Metamorphosis of the Home: Proactive Information Technology as a Design Challenge

ABSTRACT

The majority of microprocessors in the home are not found in PCs but in objects like toasters and toys. The number of microprocessors and sensors will continue to increase radically. The question is how to design this revolution in a way that people can accept and enjoy it.

The notion of "proactive computing" is discussed as an extension of "ubiquitous computing." We have approached this design problem by conducting scenario-based home interviews including priming materials. These priming materials included a minidesign of lamp that was suggestive of proactive technology features and questions.

Our study suggests that design plays an important role in whether and how proactive technology is accepted. However, our study also suggests that design may make functions imperceptible, a consideration which should be taken seriously while creating the designs. However, some people accept proactive technology for doing the dirty work but that reactions were more cautious if the technology could interfere with people's normal social behavior.

.

Kristo Kuusela
School of Design, UIAH
author@affiliation.com

Ilpo Koskinen
Frans Mäyrä
School of Design, UIAH
University of Tampere, Hypermedia Laboratory
secondauthor@affiliation.com
thirdauthor@affiliation.com

(Leave all author information Blank if Blind Review)

INTRODUCTION: UBIQUITOUS AND PROACTIVE COMPUTING

This paper explores the challenge of designing proactive information technology. Specifically, it explores whether and how proactive information technology in the home should be communicated in the design, and how the users' understanding of technology related to how they accept design.

Over the last 30 years, information technology has increasingly spread into our everyday environment. Personal computers have become icons of modern information technology, but they contain only a small portion of our processors. Most processors exist in other technological equipment: toys, mobile devices, alarm clocks, thermostats, ovens, and toasters. This is what Mark Weiser [1] observed over a decade ago, coining the term "ubiquitous computing" to name that phenomenon. Since then, ubiquitous computing has become an increasingly important area for design, extending from such "obvious" cases as DVDs and digital TV to more traditional things like furniture, and to spaces and environments [2, 3]. Edwards and Grinter have identified several problems that explain the slow diffusion of ubiquitous technology [4]. These are the "accidental" character of technology's entry to homes, its reliability, and lack of systems administrator (no central planning); interoperability (for example, how to connect new and old technologies); designing for domestic use and the social implications of aware home technologies; inference (inferring intentions is difficult for humans, and exceedingly difficult for computers) [5].

Partly overlapping with this idea is the more recent notion of "proactive computing," first introduced by David Tennenhouse [6]. He observed that as the number of IT devices in human environment increases, people are not able to control all of them anymore – attention is the most scarce resource in designing interactive products. Humans have to get out of the loop: increasingly, devices are designed to take action on their own, and perhaps work as a network. Information technology takes initiative on its own, reacting in real time: the environment is infested with technology that takes actions and adapts to the users' whims and wishes. All these processors can be connected to a server, but may also function autonomously or as a network.

The main difference between ubiquitous and proactive computing is that the former originally captured the idea that information technology has spread into the environment, while the latter captures a more challenging idea: information technology senses our actions and/or environment and reacts to them without conscious action from the user's part. If we accept this definition, the PC can be proactive, when it reacts to information transmitted to it by various sensors in our environment. However, in its general thrust Tennenhouse's notion is an elaboration of Weiser's observation concerning ubiquitous computing. A proactive system is integrated into existing material objects in human environment, which may function independently, or exist in a network (typically

wireless), but there is no centralized intelligence. In its extreme form, the notion of proactive computing, then, means technology that can be anywhere around us, reacting to human actions and changes in the environment on a constant basis. Typically, this technology is "calm," barely noticeable [7].

