Chapter 11

Challenges for End-User Development in Intelligent Environments

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Abstract. Intelligent environments will be able to observe and sense the events that are happening around them. For these environments to become intelligent, however, they need to learn what appropriate and sensible behavior is in a given situation. The main challenge of ambient intelligent environments is not to *physically* integrate technology in the environment, but to *socially* integrate the system behavior into the fabric of everyday life. This means that an intelligent environment needs to be taught by its users how it should conduct and what position it should take. This paper will discuss two examples of end-user development in intelligent environments as a way to indicate the research challenges in this area.

Key words. (end-user development), ambient intelligence, home experience, content awareness.

1. Introduction

Many of today's devices already know what time and day it is, and what their location is. Besides this, in the near future, devices will be able to sense the things that are happening around them. This means that besides the *when* and the *where*, they will also figure out *who*'s around, and *what* they are doing. And when these devices become networked, they may be able to enrich this awareness of the user's context by gathering contextual cues and information from their neighboring peers. Being able to observe and sense is not enough for becoming an intelligent environment. The key question is *how* to behave in any particular situation. A system does not have a clue about the personality and the cultural background of an end-user. That means that in many cases it may only guess on what the appropriate system behavior would be in a given situation. It means that somehow, users need to teach the environment how to conduct and what position it should take.

Many researchers and futurologists envision a future of ambient intelligence, which refers to electronic environments that are sensitive and responsive to the presence of people (Aarts and Marzano, 2003; Dertouzos, 1999; Weiser, 1991). The idea is that the user is surrounded by a multitude of interconnected, embedded systems, which are integrated in the everyday environment and that can behave intelligently in order to improve the user's quality of life. However, the challenge is not only to physically integrate these systems in the environment, but also to integrate these intelligent systems into the social fabric of everyday life. This implies that having an understanding of everyday life, and of people's routines and rituals is of crucial importance in the creation

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of ambient intelligent systems. Since most of our work is targeted at the home domain, in earlier work, we have conducted extensive user studies to understand what "everyday life at home" actually means to people, and to find out how people would like to live in their "dream home." (Eggen et al., 2003). In this study, we explored people's home experiences and possible application and interaction concepts that can enhance this experience. This was done using a variety of techniques such as telling, drawing, writing, taking pictures, interviewing, and free association (Gaver et al., 1999). These techniques were employed to stimulate the families to express their personal home experience. An important conclusion from this study is that people, when they talk about home, they do not talk about appliances, devices, or home networks. People talk about home in terms of social activities and family rituals, such as having dinner together, bedtime storytelling or a birthday party.

In this study, people were also asked to think of their "dream home." They were asked to imagine that everything would be possible and that they should tell us what they would like. In general people would like the future home to take the role of an assistant. In many occasions it could give advise, create the right conditions, and support the family in their activities and with the things that have to be done. They described a home that would optimally facilitate them in their everyday routines and that could enhance the experience of their rituals.

When talking about their everyday life, people often refer to various recurring patterns of activities. In this respect, they clearly distinguish between routines and rituals. A ritual is something that people value, something that delivers a valuable experience, for instance, preparing a romantic dinner, having an extensive breakfast or smoking a delicate cigar. A routine, on the other hand, is related to certain tasks that people have to do. For instance, before going to bed one needs to lock the door, switch off the lights etc. Although it may be important that those things get done, people do not attach much value to the course of a routine. In summary, the experience of a ritual should be maintained or even enhanced, whereas the user experience of a routine may be minimized or even eliminated. It should be noted that the classification of activities into routines and rituals it a very subjective matter. Activities, like cooking or having dinner, can for some people have the meaning of cherished rituals, whereas others would consider them as necessary routines.

Through embedding some form of system intelligence into the environment, the user can be relieved from performing routine tasks. Moreover, the fact that a system is capable of taking over the routine tasks of the user brings the experience of freedom. Like with any form of automation it is very important that users are in control, that they have the option to define or modify a system's behavior. Beyond simple parameter specification we have investigated how end-user development can empower users to define or modify the behavior on an intelligent system or environment.

