   ○ Other

3. Age:

   ○ under 18
   ○ 18-24
   ○ 25-34
   ○ 35-44
   ○ 45-54
   ○ 55+

4. Occupation:

5. Education completed:

   ○ High School
   ○ Post-HS Education
   ○ College Degree
   ○ Graduate Degree

Proceed To Page 2 of 3, Your Info

Figure 41: Demographic On-Line Survey Data, page 1

Step:	Introduction	Consent	Your Info, Page 2 of 3	Survey	End

Communication Information

1. Communication devices and services **I use at home** (Check all that apply):

   - ☐ Telephone (Home Land-line)
   - ☐ Cell Phone
   - ☐ Answering Machine
   - ☐ Caller ID
   - ☐ Fax
   - ☐ Email
   - ☐ Other

2. I like to know about the newest technology and computer equipment.

   agree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 disagree

3. I consider myself an early adopter of the newest technology and computer equipment.

   agree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 disagree

4. Communication devices and services I use to reach **Georgia Burdell** (check all that apply):

   - ☐ Telephone (Home Land-line)
   - ☐ Cell Phone
   - ☐ Fax
   - ☐ Email
   - ☐ Other

Figure 42: Demographic On-Line Survey Data, page 2

5. My social relationship with **Georgia Burdell** is:

- ○ Spouse or significant other
- ○ Parent
- ○ Sibling
- ○ Other family member
- ○ Friend
- ○ Neighbor
- ○ Other

6. I typically talk with **Georgia Burdell**, including face-to-face or by phone:

- ○ More than once most days
- ○ At least once most days
- ○ Several times each week
- ○ At least once a week
- ○ Not every week

7. I go to **Georgia Burdell's** home

- ○ At least once most days
- ○ Several times each week
- ○ At least once a week
- ○ Once a month or less
- ○ Never

8. The distance between my home and **Georgia Burdell's** home is ...

- ○ None, I live in the same house
- ○ Within a block of each other
- ○ Within the same neighborhood (less than 2 miles apart)
- ○ In the same geographic area, between 2 and 20 miles apart
- ○ More than 20 miles, but less than 100 miles apart
- ○ 100 miles or more apart