However, there are two different ways to understand the notion of proactivity in terms of interaction design. First, it can be taken to mean that computers (and other IT devices) are aware of human actions, doing things like turning off lights only under the command of people. In more recent and extreme form, proactive technology utilizes a set of decision-making algorithms to anticipate human actions before they happen: "anticipation is a cornerstone of proactive computing. For systems to be truly proactive, they need to in some sense predict the future" [8: 131]. For example, when a sensor tells that voice level in a room is high, and CO2 level has risen considerably, the computer takes this as evidence that there is conversation going on, and the room needs more oxygen. Ultimately, such systems could be adaptive and over time learn new things without humans teaching them. Such systems could also communicate with the user in an intelligent fashion. This is the vision that exists in science-fiction with computers like the notorious HAL in *Space Odyssey 2001*.

PROACTIVE TECHNOLOGY AND DESIGN: AFFORDANCES AND DESIGN

From the design point of views, the crux of the matter is that if our future is proactive, it means that many things and objects that currently exist in our environment become not just computerized, but also may take action on their own. The workplace, the living room, and the kitchen lives: it is in one state at a certain time, but acts differently at another. Inputs to the system are human actions traced from environment with sensors. These sensors may measure issues like pressure, movement, or even CO2 level. Outputs are changes in the environment.

The basic design problem is that objects such as pillows, sofas, tables, chairs, not to mention ceilings and walls have traditional, conventional uses, or "affordances" [9,10,11]. People expect them to function in certain ways. These objects are familiar to us from their childhood, and they have formed and penetrated homes for decades, if not for centuries. Consequently, many people do not think of these objects as technological items. For convenience, we will use the term "culturally familiar objects" to discuss these familiar objects. The problem is that if culturally familiar objects come to have new functions, people experience such environment as uncanny, out-of-control, as their trust in their own, traditional methods of action fail to anticipate its behavior.

The design question then focuses on whether users understand that intelligence and control functions are embedded in the environment, not in a centralized control panel or remote control device? How can designers communicate the fact that culturally familiar objects and things have new, technology-induced affordances?

(1) The null hypothesis states that no special designs are needed: people will learn to use new functionalities over time even if they are not communicated in design. However, If proactive technology is integrated completely into the environment, it may become incomprehensible. If technology becomes invisible, users lose the possibility of controlling it [12]. At worst, technology is experienced as threatening: as it does things on its own while users lose the feeling of control.

(2) An alternative hypothesis starts from traditional design wisdom. If familiar objects come to have new functionalities, designers need to search new forms and other design solutions to communicate them. Changes in design communicate that the object is somehow new, and functions differently from objects with traditional affordances.

The alternative hypothesis has two variants. The first variant **(2A)** is less radical, stating that new functions in familiar things and objects are accepted if they utilize familiar, liked forms such as IKEA form language in new objects. Attractive design gives the "credit" technology needs to be accepted despite initial worries and suspicions. The second variant **(2B)** states that a radically new function in a (culturally) familiar object needs to be communicated with radically new means such as odd shapes, materials, or odd behavior. Examples could include sounds in sofa, movement in books, and "phicons" – physical icons [13,14] – that signal through shape changes that they are to be taken differently from cultural conventions. An example of such phicon could be a vase that functions as a TV remote control by changing colors or shapes according to its state.

These design questions are particularly important at home, which is an intimate environment, where people relax and spend time together with others. Studies of smart homes suggest that the home should not be what the proactive vision wants it to be. For most people, the home is about the only place they can control; taking control away from them is just what one should not do without careful consideration. Several things distinguish homes from the workplace. In the latter, the degree of personalization is much smaller than at home. First, people decorate their office desks with pictures of their children, posters, background images in PCs and sometimes music. However, the home is a personal place from ground up; the office is not. Secondly, workers can be taught to use new technology; at home, people have to learn technology typically without professional or organizational help. Third, the motives for accepting technology are personal at home, but organizational at work. [15,16,17,18,19].

DATA AND METHODS

The data for this paper comes from "Morphome," a project focusing on the design of proactive technology to the home environment [5]. The key aim of the project has been to explore design principles for proactive homes [20], how to communicate new functionalities embedded in culturally familiar objects, and how to implement such technology with wireless RFID-based radio technology. This paper focuses on the design parts of the study. The study has proceeded in three phases, the first two being completed by early 2005.

