

# How Do Users Think about Ubiquitous Computing?

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## ABSTRACT

As ubiquitous computing technology migrates into the home environment, there has been a concurrent effort to allow users to build and customize such technologies to suit their own specific needs. Many tools have been built to enable users with little or no programming knowledge to build such applications. Despite the de-emphasis on programming, however, these tools are often device-centric, rather than user-centric. In this paper, we investigate how people describe and conceptualize ubiquitous computing applications and technology. We examine how people naturally express ideas for novel applications to build conceptual models upon which to base future interfaces for creating ubiquitous computing applications.

## Author Keywords

Ubiquitous computing, automated capture and access applications, design models, end-user programming

## ACM Classification Keywords

H5.2. User Interfaces: Prototyping, User-centered design.

## INTRODUCTION

Ubiquitous computing (ubiquitous computing) research has traditionally centered on designing and providing users with technology that integrates seamlessly with their lives. Much recent work, however, has focused on empowering users by providing them means with which they can create their own ubiquitous computing applications to address their own unique needs, especially in the domain of technology-enriched home environments. Recent projects have explored interfaces that allow end users with little or no programming experience to customize the behavior of devices in “smart” homes by using simple languages [1, 2] or metaphor-based graphical interfaces [3,4]. Despite having greatly simplified the process of creating ubiquitous computing applications by offering alternatives to extensive programming, these interfaces still focus more on technology than user needs because they are *device-centric*, rather than user-centric or task-centric. While they do not require much explicit programming knowledge, they require that users conceptualize applications the way that a developer would—as a confederation of devices and their interactions with each other rather than the goal the user is trying to accomplish.

For example, work by Humble *et al.* [3] uses a “jigsaw puzzle” GUI metaphor in which individual devices and sensors are represented by puzzle piece-shaped icons that the user “snaps” together to build an application. While the metaphor is comprehensible and the interactions are simple, the interface still treats the application creation as the configuration of devices. In order to provide interfaces that are genuinely easy-to-use and that allow end users to build ubiquitous computing applications that truly suit their needs, we believe it is important to design to fit users’ natural conceptualizations of ubiquitous computing technologies.

In this paper, we present a study that examines how users express their ideas about ubiquitous computing applications, specifically for the purposes of capturing events and information in the home for future access. Our study results include a breadth of ideas for ubiquitous capture and access applications suggested by potential users of ubiquitous computing application design interfaces. Based on the content and expressions of these ideas, we derive a set of conceptual models to inform the future design of interfaces that enable end-user ubiquitous computing application design and creation.

## STUDY DESIGN

We conducted a study in which we introduced participants to the notion of capture and access and the presented them with scenarios presented as comics illustrating uses of this technology. The survey asked participants to explain the applications in the scenarios in their own words and design a capture and access service of their own.

The goal of this study was to understand how users naturally conceptualize ubiquitous capture and access applications. This required that we be careful to avoid biasing participants’ perceptions of how such applications function when introducing the concepts behind capture and access. It was also necessary to recruit a diverse population of participants to address a broad spectrum of needs and skills. To obtain data from a large, diverse subject group, we used a Web-based survey, propagated through email.

## Advertising the Web Survey & Recruiting Participants

We aimed to gather at least forty responses to ensure a breadth of viewpoints. Because participation was voluntary and we could not assume that all recipients would complete it, we needed a method of disseminating the survey to a population larger than our target number of responses.

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We created an email that included instructions requesting that the readers take the Web survey and then forward the email to ten acquaintances. To prevent over-propagation, the email contained a value that indicated the number of times it had been forwarded. Readers were asked to increment this number before forwarding the email. Recipients who received an email that had been propagated five times were asked not to forward it any further. Two of the researchers initiated the circulation of this email by sending it to friends and family; the email propagation helped to ensure a diverse subject population outside of the researchers' circles of acquaintance.

### Presenting Concepts and Scenarios through Comics

After reading a brief and simple introduction to ubiquitous capture and access environments, users were shown a pair of "comic strip scenarios"—situations presented in the graphical style of comics (Figure 1). These scenarios depicted a family of three—father Jim, mother Jane, and son Billy—using and creating capture and access applications in a technology-enriched home environment.

We opted to present the sample scenarios through pictures and dialogue between characters rather than as text narratives or description in order to avoid biasing how participants described the applications in text later. The scenarios depict the applications in action pictorially to avoid using specific language that would bias the participants' conceptualizations and descriptions of how the applications function.

The following two scenarios are paraphrasings of the comic strip scenarios given to the participants. We present text versions rather than comics here for the purposes of space; the text versions did not appear in the Web survey.

