Ethics of Living Technology
Design Principles for Proactive Home Environments
Frans Mäyrä & Tere Vadén

The entry of proactive technology into highly sensitive environments, such as the home, produces specific design challenges that are inextricably linked to ethical issues. Two design goals are presented and analysed: proactive solutions have to be both personalized and consistent. These requirements are partially contradictory, and need to be understood in the context of the socio-cognitive setting of the home. The embedding of proactive technology into a home environment has to provide the user with an awareness of the possibilities of control and play. These design goals are further developed with regard to different user cultures: here we concentrate on early adopters and elderly people.

Promises and Challenges of Proactive Home Environments[1]

The concept of proactive computing was introduced by David Tennenhouse (*Communications of the ACM*, May 2000) from the perspective of computer science and information technology research and development. Under the concept of proactivity, Tennenhouse proposes three research agenda: a) getting physical – proactive technology that interacts with the world through sensors and actors, b) getting real – reacting in faster-than-human time-scales and c) getting out – replacing humans, either so that they can be left out of the loop or so that they are above the loop (Tennenhouse 2000, 44). Tennenhouse asks what the computers will be doing in a situation where "networked computers outnumber human beings by a hundred or thousand to one." (Tennenhouse 2000, 43) Thus, the main motivation in Tennenhouse's agenda is technological

"push" rather than consumer "pull" or demand. Consequently, several critics have suggested that especially in home environments pervasive or smart technologies are "solutions to problems that do not exist," and that the widespread integration of diverse computing technologies in homes is going to lead to increasing complexity, unreliability and often stress. Of the ethical questions raised by proactivity, the issue of privacy has received most attention (see e.g. Intille 2002; Stone 2003; Edwards & Grinter 2001). While we do agree with some of this critique, we are in favour of a more detailed approach to the ethical issues and design guidelines of proactive technology. There are indeed some areas where implementations may be extraneous or intrusive, but there are also opportunities for genuinely useful, enriching and even lifesaving proactive home technologies. In our view, by looking at the nature of the (human) control and awareness necessitated by proactive technology in a home environment, especially by looking at what is the nature of the ethical and social issues involved, we gain a fuller understanding of the requirements for the design principles of proactive technology.

A discussion of design principles for home technology should start from an understanding of homes as particular environments with phenomenal features of their own. A home is an intimate social space, and the proactive solutions applied there have to meet particularly high standards in usefulness, reliability and security, as well as excel in the areas of aesthetic and social usability, in order to become widely adopted and accepted by the occupants. Social dimensions are particularly important: homes are environments that are closely connected with their inhabitants' personalities and tastes. Solutions that are not engineered and designed starting from an understanding of home environments and the contemporary development of lifestyles in them, are likely to be rejected.

Thus the ethical questions to be discussed arise from two sources. The first set of questions is prompted by the imbalance between the "push" and "pull" factors mentioned above. The very fact that *acceptability* is a central issue in connection to proactive home technology points to the involvement of multiple questions of self-determination and autonomy. The second set of questions is more specifically related to homes as settings for proactive technology. The socially and emotionally rich and sensitive aspects of a home as well as the variation in homes necessitate

analysis that is informed by an understanding of the ethical nature of all modifications of the home environment.

In the following we analyse some of the reasons behind the issues that arise around acceptability. Based on that analysis we also suggest guidelines for taking the ethical issues into consideration when designing proactive home environments. The analysis will be divided further according to the needs of special user groups and cultures. We will consider especially two qualitatively different user groups that put their own types of questions on the ethical agenda: early adopters and elderly people.

Two Main Design Principles: Consistency and Personalization

If we reflect on everyday experiences, it soon becomes clear that intelligent environments and services present us with unique design challenges. Entering or leaving buildings with automatic doors, we have all sometimes experienced momentary confusion when some of the doors open when approached and some do not even though the doors appear similar. Here we run into our first design principle, which we will call *consistency*: if a function or element is delegated to be controlled by proactive systems, that function or element should demonstrate similar behaviour consistently. In a transition period where automatic (or intelligent) and non-automatic (or non-intelligent) components are mixed into a heterogeneous compound, there have to be some standardized signals that convey information about the capabilities and expected behaviour of the environment. These expectations and the standardized cues that confirm or disconfirm them are needed in order to instil an awareness of proactive technology. In today's buildings, it is often possible to look up while approaching a door and perhaps notice the blinking red LED of a proximity probe that signals that the door is automatic. Another signal is the absence of a door handle; such a design feature is a coded affordance of the door as a proactively operating interface. However, as many standard doors do not have door handles either as they are designed to be pushed rather than pulled or turned open, this kind of traditional affordance is ambiguous. The concept of affordance (as introduced in Gibson 1979 and Norman 1988) means that the fundamental perceived properties of an object determine how people approach it and how they are going to use it. Proactive implementations are going to change the