In *the first phase*, the project reviewed literature from smart homes. There is no lack of vision literature and technological literature on smart homes, but solid empirical research is wanting (but see [15,17]). To supplement our understanding of design issues involved, we conducted a probes study of six homes in the Tampere and Helsinki regions [21]. The focus was on home as an emotional ecology (i.e. how places, rooms and objects have meanings, and whether they are available for technological design). Technologically, we implemented a wireless network of two cushions with an RF-node, Bluetooth module, and RFID in its different versions. Literature review and the probes study pointed out that people are willing to accept proactive technology that affects the ambient environment (for example, lighting and soundscape) rather than more significant systems.

What remained open was the content of the ambient environment. In *the second phase*, we focused on that. We explored the second design hypothesis **(2B)** by building

(1) An IKEA-type lamp was used as a "mini-design" [22] for studying design ideas, and priming item for scenario interviews: we installed the lamp in two homes in Tampere and Helsinki, and conducted interviews with 12 homes a couple of weeks later. These 12 homes received "priming" questions (see Figure 2) a week before the interview. The point was to give people food for thought and sensitize people about their domestic routines and technology uses. Through the variety of the scenarios we also wanted to make sure that the participants would not see proactive technology as just threatening and useless. The minidesign was built to be stereotypical: it was built into an existing IKEA frame. Technology was fitted into the lamp, but a control panel was added. The reason why we selected this kind of design to our test was that we wanted to exclude the influence of strange design in the first step. The design was planned to be as neutral but also stylish and as commonly accepted as possible.

(2) In addition, we explored possible uses of the lamp with visual scenarios about design possibilities [23,24]. These scenarios were used as props in interviews conducted in the participants' homes.

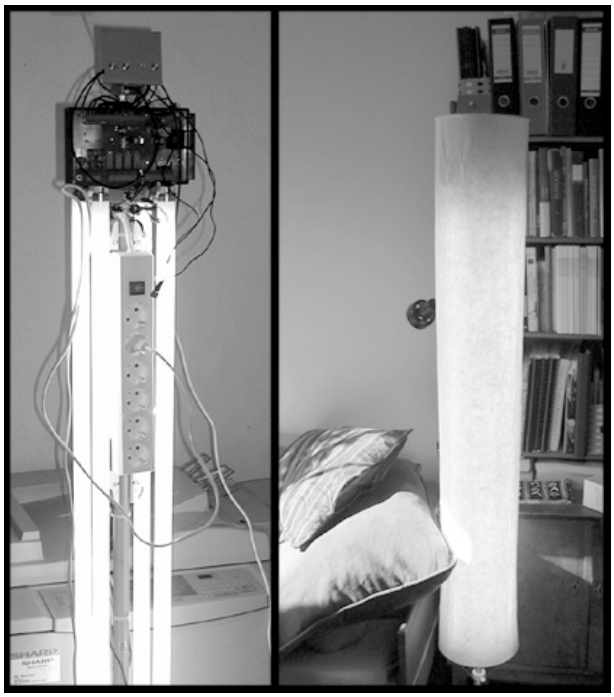


Figure 1: The Lamp: Electronics and Its Four States. The lamp had four states. [1] A normal lamp with button for adjusting light; [2] a 10 minute cycle in which colors changed from warm to cold; [3] a sensor designed to keep light constant in the lamp's surroundings [4] a state in which red and blue LEDs reacted to sounds. It was also possible to attach other electric devices to the lamp. The lamp had four 36 watts light tubes (2 colored, 2 normal).

Participants for the second phase were selected to represent different modes of living (including a single person, families with and without children, a couple with adult children living in their own homes, households with and without pets) and diversity in ownership of media technologies. The average age of the participants was 30 years, the youngest participant was 13 and the oldest 52 years old. We had 15 people in the working life, seven students, and one pupil in an upper level of comprehensive school.

