

Challenges in Developing a Context-Aware Family Intercom

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INTRODUCTION

If there exists a next generation “killer application”, we argue, it is associated with human communication. Our communications are usually in support of ongoing relations with family and colleagues, not isolated interactions with unfamiliar persons. Interpersonal communication is characterized by both simultaneous interaction with another person and a mutual influence on the persons involved. This meaning-making, shared experience is an essential part of being human [1]. We are investigating how situational awareness can enhance human-to-human audio-only communication, within the trusted relationship of the family. As we explore innovative interactions with ubiquitous interpersonal communication technology, we find the human interface issues are just one aspect of the research. There are also challenges in developing the technological infrastructure and in accounting for social implications of the technology.

In this paper, we present the two context-aware domestic communication prototypes we have built. Using these as examples, we then present the inter-related challenges to developing context-aware domestic communication: developing innovative, lightweight, multi-modal interactions, building infrastructure upon the engineering technology, and managing social implications. Ending with some of the issues that impact progress in the development of useful and usable context-aware home communication technology.

DEVELOPING THE FAMILY INTERCOM

Our experience designing and developing family-oriented technology, is within the Georgia Tech Aware Home Research Initiative (AHRI) [6]. The Aware Home is just that, a two-story home built to standard residential construction specification, but with extensive network support and sensing installed as after-construction add-ons. This research facility supports the development of applications and technologies in a home environment that perceive and assist the occupants. One such application, the Family Intercom explores how awareness of location and activity can facilitate both intra- and inter-home communication. Information gathered from the environment provides context for either automatic or

human-mediation of communication at each end-point of the conversation:

- Where is the intended recipient located?
- What is the recipient doing, and is it OK to interrupt the recipient at this time?

We have developed two prototypes to explore how ubiquitous contextual awareness may enhance family communication.

Within Home Intercom

The initial context-aware intercom prototype has been installed in the Aware Home, where our model of interaction is hands-free by providing voice interaction. A conversation is initiated between two persons, with no knowledge of location. The conversation connection then follows participants as they move from room-to-room, with no explicit user action. We created a hands-free interface to the intercom using voice recognition of simple commands to initiate conversations from any spot in the home. In this prototype, each member of the household wears a wireless microphone that is connected to a dedicated PC running the IBM ViaVoice® software. The hardware includes a commercial positioning system to provide room-level location, an audio switch for simultaneous point-to-point communication, personal wireless microphones, and speakers mounted in each room. The positioning system was not dependably accurate to room level and the speech recognition was not reliable as the sole interaction mechanism. While the within home prototype demonstrates the ability to initiate conversation via speech commands and audio connections that follow household members movement, there are technical limitations to its use as more than a demonstration of concept.

Between Home Intercom

The second prototype supports between home communications through an augmented digital image in one home that provides context and communication mediation with another home. The Digital Family Portrait, that displays a qualitative perception of activity for the remote family member [5], was augmented to provide an interactive communication portal to the Aware Home. The portrait portal includes a flat touch screen enabling any

household member to initiate a two-way audio connection to the remote family member pictured and to view the communication status. The context available is asymmetric; only identity is available in one home, but richer activity information from the other. We use an internet voice connection and simulated availability status to mediate the initiation of conversation from home-to-home. This prototype couples the communication interaction to an artifact in the home, using the portrait to mediate conversation initiation. The sensing in the instrumented home does not yet provide the context required to mediate the communication requests. Simulation widgets were used to explicitly set the availability status of the recipient in the Aware Home. While the reactions to using the portrait to talk with a family member were favorable, several short-comings were also revealed during in a four-day exhibition demonstration. While the infrastructure is reliable, the lower quality audio as compared to the telephone is a problem. Also, the immediate connectivity of the conversation did not provide the initiator a cue to begin talking. This was seen in awkward inquiries, "Hi... Are you there"? The between-home intercom has shown the ease of use and acceptance for a new communication interface, but it has also revealed the complexity of the social expectations associated with remote communications.

Evolving Intercom Prototypes

Both intercom prototypes use the Context Toolkit [3] to abstract the actual sensor data and audio hardware services from the application. This allows other location sensing and audio services to be added or substituted, with no change to the communication application components. This flexibility enables the Family Intercom to change the engineering infrastructure with minimal change to the application itself. The use of simulated context widgets, enables us to use Wizard of Oz techniques to explore context-aware audio communication in the absence of sophisticated sensing. Our prototypes have provided a testbed for further exploration of context-gathering technology and its use to enhance socially appropriate conversations.

CHALLENGES TO UBIQUITOUS COMMUNICATION

One lesson is clear from our experience in building context-aware, ubiquitous communication services for the family. Creating such an application requires a robustly engineered technology infrastructure to enable exploration of a variety of human interaction modalities, all of which have social implications. We discuss issues in the setting for the technology, design strategies used, lightweight interaction interfaces, and social implications.