way we relate to our surroundings, as everyday things intelligently anticipate our needs and offer novel functionalities.

At the same time as we present this first tentative design principle, we are faced with contradictory demands on the proactive implementations in a home context. The context of an automatic door to an office or some other public building is quite different from the context of a door to a home. A home is a personal space and mirrors to varying degrees individual tastes and preferences. We are accustomed to expect generic and standardized solutions to be applied in public spaces, whereas entering private homes as a guest, it is customary to be told about some "rules of the house" that reflect practices and preferences adopted and followed by this particular individual or family in their private space. This points to a second design principle, which we will call *personalization*. Personalization exists in a dynamic tension with the principle of consistency: when operations of services or their interfaces are personalized, they do not necessarily follow the common logic or standard behaviour of public spaces.

Rather than seeing this tension between the demands of consistency and personalization as an obstacle, we see it as a productive opportunity. Proactive technologies, if properly implemented, will offer novel ways to create and standardize the most useful ways for augmenting environments and enriching the skills of people with various sets of intelligence and site or context specific services. The real challenge is to create the *language*, understood in a wide sense, that conveys awareness of these services both to the occupants and to the occasional visitors in these proactively augmented spaces. To help create an initial mapping of this design space, we provide the matrix in Table 1.
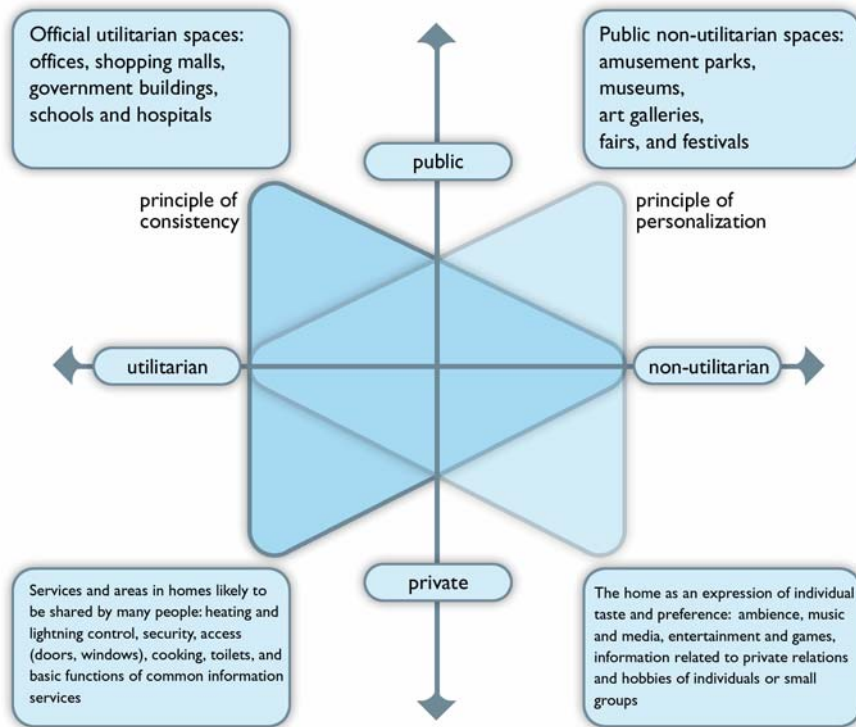
Table 1. Design matrix for proactive services' interface design

The dynamic relation of the two opposing principles is illustrated by the two triangular arrows, the *principle of consistency* having its roots in the area of universal logic and commonly shared solutions, while the *principle of personalization* is driven by the pursuit of the particular and the unique. Balance and dialogue between these conflicting pursuits are reached in various forms in different real world contexts. These are mapped in the fourfold matrix using the axes of public–private and utilitarian–non-utilitarian. Even as generalisations and abstractions, each of the four emerging fields presents a distinctly different context for design. Also, it can be seen that a home is not a uniform design environment. On the one hand, a home has aspects and elements that should be mediated in as standard and universal a manner as possible,

and, on the other hand, it has many functions that are very intimate and deeply personal in character. Thus, there is no single universal guideline to inform design decisions for all future proactive services; rather several, even conflicting principles have to be applied.