Proceed To Page 2 of 3, Your Info

Figure 43: Demographic On-Line Survey Data, page 2 continued

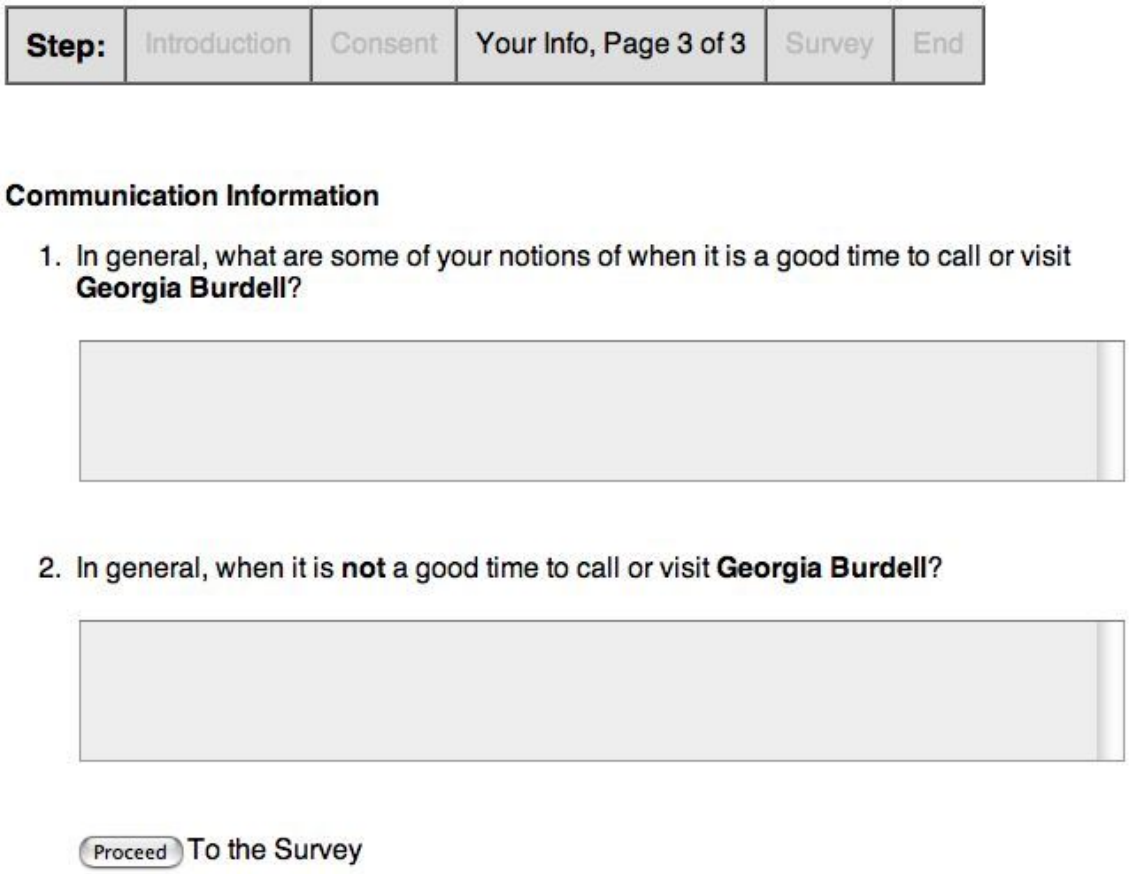

Figure 44: Demographic On-Line Survey Data, page 3

Step:	Introduction	Consent	Your Info	Survey Intro	End

How this survey works:

You will look at some information about **Georgia Burdell** and use it to predict his or her availability.

- First, you will be given only the **day of the week and time of day**, for example

Survey Situation #1	Home Information #1 Saturday, 5 p.m.
	

- On the next screen, you will be given **more detailed information, for that same day and time**, for example

Survey Situation #1b	Home Information #1b Saturday, 5 p.m
	**Mealtime Routine** Location ◦ He/She is in Kitchen Activities ◦ Preparing food

- Each situation will be identified by number and a unique picture. You will see #1 and then #1b, where both have the same day and time, and the same picture.

Figure 45: Introduction to On-Line Availability Survey

In each case you will be asked these **two questions**:

1. Would this be a good time to get **Georgia Burdell** to answer an important question for you that requires full attention for a minute or two?
   (Some examples of "Important questions" are: making plans and resolving scheduling conflicts, asking for help or advice, and providing timely reminders.)
   - No, they would not be available
   - No, they would prefer not to talk
   - Yes, they could be available for a minute or two
   - Yes, they could be available for several minutes or more

2. Would this be a good time to catch up on social news, activities, and events?
   - No, they would not be available
   - No, they would prefer not to talk
   - Yes, they could be available for a minute or two
   - Yes, they could be available for several minutes or more

Thank you for your participation in this study!

PROCEED START SURVEY

Figure 46: Introduction to On-Line Availability Survey, continued

Step:	Introduction	Consent	Your Info	Survey Situation 1 of 12	End

Survey Situation 1 of 12	Georgia Burdell Tuesday, 2:03 p. m.

ANSWER THE FOLLOWING QUESTIONS BASED ON Georgia Burdell's INFORMATION

1. Would this be a good time for her/him to answer an important question for you that requires full attention for a minute or two?
   (Some examples of 'Important questions' are: making plans and resolving scheduling conflicts, asking for help or advice, and timely reminders.)

   - ○ No, they would not be available
   - ○ No, they would prefer not to talk
   - ○ Yes, they could be available for a minute or two
   - ◉ Yes, they could be available for several minutes or more

2. Would this be a good time to catch up on social news, activities, and events?

   - ○ No, they would not be available
   - ○ No, they would prefer not to talk
   - ○ Yes, they could be available for a minute or two
   - ◉ Yes, they could be available for several minutes or more

Proceed **To Situation 1b of 12**

Figure 47: On-Line Survey Data, Day of Week and Time of Day only Condition

Step:	Introduction	Consent	Your Info	Survey Situation 1b of 12	End

Survey Situation 1b of 12

Georgia Burdell Home Information
Tuesday, 2:03 p. m.