2. The Wake-Up Experience

In the user studies on the home experience, as referred to before, many people indicated that in their future home they expect to wake up in a more gentle way than they do

nowadays. There is a broad area of sleep research that covers topics such as the different phases of sleep, sleep deprivation, dreaming, and the physiological effects of sleep (Chase and Weitzman, 1983; Ellman and Antrobus 1991; Thorpy and Yager, 1991). A great deal of work has been done in this area, with a special focus on sleeping and going to sleep. However, hardly any research has focused on the process of waking up and the subjective experience of awakening. Wensveen et al. (2000) have been exploring new ways to interact with an alarm clock. Their main research question was how a user can communicate his or her emotions to a product, and the alarm clock was used as an example product in this study.

We learnt from the family studies that people want the wake-up experience to be pleasant, in contrast to the current annoyance caused by a "beeping" alarm clock. This made us decide to focus part of our research on enhancing the wake-up experience. The main question is in what type of ambiences people would like to be awakened, and what an easy way is for people to "specify" such desired ambiences?

2.1. ANALYSIS

With an online questionnaire, additional data on user needs and requirements was gathered from 120 subjects spread all over the world. Target subjects were selected by the age, gender, and location in order to obtain a balanced group of different categories using a messenger program ICQ (www.icq.com). This program has a search engine, that provides the possibility to select a certain group of people by specified criteria.

Besides questions about the current wake-up process, people were also asked to describe their ideal "wake-up experience." 5776 requests were sent to ICQ users in 25 countries. 120 users replied with a filled-in questionnaire.

The results of the survey confirmed that most people are dissatisfied with their current wake-up experience. When asked to specify what their ideal wake-up experience should be like, respondents describe experiences that greatly differ from person to person. For instance, some people want to be awakened with the smell of coffee and the sound of singing birds in a forest. Others would prefer a piece of music or sunlight. In general, most people desire a soft and peaceful wake-up experience in the morning hours. Some people construct complete scenarios of how different pleasant stimuli should be generated gradually to wake them up in an ideal way. The following quote gives an example of such a scenario:

> The gradual and eventually rich strong aroma of coffee you get in cafes and the sound of birds chirping ever so slightly and gradually increasing in level. The lights will be very dark initially but the ceiling will illuminate to eventually produce a soft but bright light. The room temperature would regulate in concert with the temperature within the covers of the bed so that there is little temperature variance when first placing that foot on the floor . . .

We formulated a set of requirements for a wake-up system based on this user input. For instance, it should be able to generate several stimuli simultaneously. It should also be easy to create a personal wake-up experience and to alter it every day. People should

be able to set the intensity of the stimuli so that it would allow them to wake up in their own rhythm. Those specific requirements were used, in addition to the general design principles that were derived from the domain exploration, as basic input for the concept development phase.

2.2. DEVELOPMENT

The major question was how we could come up with an interaction concept that enables users to "specify" their desired wake-up experience in an easy way. It is generally known that people are not very good at programming. Many people have great difficulties in programming a videocassette recorder. This means that this "programming task" should be kept simple. It should ideally be a pleasant task, and it should stimulate people's creativity.

A workshop was held to generate many different concepts for creating one's desired wake-up experience. After weighing the concepts against criteria (such as feasibility, novelty, usability, and fun), one concept was selected to be developed further.

The selected concept is based on the analogy of making a painting. The idea is to use a pen-based pressure-sensitive display to let users "paint" their desired wake-up experience. This display could be positioned on the bedside table where it could act as any normal alarm clock, just showing the time. However, when the pen approaches the display, the clock changes into a painting canvas. Here, users can select a certain time interval, for instance from 7.00 to 7.30 a.m., for which they can start painting their desired wake-up experience. A timeline for the interval is shown at the bottom of the canvas. People can choose a color from a palette of predefined wake-up stimuli, such as sounds of nature, lighting, coffee, or music. The position of a stroke determines the time of "activation" of the stimulus, whereas the thickness of a stroke, controlled by the pressure on the pen, represents the intensity of the stimulus. At the moment of "painting" there is an immediate feedback on the type and intensity of the stimulus that is set (except for the coffee maker, for practical reasons). For instance, while making a green stroke, sounds from nature are played with the volume adjusted to the current stroke thickness.