Challenges and Solutions for Home Technology Design

Recent research has already identified several key challenges affecting how proactive technologies can be implemented in private homes. Several of them have emerged from the research on ubiquitous computing, since the design philosophy of "ubicomp" (pervasive, calm, empowering peripheral perception) is close to that of proactive computing. Here, we want to highlight the work of W. Keith Edwards and Rebecca E. Grinter of the Xerox Palo Alto Research Center. They have identified seven main challenges of bringing ubiquitous computing to homes that we summarise here (Edwards & Grinter 2001):

1. *The "accidental" character of technology's entry to homes* (reality is implemented "piecemeal," there is no central planning and new interoperating technologies are in danger of bringing in such a degree of complexity that the functioning of homes becomes unpredictable).
2. *Impromptu interoperability* (simple and seamless ability to interconnect future devices and services demands radically new models of connectivity and interoperability as compared to the current model of proprietary device drivers and software upgrades).
3. *Lack of systems administrator* (both the traditional appliance model and the utility model where most of intelligence resides in the networks bring their technical and design challenges to a traditionally personal, non-technical environment).
4. *Designing for domestic use* (need to understand better the home routines, the social and cultural appropriation and adaptation of technologies by occupants).
5. *Social implications of aware home technologies* (there will be unforeseen social consequences when new technology is placed into the home setting).

6. *Reliability* (very high reliability goals have to be build into the system architecture itself, which is a challenge to developers, manufacturers and regulators, as well as for researchers and consumers).

7. *Inference in the presence of ambiguity* (there are tasks related to inferring internal human intent in some situations that are hard even for human intellect, and therefore should not be designed to be dependent on any machine intelligence).

We feel that Edwards and Grinter have identified several key challenges for "smart homes" that are relevant to the designs and implementations of proactive technologies. Particularly their emphasis on *predictability* is similar to our principle of consistency; in order to feel relaxed and safe, users must always be able to be aware of what to expect from their homes. This means design that facilitates symbolic or practical communication (based on perceptible functionalities, or affordances, or sometimes on symbolic conventions) between occupants and their environment. Even within the calm design imperatives, certain key factors have to reach the awareness of occupants: users have to know what to expect from a system or service when particular conditions occur; they should be aware of how the system detects or infers these conditions; and there should be means for the occupants to override any automated behaviour (cf. Edwards & Grinter 2001, 269). This leads to the two key concepts that we want to explore in terms of proactive home design: *awareness* and *control.*

By "awareness" we mean that the users of the proactive systems have to have knowledge of the capabilities and internal states of the proactive system in order to be able to use and further modify them. The term is not meant in the sense that the users have to be continually conscious of or deliberate on the technological affordances for extended periods of time. That would be quite counterproductive and cumbersome, not to speak of the ensuing "un-calmness" that would be unwelcome at home. Rather, the term indicates an internalized, situated (possibly sub-conscious) knowledge of the possibilities and limits of the technology available. This internalized knowledge can be brought into focus and to

the centre of attention if needed, but for the most part it is displayed in habituated and situated cognition and action.

The creation of this kind of awareness is not only connected to the issue of how the capacities, properties and limits of the technology are made available, usable and malleable to the users, but also to the issue of how much and through what means the users want to be in *control* of the technology. If too much control is needed, focal awareness is aroused annoyingly often, and the technology fails to be "proactive" enough. On the other hand, if the options for control are too limited, a disturbing experience of not being "at home" with the technology may result. The options for control have to be such that they can be brought from implicit awareness into focus, if needed, and at the same time the way in which the system is controlled has to be robust enough so that the need for control (such as signals from the machinery) can be ignored. The key to acceptability, in our view, is striking a balance between these two requirements.