The third phase is still being prepared, but three things will be done during Spring and Summer 2005. First, more futuristic scenarios will be created for evaluation in interviews. Secondly, we will build a media environment that functions as an experience prototype. The third task consists of optimizing the function of the electric circuit and implementing designs with soft and pliable materials. We are just getting ready a set of three lamps with different design with same "decibel lamp" functionality. The lamp reacts to the sound level of home and changes its color according to that.

THE LAMP DESIGN: IKEA STYLE AND PROACTIVE TECHNOLOGY

Our second hypothesis stated that when we deal with proactive technology, it is important to communicate with design that culturally familiar objects have in this case new functions. We proposed two variants of this hypothesis, with one proposing that design can follow traditional form languages, and another proposing a more aggressive approach, stating that new functions need to be communicated with radically new design solutions. In this section, we study the first variant with empirical data from Morphome. We started our design interventions from this variant simply because we did not want to arouse curiosity – and possibly suspicion – towards new technology with radical design; the tack chosen for the lamp was in this sense "calmer."

In general, the impression gained from the lamp was favorable. After a use period that lasted from one to two weeks, the participants told in interviews that they used the lamp on a constant basis. During the first days they did not distinguish clearly what were the differences between the states. It seemed that people are not used to stare at lamps in their homes in order to find how they work and because of that they preferred the lamp "to live its own life" rather than actively following what it is doing. They did not experience any major usability problems, even though they found the unfinished user interface annoying. However, this feeling had little impact on how the lamp was used during the field period. Most interviewees would have liked to use the lamp longer.

S & H: The day thing [in state 2] in the lamp was kind of fun because it illuminated this room in a different way than the sun... Especially in the evening when the room was let's say bright. Especially when the light was cold and came from the corridor to this direction, and when you didn't see the lamp... Then all walls were lit up just like in bright sunlight even though that light was cold and annoying as such. (5.8.2004).

We learned that design was important in terms of how the prototype was experienced. People trusted the lamp and were willing to let the lamp adjust other lighting according to its behavior. When the interviewer asked if the participants felt insecure to use the minidesign we were told that "No, it didn't prompt that kind of feeling, mainly perhaps because of its design. It is much like an IKEA design… even though I saw the string mesh inside the lamp I wasn't unsuspicious at all." (29.9.2004). In another case, we were told about the feeling aroused by the IKEA type design for the lamp. Again, the interviewer had peeked inside the lamp and seen its wiring system. Still, the design aroused trust: "The wiring system

inside is pretty impressive. Still, you get a safe IKEA feeling from the papery cover" (5.8.2004).

If this initial reaction generalizes, we can see the importance of design. If new functions are built into existing objects, design is an important thing to consider. Even when people saw the complex wiring inside the lamp, its stereotypical design created trust and belief in the device. We do not know how a more aggressive design would have been taken, but at least hypothesis **2A** – which states that new functions in familiar things and objects are accepted if they utilize familiar forms – appears well-founded as long as technology remains simple.

Thus, our reasoning behind the alternative hypothesis and its variant **2A** appears to be founded to a small extent at least. Familiar form language arouses trust and keeps fears in check. At present, we cannot study variant **2B**, though, because more futuristic designs are still pending. However, although evidence is weak, we can still claim that design does affect people's perceptions of proactive devices, and this perception affects whether they accept technology or not.

CAN DESIGN HIDE FUNCTIONS?

However, a global acceptance of particular design does not mean that it is accepted in every detail. As quotes above suggest, people paid attention not just to the lamp as such, but also its individual functions and states. The most interesting state, for us as researchers, was related to the tone of the color, which was implemented by changing the light source between the two brighter and the two more cloudy tubes. Throughout the cycle, the lamp emitted a constant amount of light. The cycle was ten minutes. The change of the tone was considerable: at its coldest, light was clinically bright. The change was maximized in designing the lamp to make it easy to perceive. However, in interviews, people did not report noticing significant changes.