Location
- Georgia in kitchen
- by herself

Georgia's Activities
- Eating meal/snack
- Laundry/Housecleaning
- Reading

ANSWER THE FOLLOWING QUESTIONS BASED ON Georgia Burdell's INFORMATION

1. Would this be a good time for her/him to answer an important question for you that requires full attention for a minute or two?
   (Some examples of 'Important questions' are: making plans and resolving scheduling conflicts, asking for help or advice, and timely reminders.)

   ○ No, they would not be available
   ○ No, they would prefer not to talk
   ○ Yes, they could be available for a minute or two
   ◉ Yes, they could be available for several minutes or more

2. Would this be a good time to catch up on social news, activities, and events?

   ○ No, they would not be available
   ○ No, they would prefer not to talk
   ○ Yes, they could be available for a minute or two
   ◉ Yes, they could be available for several minutes or more

Proceed **To Situation 2 of 12**

Figure 48: On-Line Survey Data, same day and time, added Activity and Location Information

Step:	Introduction	Consent	Your Info	Survey Situation 4b of 12	End

Survey Situation 4b of 12	Georgia Burdell Home Information Wednesday, 2:47 p. m.
	Schoolwork Time

ANSWER THE FOLLOWING QUESTIONS BASED ON Georgia Burdell's INFORMATION

1. Would this be a good time for her/him to answer an important question for you that requires full attention for a minute or two?
   (Some examples of 'Important questions' are: making plans and resolving scheduling conflicts, asking for help or advice, and timely reminders.)

   - ○ No, they would not be available
   - ○ No, they would prefer not to talk
   - ○ Yes, they could be available for a minute or two
   - ○ Yes, they could be available for several minutes or more

2. Would this be a good time to catch up on social news, activities, and events?

   - ○ No, they would not be available
   - ○ No, they would prefer not to talk
   - ○ Yes, they could be available for a minute or two
   - ○ Yes, they could be available for several minutes or more