It has quickly become apparent that new solutions are needed for controlling intelligent objects and services, and for mediating awareness of their capabilities and internal state to the users. There is no single area of expertise or viewpoint that would be enough to provide all the information necessary for outlining such solutions. An interdisciplinary collaboration between media and cultural studies, social sciences, industrial design and engineering sciences is needed. Focusing on homes, particularly as the contexts for family life, leads to the main design challenge: how can distributed, non-intrusive access and input be designed and implemented so that it facilitates adaptive control and awareness?
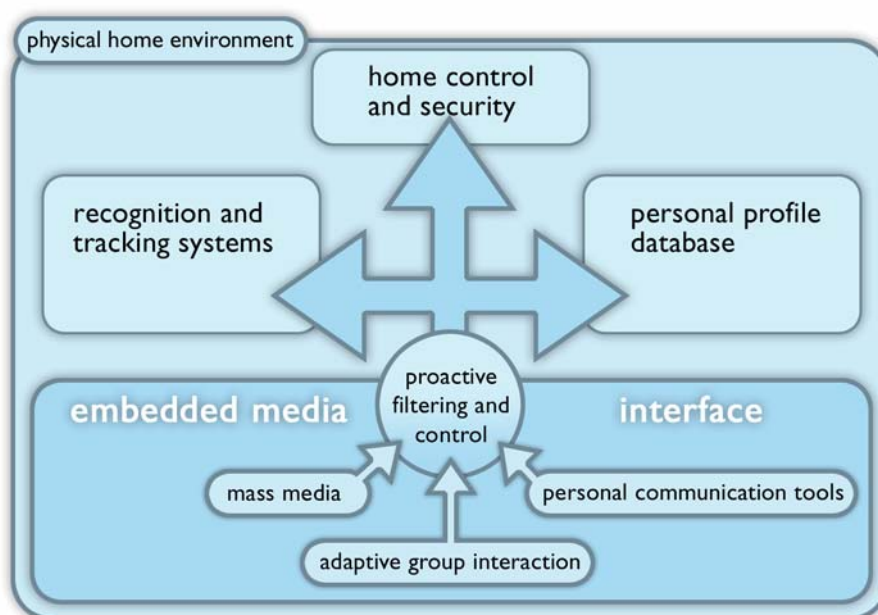
Figure 1. Some central design dimensions of a proactive environment

One important qualifier of such a solution is that it has to be able to serve multiple users sharing the same environment, while they exhibit some common (social) and some individual (private) usage patterns. A learning environment like that suggested by Stephen S. Intille (2002) is one promising approach to the complex control and adaptivity problem. Since multiple proactive services should not monopolise the user's attention, the material design and software design have to be brought into close contact (see Figure 1, above). The home as the use context forms a social and cultural, as well as material, environment, that has to be taken as the starting point of the proactive implementations embedded into its fabric (cf. Suchman 1987). We suggest the design principle of *embedded media interface*, where the main goal and task for proactive technologies in homes is to provide filtering and control that negotiates the boundary between "home-as-shelter" and the need to maintain contact with the "world-out-there." An embedded interface implies that the elements to be mediated to the awareness of occupants are non-

intrusively situated in the physical everyday environment in the form of dedicated objects that carry particular messages pertaining to their function.

The term "media" should not be understood in the traditional, narrow sense of mass media in this context. Rather, "media" include all (technologically) mediated forms of information exchange. This includes mass media like television, and person-to-person communication in the form of telephone or televisual discussions, and also adaptive group interaction, which is the hallmark of networked media. A home extends its physical boundaries to include people not physically present, and these "virtual" persons are a part of the communities that family members maintain or participate in. Also, the embedded media interface can be a very flexible tool in distributing the control of media and communication functions, as well as shared or private home functional-ities, into multiple devices and modalities, rather than to a single access point. This is why the affordances of proactive technology have to be conceptualised with special care. In a proactive home environment, material objects, sounds, visual or tactile signals are needed for communicating the presence of new capacities in the environment. They must be coded in a manner that is both an intuitive part of the home, and flexible enough to suggest new functionalities.