S & H: Yeah, I didn't really notice it because the change was so small. It wasn't easy to perceive... the slow change of the system was pleasant, you could notice that something happened but it wasn't really vigorous. I think it was good too. My friends did not notice anything either.

Because the change [in state 2] was so small, it wasn't annoying. Instead, in a sort of funny way, it was a nice thing. I didn't really pay attention to it, though I noticed the function. Perhaps it was just because of this feature that I kept it on. However, I didn't turn it on because of just the same thing.

Part of the problem may be related to the basic design solution. If people have a strong culturally based idea on, say, how certain types of free standing floor lamps function, it may be difficult to register behaviors that depart from that model. This may be a serious design problem. Design ought to offer the user something that tells him that there are new types of functions, or they remain little or even unexplored. However, as soon as people realized that there are new functions in the lamp, they were able to observe them. It may also be that people got used to significant changes in the color tone, and do not find it disturbing. People are used to changes in the amount of light and tone outdoors and also indoors.

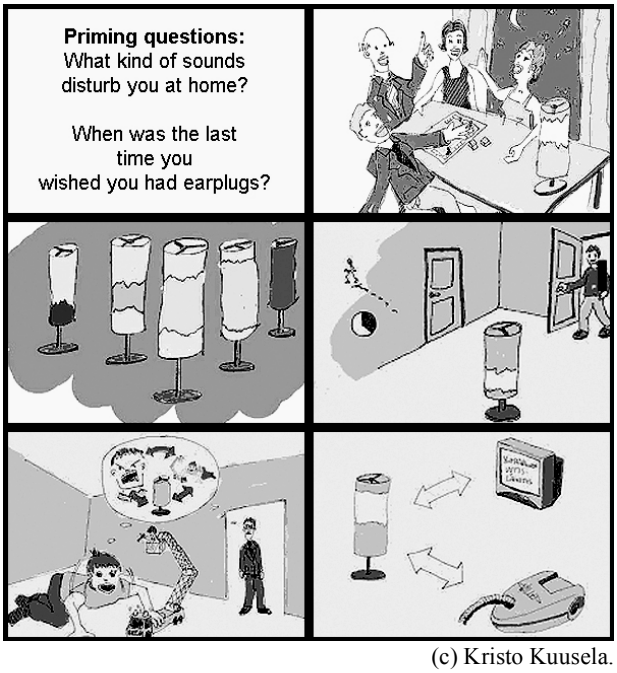
This observation as such supports the idea that ubiquitous – and by implication, proactive – technology ought to be "calm" to be accepted [7]. However, the IKEA association is so strong that people construct their understanding of the lamp based on that association alone. It captures people's imagination and, much like all stereotypes, blinds vision. People do not see behind the cover.

On the other hand, the winking in State 4 was seen as too strong and disturbing. The only use people could imagine for this function was for presentations and amusing children. Thus, it is difficult to find a suitable level of changes in design without testing it with users. These changes ought to be noticeable to be interesting and desirable, but not annoying. "I didn't use the fourth state because the light effects were pretty strong. If the second state [the changing tone] would have been this strong, I think it would not have been used either" (5.8.2004).

COMMON-SENSE SOCIAL REASONING AND PROACTIVE TECHNOLOGY

Since the minidesign mainly tested a design hypothesis rather than technology, it did not make it possible to study more serious technological issues. If proactivity is implemented, and the design is successful with simple ambient elements, it is perfectly possible that it is not accepted if it is given more powers with technology. To study this issue, we embedded the lamp design described above into a scenario that situated it into five types of context (see Figure 2).

With these scenarios, we probed the limits of acceptable technology in the IKEA design. We asked people to tell their ideas about the lamp and its functions. The interviewers' questions were used to maintain discussion rather than direct it in detail. The aim was to let the participants to illustrate things and ideas in scenarios with examples from their own homes.



(c) Kristo Kuusela.

Figure 2: Examples from Scenarios. Up: the priming question sent a week earlier, the sound world of the home (preparatory question); **Middle**: the lamp reacting to sound, *Memory Trace*; **Down:** the lamp in social context, the lamp as a control to other technology.