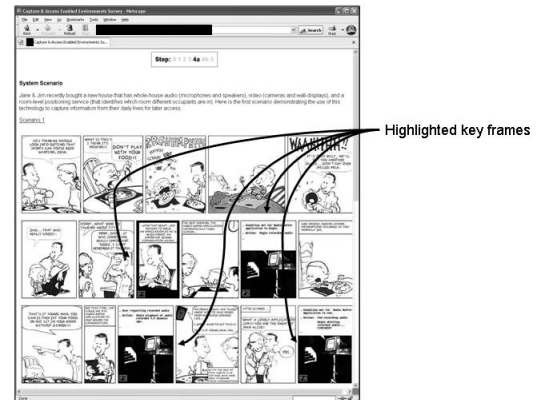
#### Scenario 1: Buffering Dinner Time Conversations

*Jim and Jane often have much to talk about during dinner. Too often, however, little Billy interrupts their conversation with a dinner disaster causing them to forget what they were talking about. To address this problem, Jim creates an application that records conversation and allows the family to review it on demand. The next night it comes into action during dinner when again Billy interrupts their conversation. This time, Jim is able to play back the audio from right before the interruption occurred, allowing Jane and Jim to resume the conversation. The application deletes all recorded audio when dinner is over.*

#### Scenario 2: Capturing Precious Spontaneous Moments

*Jim and Jane often struggle just to take a nice picture of their mischievous Billy. One night, Jane brings Billy to kiss Jim goodnight. It is moments like these that are the hardest to anticipate and photograph. That night, Jim decides to take advantage of the existing cameras in the house and create an application to capture such moments. Very late one night, Billy awakens everyone by getting out of bed and dancing to loud music. After putting him back into bed, Jim tells Jane what transpired. Eager to see for herself, Jane uses the application to review captured photos of Billy*

*dancing. From this collection, Jane saves a few particularly adorable shots. The application automatically deletes the other photos after 15 minutes.*



**Figure 1.** A comic strip scenario presented in the survey, with highlighted key frames.

For each comic strip scenario in the survey, we highlighted four key frames in each comic strip and ask participants to describe what is happening in those frames in their own words to assess their understanding of the situation. The scenes in which characters create applications are intentionally ambiguous, with no detail as to how the character actually specifies the application. We then ask our participants to describe what they believe the character did to create the application to understand their intuitive notions of how the system should work.

### Extracting Novel Application Ideas

After presenting the two scenarios, the survey asked participants to describe in their own words a capture and access application that they would like for their home. We asked subjects to provide as much detail as possible to help us understand what the applications would do and how they would work. Participants were given an empty text box in which to describe their application. We chose this flexible format to allow them to express ideas naturally and to avoid imposing any structure that might bias their responses.

### THE STUDY RESULTS

We collected survey data over the course of a three-week period from a total of 45 participants who completed the survey in its entirety. Our study drew responses from diverse participants with a wide variety of professions including attorneys, librarians, bankers, managers, entrepreneurs, homemakers, graphic designers, educators, anthropologists, students, engineers, and analysts. While over ninety-five percent of the subjects use computers daily, only one third actually had hobby or professional programming experience.

Sixty percent of the respondents were female and forty percent were male. Participants ranged from 22 to 64 years of age. We found that the age, marital status, and living situations of the participants influenced their responses

regarding the technology. In general, married respondents had family focused responses while single people living alone had individual task-oriented applications, such as a “ubiquitous note-taker”. Younger adults who are primary care providers often wanted applications for monitoring their children while middle-aged adults desired the ability to check on the well-being of their elderly parents remotely.

### What People Want the Technology to Do

Although seven subjects expressed no use or general desire for the ability to define custom capture services, the majority of the participants described potential applications for capture and access; some even offered multiple different applications. There was significant overlap among the applications suggested, with multiple participants offering variants of the same general idea. Overall we obtained more than a dozen general application ideas that we grouped into three categories of applications to:

- provide peace of mind,
- collect records of everyday tasks or objects, or
- preserve sentimental memories from experiences.

#### Providing Peace of Mind

The first category consists of applications intended to *provide peace of mind* for the user. These applications help users feel secure by allowing them to monitor their home or children. The most popular application idea provided by participants in our study was a home security system that automatically begins recording when the user leaves the home and allows her to easily review the captured content remotely or when she returns home. Some application ideas suggest monitoring people instead of spaces. For example, many parents of very young children or expectant parents described an application that would allow them to monitor the actions of a hired caretaker. One participant expressed this idea as follows:

*Since I am pregnant, the idea of being able to record a nanny or sitter as to the care my child will be receiving is nice. I would want the house to watch my child and record any and all activity. Then allow my husband and me to review the treatment of our child... help us ensure that we are taking the best possible care of our child.*

A related idea was to allow adults to check on the well-being of their elderly parents remotely.

#### Collecting Records of Everyday Tasks or Objects

The ideas in the second category consisted of applications to help the user collect and keep records of everyday tasks or objects. In these applications, the desired information is not captured for sentimental value or any overarching peace of mind. Instead they provide a record of activity *for convenience*. Participants suggested the use of capture in the home to allow users to help the keep track of objects (such as car keys) and track when and where they were moved. Many people also suggested a simple on-demand audio recording application to allow them to easily record quick notes as needed, possibly for keeping track of to-do items or creative ideas:

*I come up with the best ideas when I'm in the strangest places and at the strangest times (bed, bathtub, etc). A ubiquitous memo pad would be really cool. This tracking of information could extend to a to-do list. Then I could vocalize the to-do list and it would be stored electronically for easy retrieval. The power would be the consolidation of all this important information. Right now I have post-its and papers everywhere. Yuk.*