The future home is a hybrid with both material and immaterial dimensions – the contemporary home includes these aspects, too, but in the future home these immaterial aspects will be functioning services and information spaces, not only mental dimensions. Everyday objects may hide functions and potentials that are currently just beginning to emerge in powerful information and communication systems. This creates a complex interface problem as the users are living inside a system that they are also controlling. While researching proactive systems, one should not forget that the capabilities of rich, audiovisual media will be available in the future home; access to sound and images and various means for input are not likely to decrease, as the general thrust of our culture has been towards the mediatization of communication and increase in audiovisual content. But since our environment is already saturated by images, it is important to develop alternative ways to mediate and control information systems, as well as to create principles

for making informed choices in application design. Home media, entertainment and communication systems will be the most complex sources of individual or socially shared information and services that proactive systems will help us to control.

Ethics of Proactive Designs

There are two alternative ways of relating to the promise of proactive computing: we will call these the strong and the weak interpretation of proactivity. The *strong* interpretation emphasises the invisibility and autonomy of proactive technology. The aim of strong proactivity is to remove humans from the loop (cf. Tennenhouse 2000, 44) and build implementations that are self-sustained and in practice the opposite of those of interactive computing. In our view, a total elimination of human interaction holds several ethical and even safety problems for the overall system development, not to speak of the technological challenges involved. (The term "strong" here also indicates that in order to be reliable and acceptable, strong proactive technology would have to solve the problem of genuine, "strong" AI.) In view of these still unsolved problems, we advocate for the time being a *weak interpretation of proactive computing*, one that perceives the communication and control issues of proactive technology as one of the key areas to be investigated before these systems are implemented on a large scale. There have to be ways for human users to get information about the internal state of proactive systems and they should be given the option of influencing the behaviour of the system, even if the vast majority of processes do not need active attention or intervention. This supervision does not, of course, have to be constant or initiated by the human. The idea of "weak" proactivity is to minimise and make more effective the necessary supervision, while at the same time creating a comfortable awareness of the options for control – a goal quite different from the elimination of supervision. As indicated above, we think that as a conceptual basis, "weak" proactivity has better chances of achieving the design goal of acceptability.

It seems to us that, when discussing technology in general and the questions of proactive control and awareness in particular, the most fruitful way of seeing the field of ethics is not through the ideas of

systematized sets of rules and calculation (whether utilitarian or deontological ethical systems) but through considering the sets of shared ways of living that constitute our culture. In its Homeric origin, the word *ethos* describes the field of interests, commitments, desires, fears, etc. that forms a particular way of life. The ethical space is created when forms of life are contested through the differences in the commitments and values that underlie different ways of living. Ethical theory and consideration is needed because different ways of life, different *ethoi*, come into conflict and need to negotiate the terms of their common "third" ethos, the co-ethos, the inter-subjective field of intersecting ways of life.

This perspective is especially pertinent in the consideration of the home environment. The functions of a home are largely determined by the individual and collective ways of life of the people who inhabit it. In phenomenological terms, the home as a space for being can to a large extent be seen as an extension or embodiment of the inhabitants living in the home. The skills, knowledge, desires and fears of the inhabitants are not only coded but in a very concrete way present, embodied in the physical lay-out of the home. There is ample scope for individual variation and personalization in the home. (Human memory and perception of space rely to a great extent on mental scaffolding of the physical environment; see, e.g., Tversky 2001; Hutchins 1995).

In order to illustrate the way in which the cognitive and emotive content – skills, abilities, capacities, and dispositions for coping in the world – is embedded in the physical environment, let us use a famous example from cognitive science. John Haugeland (1998, 234f.) describes the way in which a cognitive skill is embedded in the complete whole of "agent plus environment." Think of the way in which a person can find her way by car from one city to another. It is quite likely that the ability to find one's way is dependent on the physical existence of the road system. The cognitive skill and the information needed are coded in the physical environment which in this sense makes possible the intelligent behaviour of finding one's way. If the road system did not exist, one could not find one's way to the desired place even if the means, say a helicopter, were available. "Finding one's way" as a cognitive skill is a property of the agent plus the environment. Changes in either of these

will change the skill. In this way, many of the cognitive skills that we have are in fact distributed, embedded and situated in the physical environments and tools that surround us – our body being the main vehicle of skilled coping in the world.

If the above is true in the relatively straightforward case of finding one's way with the help of the road network, consider the more complex cases of environment, such as architecture, texts, or, indeed, information technology. Furthermore, we need to keep in mind that it is not only or even primarily the cognitive skills that are distributed and embedded in the environment. Thinking of the home, it is clear that emotive, volitional and also cognitive tasks and habits are, so to speak, inherent in the "agent plus environment." The physical and informational-virtual structures of the home are integral parts of the emotive contents and cognitive skills of the inhabitants. Consequently, the awareness of the possible functions and skills available at a given time is distributed.