In the morning at the adjusted time interval the system generates the created "wake-up experience" by controlling the devices in the networked environment (such as lighting, coffeemaker, music, and fan). Figure 11.1 shows an example of a "painted wake-up experience" starting at 6 a.m. lasting until 9 a.m. In this example the system would start to raise the room temperature (red), then activate soft lights (yellow) and soft sounds of nature (green). These stimuli will gradually increase in intensity. The coffee maker will be switched on after some time (brown) and somewhat later music will be played for a few minutes (blue).

3. Evaluation

The wake-up experience prototype was assessed by a small number of experts on its estimated level of user acceptance. Special attention was paid to usefulness, effort/benefit rate, and usability criteria. In general, the experts could understand and

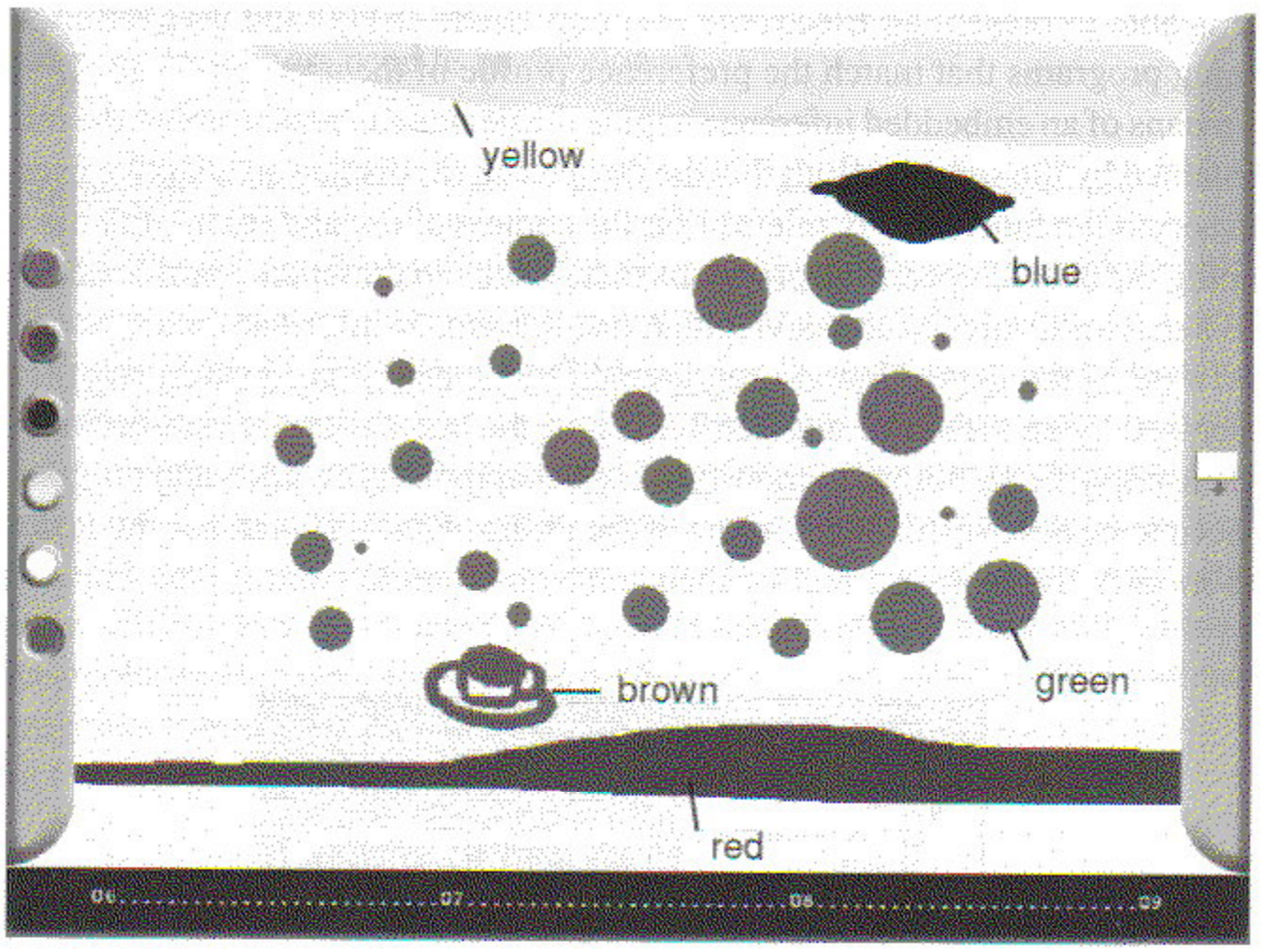


Figure 11.1. The wake-up experience prototype.