Proceed **To Situation 5 of 12**

Figure 49: On-Line Survey Data, Add Routine information

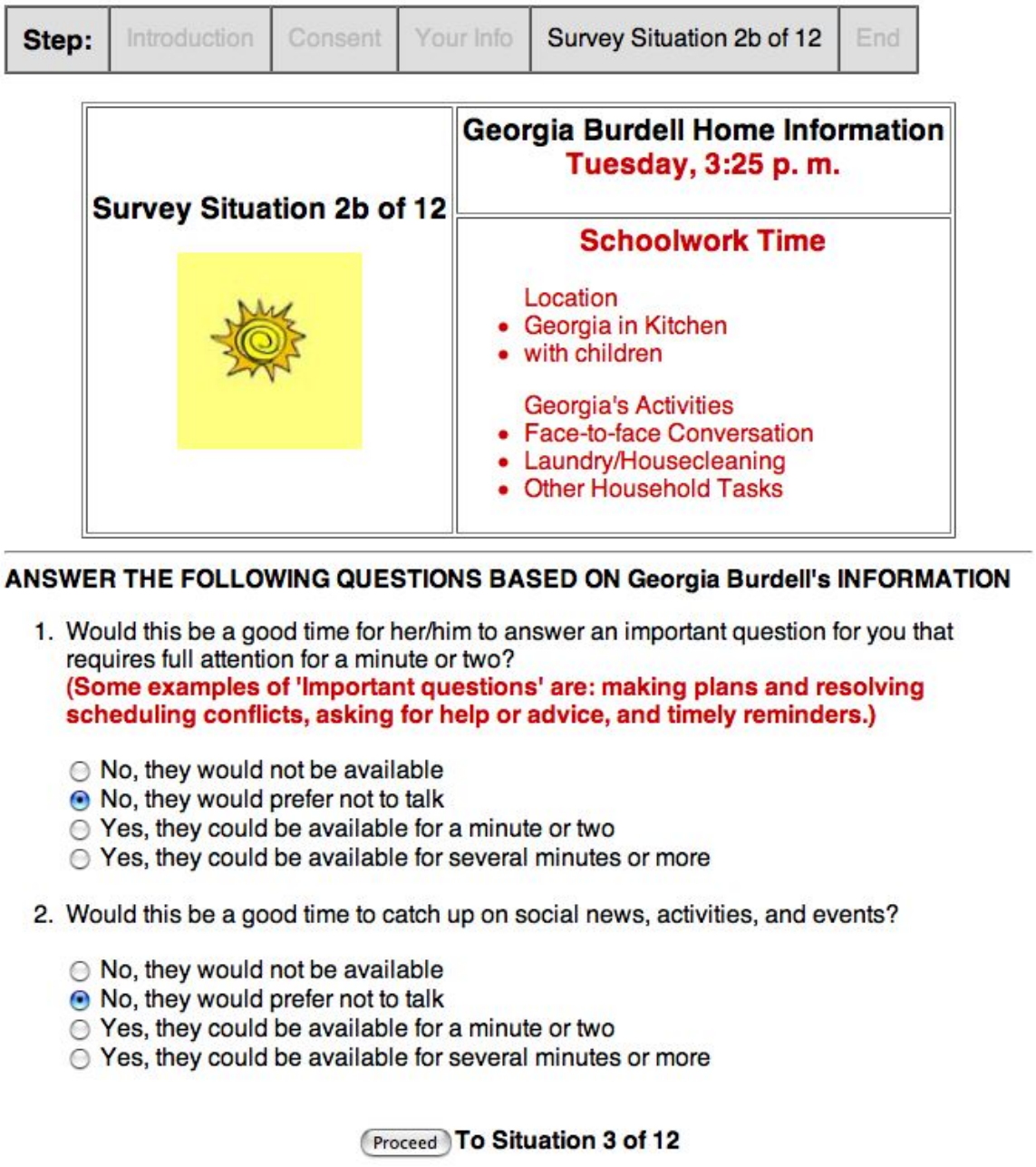

Figure 50: On-Line Survey Data, Sample Both Data Conditions, Routines plus Location, Activity, Presence

Step:	Introduction	Consent	Your Info	Survey Situation 12b of 12	End

Survey Situation 12b of 12

Georgia Burdell Home Information
Saturday, 9:25 p. m.

Leisure Routine

Location
- Georgia in Home Office
- by herself

GeorgiaGeorgia's Activities
- Email
- Game Playing

ANSWER THE FOLLOWING QUESTIONS BASED ON Georgia Burdell's INFORMATION

1. Would this be a good time for her/him to answer an important question for you that requires full attention for a minute or two?
   (Some examples of 'Important questions' are: making plans and resolving scheduling conflicts, asking for help or advice, and timely reminders.)

   ○ No, they would not be available
   ○ No, they would prefer not to talk
   ○ Yes, they could be available for a minute or two
   ○ Yes, they could be available for several minutes or more

2. Would this be a good time to catch up on social news, activities, and events?

   ○ No, they would not be available
   ○ No, they would prefer not to talk
   ○ Yes, they could be available for a minute or two
   ○ Yes, they could be available for several minutes or more

Figure 51: On-Line Survey Data, Sample Both Data Conditions, Routines plus Location, Activity, Presence