After discussing the sound world of the home inspired by priming and preparatory questions (Figure 2, up) the focus moved to the lamp and its potential features. In the scenario the decibel lamp was also depicted as a pedestal lamp resembling the Ikea type of design. Differences in attitudes among the interviewees related mainly to the size and visibility of the lamp among domestic objects. Most thought that the lamp should have a noticeable place, usually in a living room while others preferred that the lamp should be situated in an unobtrusive place at home.

As expected, people were willing to delegate some pieces of their "dirty work" to the lamp installed in the network, and let it control automatically some functions. When we asked whether the lamp could turn down the voice of other devices like vacuum cleaners when there is a phone call, we received encouraging responses. These were based on people's experience in juggling between the demands of several technologies. When we asked about the vacuum cleaner's relationship to the lamp, we were told stories about instances in which such function would have been not just useful, but also safe.

J: Yes, in fact I was vacuum-cleaning today and took my mobile phone to the pocket so that I'd feel when it starts to vibrate (laughs) because you don't hear its sound when you're cleaning. Similarly, when I'm taking a shower, such system would be good, because when you have to rush to the phone with soapy feet... it'd be a good idea.

However, the situation changes as the scenarios started to explore how proactive technology would affect social affairs. Although the first question in our interview guide focused on the lamp, it already had a cue to social issues – a noisy party. Thus, we asked whether the lamp would be a suitable feedback mechanism about sound level, whether its behavior should change in the course of day, and what kind of feedback could it give to people about sound? The answers were again generally speaking positive. In particular, people thought it would be a nice, playful addition to the home. In the following quote, one couple figured that it would function as a toy when entertaining guests.

AM: It'd be visually pretty much fun. Don't know whether there would be any practical use for it, but it'd be a kinda fun thing. And I think it'd give a good boost to guests.

J: Yea, people try to beat the earlier records (laughs). It'd bring out a good old teen mood, for sure

Some reservations that came up in interviews were related to practical issues. One couple claimed that they do not like the idea that the lamp's main role is to "give feedback" about decibel level at home. Their explanation was that because you can hear with your ears the decibel level, the lamp could easily emphasize the current decibel level too much. They remarked that some stentorian sounds can also be pleasurable and in that case the lamp winking with red light would be irritating. They perceived that in their home the lamp should be an "ambience creator" or decoration element rather than a decibel indicator. Thus, they did not question the basic functionality of the lamp but were critical of potential obtrusiveness the lamp can entail with its output.

More significantly, when we probed what people would think about a lamp that would have a *Memory Trace*, a function which dimmed the informative light (warm chair effect)and whether they would allow it to be linked to a home-wide network, people got reserved. In particular, the issue was privacy. Originally, we explored the idea whether the lamp could sense the presence and absence of people, and communicate that by, for instance, getting increasingly dim over time when no one is present. However, people though that this solution would simply translate into a surveillance technology. They also were worried about how neighbors and criminals would use cues from the lamp for evil purposes.

J: No.

AM: I don't think that either. I think that it'd only prompt... it might prompt quarrels like 'Yeah, you've been away so long already even though you only were supposed to visit there, but now you've been there for ages (laughs quickly)'. I think it's simply be a device for surveying others

Although in general, experience with the lamp and its familiar design lowered the threshold for accepting proactive technology, people saw several problems in scenarios. Some ideas – such as the Memory Trace – were characterized simply as silly, and rejected on social grounds. People were concerned about the fact that it is quite impossible to anticipate when one is coming home, while one doesn't know that for sure even by itself. They were given examples: what if I meet neighbors at stairs and have a chat with, and so forth. They were also worried about the lost of surprising positively family member. For example one cant surprise ones love anymore by coming home earlier than it was planned even if ones love is sick and at home alone. Most of our participants insist that they want to "pull the trigger" by themselves for the system to tell that they are coming home, then the lamp could show their approaching. But they did not want to let the system to launch the functionality. Basically people preferred to be without information rather than would take a risk of being observed by technology.