operate the system with little effort. A number of valuable suggestions were also made with respect to design improvements, extensions to the system (functions, and appliances), and alternative uses of the system. The most important suggestions for improvement of the design had to do with the icons, which were not clear enough, and with the timeline which should have a more detailed scale. Furthermore, it was stated that the pen should have a bigger contact area, and that there should be different pens in order to be able to make thin and thick strokes. The experts also suggested a number of extensions. For instance, it should be easily possible to "pre-experience" the programmed wake-up experience. Furthermore, it was suggested that the concept could be broadened for creating experiences for other parts of the day, for instance to create a party atmosphere, or a go-to-sleep experience.

4. A Context-Aware Remote Control

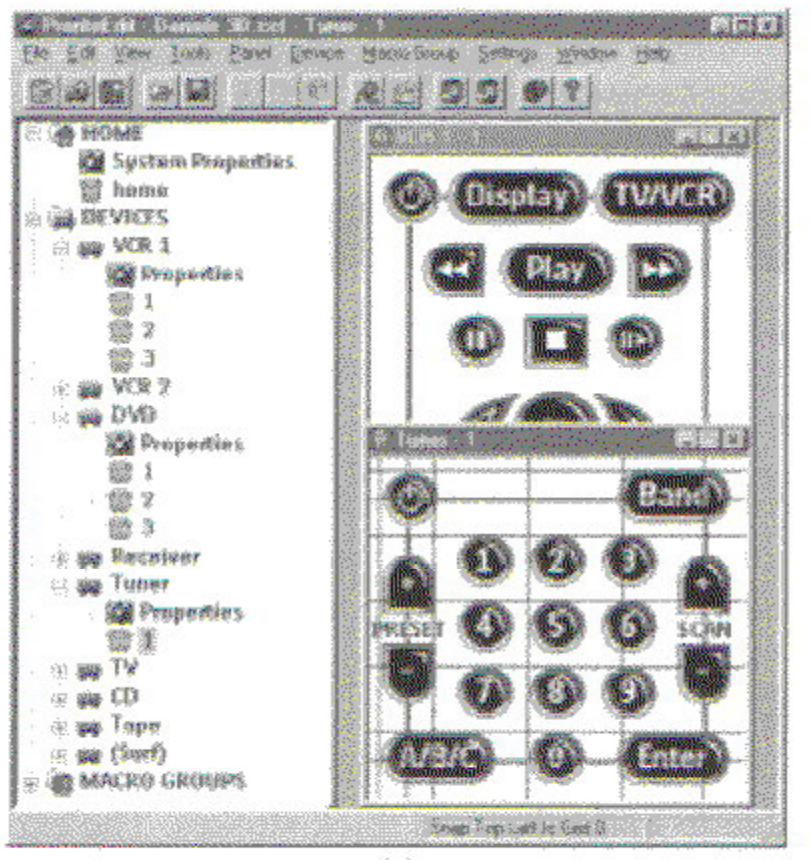
As discussed in the introduction, one important property of intelligent systems is their ability to be aware of the context in which they are being used. By adding some sensor and reasoning technology, a device can be made adaptive and exhibit adequate behavior for a given context.