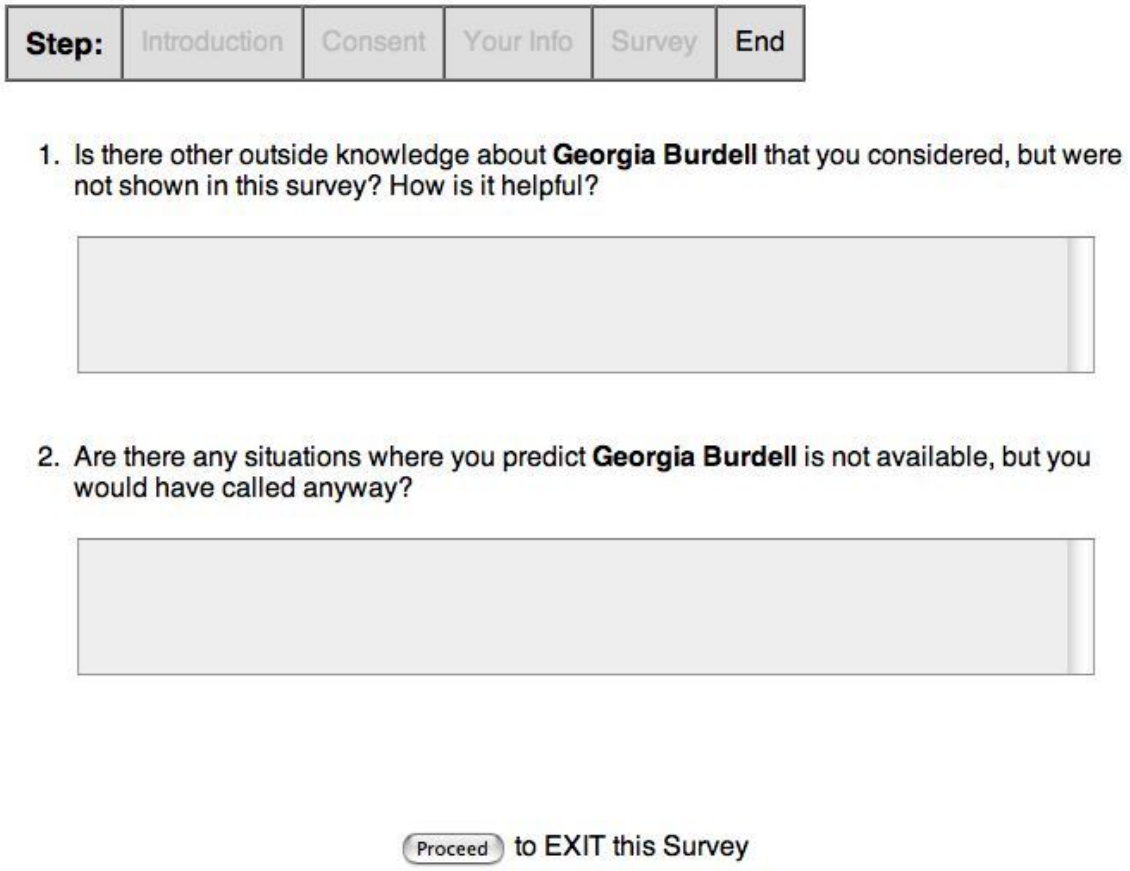

Figure 52: On-Line Survey Data, Ending Open-Ended Questions

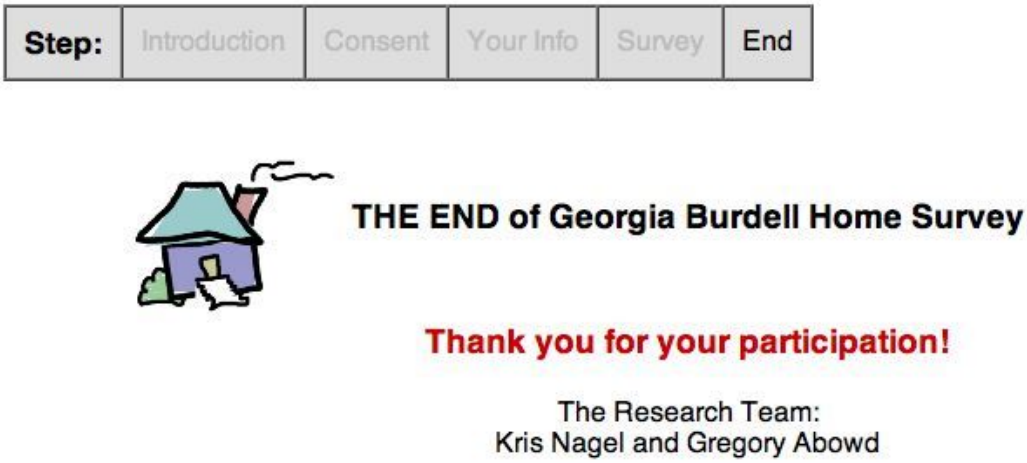

Figure 53: On-Line Survey Data, Final Page

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