A House is not a Home

The Aware Home was built as a "living laboratory", to assist the development of technology and applications to support routine activities within the home. The intent is to

use at least one of the two floors of self-contained living quarters, as a residence for long-term study of how technology can serve the occupants. There are many challenges to overcome to have a "family unit" reside within the Aware Home. Besides the socio-political hurdles, there are the engineering and technical challenges. Research projects must be sufficiently robust and reliable to provide always available services. Much of the research depends upon studying the on-going dependence and interaction of the human and the technology. Currently, we have so many researchers working in the Aware Home, we use some of the technology in our informal work environment. Can we gain insights to family technology when the house is an informal work space? If there is an intersection in how these two groups use a given technology, how can we determine these commonalities?

Designing Ubiquitous Home Technology

We employ use methodologies enabling users to participate in the design of new home technologies, with our focus on learning enough to build an operational prototype for the home. The goal is to rapidly iterate the prototype, in response to authenticate user interactions and adaptations to the activities. This supposes the existence of tools to develop applications which can be modified and re-deployed swiftly. We have used abstractions provided by the Context Toolkit [3] to guide the developers and to separate the contextual data from the application using it. However, context-aware applications are still time consuming to create, debug, and modify. The application programmer has a steep learning curve to be able to quickly iterate the application. We are improving our toolkit and seeking alternative models to abstract more of the infrastructure details away.

Supporting Human Interaction

The Family Intercom is exploring a variety of lightweight interfaces, facilitating a human's ability to decide whether a proposed conversation should be initiated or not. Within the home environment we see the need for multiple interaction modalities, depending on the distractions and other activities at hand. One such interface, a hands-free mode, using voice commands, may be useful in domestic situations when hands are already busy, such as in cooking. One challenge is to determine how humans want to talk to their homes to request services, such as finding the availability of a family member for conversation. We also envision initiating an interaction with the house infrastructure through gesture. To explore the potential of speech commands or gesture, supposes an omnipresent speech and vision processing infrastructure, capable of capturing human motions and speech, analyzing in real-time, and providing feedback to the human through another modality. Thus, to innovate through multiple modes of interactions appropriate for the home, requires an extensive engineering and technology infrastructure.

Social Implications

The home has unique privacy expectations, which cannot be ignored when exploring new ways to facilitate communication within and between homes. Within the walls of our home Americans enjoy certain freedoms guaranteed by the Bill of Rights. Furthermore, homes are no longer one-room log cabins, but have walls and doors to provide individuals a sense of autonomy, even within the home. The Family Intercom provides for conversation through these walls, and may impinge upon an individual's privacy expectations. One challenge is to use context to enhance the conversation and still respect family and individual privacy notions [4]. There is no uniform notion of privacy, within a home or between the members of a household. How can the unique communication and relationship patterns of a family and its individual members influence the mediation behavior of the Family Intercom? We have studied recent legal case rulings on privacy issues to analyze the features defining privacy for the home. We use analogies with current communication technologies to determine when the intercom achieves the same goals as existing communication technology in public use and how is it an extension of each of these. This legal analogy is very closely related to the use of metaphors to influence interface design [2]. The user thinks in terms of familiar operations, and extends the same notions of privacy to these actions. Metaphors can manage the complexity of the interface, by using actions similar to those already known. Implicit in this use of analogy is the responsibility of the designer and implementer to clearly state the motivations and goals of the new technology, providing a basis for specific privacy expectations and how they are supported.

Another challenge to family privacy is inherent in the implicit gathering of context used to enable mutually satisfying conversation initiations. The sensor network to generate this level of detail will create a dossier of family life. How long must this data persist in order to meet the goals of the Family Intercom? Can the family reasonably expect to have complete control over who accesses this information, including government agencies? In court cases, such information may be considered to be a diary or a filing cabinet of information, depending on the data collected and its designated use. The challenge is to determine appropriate privacy settings and when to apply them.

ISSUES FOR UBIQUITOUS COMMUNICATION

Development of the Family Intercom, reveals that family communication is dependent upon individual and group held notions of privacy, the appropriate interaction modality for the setting, and the technological infrastructure to support the audio connection and human interactions. Our desire is to develop and evaluate human interfaces for

domestic audio communication, leveraging off implicitly gathered situation information. Our challenge is to anticipate what the technology will enable, and create interfaces that will take advantage of these advances in socially acceptable ways. But, the evaluation of human use of cutting edge technology is challenging. How can we evaluate an interface to this technology in authentic domestic use, when the technology may not yet be reliable and robust? How do we determine if the interface and interaction is appropriate for the setting, when situations are not routine and vary across groups and individuals within the family? How do we design for mobility within the infrastructure, delivering timely context on small, mobile devices? What sequence of development and evaluation will best inform the iterative design and prototyping of family communication? In family communication, we need to predict what interactions the next technology advances will enable, design for this anticipated infrastructure, and anticipate the likely effects upon social expectations.

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