Perhaps the main problem is that if technology reports one's actions to others, the balance of social control changes. On the other hand, social issues also gave people a reason to accept proactive technology. The critical issue for proactive technology, then, is whether people think it would affect their social relations and social balance at home. If so, they pay more careful attention to it and are very wary about using it. If not, technology is accepted without many second thoughts.

CONCLUSIONS AND DISCUSSION

As Tennenhouse [6] has defined it, proactive technology is one response to the challenge posed by Weiser's [1] observation about ubiquitous computing. To make a large number of technical devices functional for humans, humans have to get "out of the loop": technology must function autonomously from constant human intervention. However, we have argued in this paper that this vision posed a fundamental design challenge: if technology disappears from sight, but still continues to function, the result is an uncanny environment in which people feel that they lose control. This is what people do not want, if we are to believe literature on smart homes [15,16,18]. How then to design proactive technology so that people understand that their culturally embedded patterns of use do not conflict with new functionalities built into the home?

This paper has explored this question with a research design consisting of two things. First, there was a "minidesign" [22], a lamp built into an IKEA frame. The key aim of the minidesign was to study whether design has any significant bearing on the acceptance of proactive technology. Secondly, after a two-week use period, users' experiences with the design were mapped in a scenario-supported interview that explored how and what kind of proactive technology people would accept. The decision to work with a lamp was partly based on the smart home studies that show that people are generally willing to accept technology that changes the ambient environment – such as lighting – rather than technologies that try to second-guess more significant aspects of our environment. This result was corroborated in a probes study [21], conducted earlier in the Morphome project [5].

We also find priming tasks (written questions as well as minidesigns) to be useful for getting the participants prepared to the interviews. The tasks enhanced their awareness of the role of technology in everyday life but also facilitated them to identify themselves as users of novel proactive technologies.

The results of this exercise, of course, are preliminary: it is impossible to give justice to a technology philosophy like Tennenhouse's with a small study like ours. However, a few things stand out. First, design – even if in IKEA's cliché-like form – makes in its part new technology acceptable. In fact, design can be decisive, as it changes the mindset people have for perceiving technology. However, resorting to a conventional design language also has its dangers: it may direct understanding to an extent that people barely notice small changes in their ambient environment. Finally, our data suggests that people are willing to accept technology that delegates dirty and repetitive work easy to forget without reminders, but not technology that would expose their activities to other people. Also, people are skeptical about claims that technology could replace human intervention in, say, maintaining order in the household. If proactive technology may become a tool in social control and surveillance, its chances of being used decrease.

Finally, this is work-in-progress. During the next months we continue to explore the design question more thoroughly with interventions into more homes. First, we will study further the idea that design is important Is this true of all design, or just conventional IKEA-type design language? Should proactivity be seeable in design details? How? Secondly, we explore more significant output environment. The lamp design changed tone, but so slowly that people barely noticed it. What happens if the output becomes easily noticeable – for example, if walls change colors according to sound level or if the lamp is able to switch off television when people start to watch photographs? Third, technical work continues to specify the technical infrastructure for wireless proactive networks. Finally, we plan to delve deeper into the two interpretations or proactive technology: whether it means technology that senses its environment, or whether it also predicts human action.

ACKNOWLEDGEMENTS

Morphome has been funded by the Academy of Finland. Its partners are University of Tampere (Hypermedia Laboratory), Tampere University of Technology (personal electronics), and the University of Art and Design, Helsinki (the School of Design).