As an example of a context-aware device, a universal remote control (based on the Philips PRONTO) with the ability to control different devices (such as TV, DVD, Audio set, etc.) is augmented with several context sensors. In addition to device control, the

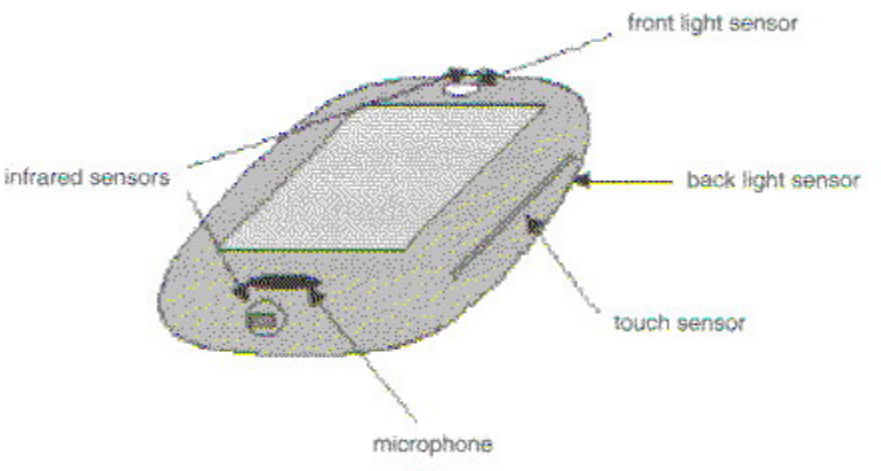
device is able to present an Electronic Program Guide (EPG) and give reminders for upcoming programs that match the preference profile of the user.

By means of an embedded inference engine the device can reason about the information obtained by the sensors. With this the device can (a) display an adaptive user interface to access the functionality relevant for the context of use and (b) modify the way of reminding the user of upcoming programs that match the preference profile of this user.

The behavioral rules of the device that use the sensor information are not fixed in the software of the device but are represented by means of production rules that can be processed by an inference engine running on the context-aware remote control. To provide users with the ability to modify these behavioral rules, adequate programming tools need to be developed. Today, users of the Philips PRONTO can use the ProntoEdit tool to modify the look-and-feel of their universal remote control (see Figure 11.2).



(a)



(b)

Figure 11.2. (a) The end-user tool for programming the look-and-feel of the Philips PRONTO. (b) The concept of a context-aware remote controlimplemented on the PRONTO.

To enable end users to modify the behavioral rules of context-aware devices, different programming metaphors need to be developed.

5. Conclusion

Technology trends can lead to future usage scenarios of consumer electronics that require users to interact more with system functionality than actually consuming Audio/Video content. The vision of Ambient Intelligence provides a framework in which embedded technology has to adapt to the needs of these users by being personalized, context-aware, adaptive, and anticipatory to the needs of users. However, by adding intelligence to interactive systems, we emphasize the importance of end-user development given the need for end-users to be in control. Two applications of Consumer Electronics that require end-user development are presented. These applications emphasize the need for suitable models of end-user development in the area of consumer electronics.

The following challenges for end-user programming can be formulated:

5.1. KEEP IT SIMPLE

Each small increase in complexity significantly reduces the number of potential users of the programming function. A solution should be found that allows users to adapt the system to their wishes in a straightforward way.

5.2. PROPER FEEDBACK

It is important that the user knows what he has programmed so far. The user should be able to easily "run" what is programmed on any moment in time. It would be even better if there were immediate feedback on what is currently being programmed.

5.3. MAKE IT FUN

The user programming method should invite the user to tailor his system or environment to his specific needs and wishes. The user should not have the feeling of being drowned in complexity. He should rather feel like a creative composer whose attention can be entirely focused on the desired composition itself rather than on the process.

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