#### Preserving Memories of Experiences

Many participants suggested applications in which the house captures memories of people during special events, similar to that presented in the scenario. Variations among the applications mainly involved the length of time the captured information should persist. The application would help users record moments they might miss while otherwise engaged during the event. Participants emphasized the importance of being able to partake in and enjoy events in their homes, rather than having to worry about manually capturing them. One user shared with us this possible use of the technology for preserving memories:

*We have an annual pumpkin carving party with about 30 to 50 people at our house every October. It is very difficult to get pictures of everybody at the event, and because we host the event, we don't always know everything that 'happened'. I like the feature of getting pictures of special moments when there is no [handheld] camera around.*

Participants expressed a broad range of other application ideas for preserving memories as well, including video to capture baby's first steps or recording fun conversations to share with others later.

### HOW PEOPLE THINK ABOUT APPLICATIONS

Based on our participants' descriptions of their desired applications and the applications depicted in the comic strip scenarios, we believe that most people tend to conceptualize ubicomp in terms of human needs, situations, and tasks rather than devices and interactions between devices. We next extracted models of their conceptualizations based on their application descriptions.

#### Essential Features in the User's Model

In analyzing the data from our survey, we found several interesting patterns that influenced our formalization of the three conceptual models. We observed two phenomena in particular that influence our understanding of how people comfortably describe capture applications.

The first striking pattern we noticed was the general lack of reference to devices of any kind. Participants rarely mentioned cameras, microphones, digital displays, sensors, or any other type of device in their responses. Though technologists often think first of the devices involved in an application, devices are not at the forefront of users' minds. The following description illustrates how respondents tended to downplay the devices involved in capture:

*I am not very experienced in cooking, so I would want to record friends or relatives cooking [in my kitchen]. I would not have to take notes and I would be able to see and hear, step by step, how to make a particular dish. I would want the house to start recording when I told it to, and to stop when I told it to. Then I could review it and literally SEE [what to do while cooking].*

Our findings suggest that a more natural way for users to describe a service is to not focus on the devices but rather on the function. People are comfortable describing situations when these services are of interest in terms of time, people, locations, and the activity being performed.

Another pattern we noticed was that most participants described the sensed situation in such a way that the data types for capture are *implied*. Participants were more likely to use statements like, “record a dinner conversation” than to specify the capture of “audio.” Words like “record,” “remember,” or “hear” are synonymous with “capture” but are more natural for users. The remainder of an application description (e.g. “dinner conversation,” “party,” “reunion”) often implies what type of data should be captured—audio, video or both—without specifying it explicitly.

#### Deriving Conceptual Models

We observed that in general, users’ application descriptions follow three patterns or models. A commonality between all three models is the importance of the “sensed situation” as the object of capture; a sensed situation is a situation that the participant defines using one or more of the “W dimensions” for capture and access applications (who, what, where, when) [5]. In all of the models, participants specified a sensed situation (e.g. “the nanny,” “dinner conversation” or “after 7PM”) for capture.

##### Model 1: System as Effector

People who perceive the technology as an *effector* view it as a system that carries out the commands of the user. Taking the first survey scenario as an example, people who subscribe to this model perceive Jim as a user who tells his house to carry out the task of recording the dinner conversation. After being thus programmed, the system acts independently to record dinner conversations as they occur. The respondents who perceived the scenario in this way described application behavior in *command-style*:

“Record all dinner conversations”

In this model, the user commands the system to carry out a task. The task then belongs to the system; the system is the operator whose job is to act upon a sensed situation.

##### Model 2: System as Assistant

Another perception of the scenarios indicated that some people regard the technology as an assistant that helps the user with a task. In the case of the first survey, people who perceive the system as an agent view the house as an assistant. The user Jim has a task or responsibility and

instructs the system to support him in that responsibility. Users who subscribe to the model of the system as agent phrased the use of the system as requests for help:

“Never let him forget another dinner conversation”

“Help him to remember what they talked about”

In this model, the task belongs to the user and the system is called upon to provide functionality to help the user in that task. The user is acting upon the situation and the system is supplementing the user’s actions.

##### Model 3: System as Effector-Assistant Hybrid

The third model we derived is a hybrid of the first two. In this model, the role of the system is perceived as shifting between effector and assistant, acting independently on user instruction but doing so for the purpose of assisting with the user’s task. This model is the least common in our data. Participants who subscribed to this model generally framed their responses in terms of a user’s task, but qualified them with system-centric instructions:

“Help me to remember dinner conversations by recording audio when there are people in the room.”

Although the users specify a sensed situation, they also express a human-centered task or responsibility.

#### CONCLUSIONS AND FUTURE WORK

Current systems that allow end-users to create ubicomp applications generally embody a technology-centered perspective. We believe the findings of our study may help to bridge the needs-technology gap in such systems. Interfaces to support end-user development may therefore be easier to use and understand if they better support how users naturally choose to express their application ideas. In the future, we aim to design an interface that will flexibly support the breadth and categories of applications that users desire for their own homes while using input languages or interactions that are based upon models of expression derived from users’ own conceptualizations.

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