REFERENCES

1. Weiser, M. The Computer for the 21st Century. Scientific American 265, 3 (1991), 94-104.
2. Binder, T. and Hällström, M. (eds.). Design Spaces. IT Press, Helsinki, 2005.
3. Jacucci, G. Interaction as Performance: Cases of Configuring Physical Interfaces in Mixed Media. Acta Universitatis Ouluensis, Scientiae Rerum Naturalium A 427. University of Oulu, Oulu, 2004.
4. Edwards, K. & Grinter, R. E. At Home with Ubiquitous Computing: Seven Challenges. In Abowd, G. D., B. Brumitt, and S. A. N. Shafer (eds.), Ubiquitous Computing. Springer-Verlag, Berlin, Heidelberg, 2001.
5. Mäyrä, F. and Koskinen, I. (eds.). The Metamorphosis of Home. Research to the Future of Proactive Technologies in Home Environments. Tampere University Press, Tampere, 2005.
6. Tennenhouse, D. Proactive Computing. Communications of the ACM 43, 5 (2000), 43-50.
7. Weiser, M. and Seely Brown, J.. The Coming Age of Calm Technology. PhysComp Notes: Working notes on physical computing and embedded networking, February 04, 2004. Available at http://stage.itp.tsoa.nyu.edu/~tigoe/pcomp/blog/archives/000373.shtml. [Accessed Feb 17, 2005.]
8. Want, R., Pering, T. and Tennenhouse, D. Comparing Autonomic and Proactive Computing. IBM Systems Journal, 42, 1 (2003), 129–135. Online: http://www.research.ibm.com/journal/sj/421/want.pdf [Accessed: June 4, 2004.]
9. Gibson, J. The Ecological Approach to Visual Perception. Houghton Mifflin, New York, 1979.
10. Norman, D. The Design of Everyday Things.: Basic Books, New York, 1988.
11. Sellen, A. and Harper, R. The Myth of the Paperless Office. MIT Press, Cambridge, MA, 2002.
12. Dourish, P. Where the Action Is. The Foundations of Embodied Interaction. MIT Press, Cambridge, MA, 2001.
13. Ishii H. and Ullmer, B. Tangible Bits: Towards Seamless Interfaces Between People, Bits, and Atoms, Proceedings of CHI 1997, ACM Press (1997), 234–241.
14. Ullmer, B. and Ishii, H. Emerging Frameworks for Tangible User Interfaces. IBM Systems Journal 39, 3&4 (2000), 915-931.
15. Leppänen, S. Kodistako älykäs? In Tekes (ed.) Digitalisoituvan viestinnän monet kasvot. Tekes, Teknologiakatsaus 118, Helsinki, 2001. [Towards a Smart Home? In Tekes, The Many Faces of Digitalizing Communication, in Finnish].
16. Harper, R. Domestic Design: An Introduction to the Research Issues Surrounding the Development and Design of Interactive Technologies in the Home. Journal of Personal Technologies 4, 1 (2000): 1-6.
17. Harper, R. (ed.) Inside the Smart Home. Springer, London, 2003a.
18. Harper, R. Inside the Smart Home: Ideas, Possibilities, and Methods. In Harper, R. (ed.) Inside the Smart Home. Springer, London, 2003b.
19. Intille, S. S. Designing a Home of the Future. IEEE Pervasive Computing 1 (2002), 80-86.
20. Mäyrä, F. and Vadén, T. Ethics of Living Technology: Design Principles for Proactive Home Environments. Human IT 7, 2 (2004), 171-196.
21. Soronen, A. and Sotamaa, O. Domestic Probes: Researching Domestic Environment by Means of Self-Documentation Packages. In Mäyrä, F. and Koskinen, I. (eds.). The Metamorphosis of Home. Research to the Future of Proactive

Technologies in Home Environments. Tampere University Press, Tampere, 2005.

22. Kyffin, S. and Feijs, L. The New Industrial Design Program and Faculty in Eindhoven. Eindhoven, the Netherlands, unpublished memo, 2003.

23. Carroll, J. (ed.). Scenario Based Design: Envisioning Work and Technology in System Development. John Wiley and Sons, New York, 1995.

24. Soronen, A. and Kuusela, K. Approaching Domestic Technologies of the Future Through Visual Scenarios. Paper presented at HOIT'05, England, 2005.