This notion of distribution or embeddedness gives the most fundamental basis to the concept of awareness mentioned above. The abstract skills of a person are dependent on the concrete physical environments, in the case of proactive technology the affordances built into the technology. By changing the environment, one can change one's cognitive-emotive capacities and habits. Therefore, as noted above, ethical issues connected to self-realization and autonomy are implied. The key is to offer the user the opportunity of being aware of the technology in a way that ensures control without simultaneously necessitating constant attention. As Edwards and Grinter (2001) point out, the issue of awareness is essentially connected to the issue of the social consequences of proactive technology, as well as to reliability and acceptability. In general, it needs to be pointed out that people react strongly to the social potential of any technology. In view of the multiple and overlapping social functions of the home environment, the awareness of the social potential of proactive technology should be considered in the design process. It seems to us that this aspect is best signalled when the "what" and the "how" of the technology are consistently displayed and the "why" left to the user. There is a trade-off here: being aware of the "what" and the "how" creates calmness in the awareness of the "why." If one knows how to control a system, its use is

calmer. Therefore obtrusiveness is to be preferred on the "low" level of abstraction; in how the system works and what it does. The social space of "why" is best left to the humans, this also because of the seventh problem mentioned by Edwards and Grinter: the inferences about the "why" of social action are complicated and intrinsically enjoyable to humans.

The view of ethics as a negotiation of a shared space also points out that the issues raised by technology are not issues of individual ethics, rather, they necessarily include questions pertaining to how the individual and the community are differentiated. Privacy is one of these questions, autonomy, the formation of needs and wants and social influence are others. As is well-known, elements of force, discipline, coercion and influence are built into technology. How different users and user cultures relate to these questions has to be analysed in detail in order to make sound design decisions. Proactive technology can be seen as a security device, as a social, cognitive or emotional augmentation, as a productivity enhancer, as a pet, and so on. Each of these views opens up its own ethical space that is not completely commensurate with the others.

Ethics of the Home: Two Examples

It is important to note that in view of both control and awareness, the home environment is different from other kinds of environments. In public spaces the malleability of the environment is limited by multiple constraints. These constraints arise in part from the fact that public spaces must cater for a wide array of cognitive and emotive styles, and consistently embed various modes of operation. In the home, these constraints are quite different. For many, the home is defined by the fact that it is to the least detail suited to a personal style of cognition and emotion, and supports them optimally.

This shows that the acceptability and related ethical issues of proactive technology differ along the public–private axis, as mentioned above. However, this is not the only variable. In private spaces, different user groups have different demands on how awareness of proactive technology is rendered acceptable. Let us consider two cases that represent different needs and wants: early adopters on the one hand; people in need of

security-enhanced and supportive environments on the other. By early adopters we mean here a group of people that is positively disposed towards technology in general and out of sheer curiosity and playfulness wants to invest time and energy into "fiddling" with new technological devices. On the other hand, there are groups of people, such as the elderly and other special groups that may welcome proactive technology that enables autonomy and security, for instance, when personal physical abilities are declining.

In general, if a home environment is seen as essentially individual, imbued with cognitive and emotive traits, then, naturally, personalization is a key to the control of proactive technology. However, personalization as such might mean different things, for example, to the two groups mentioned above, and consequently, personalization sets up multiple agendas for design.

It can be expected that when proactive technology is seen as supportive and security-enhancing, the key to acceptability is in calmness and control. These, again, are not opposites of personalization. Rather, personalization is embedded as a control that is calm, unobtrusive and consistent. The awareness of the potential and control of the technology is mediated through social interaction and is part of a social setting involving many people: individuals and possibly institutions. For inst-ance, if the task of proactive technology is to enable an elderly person to continue living in her own home when her ability to operate the basic tools and functions of the home is limited, the control and awareness of proactive technology are distributed, for instance, to a group of relatives, friends, organisations, etc. This kind of technology has to be designed with "group" control and awareness in mind. Consistency in the technology may, therefore, be a higher priority than personalization, because personalization is embedded mostly in non-information-technological elements.

For the early adopters, in contrast, awareness of the potential of technology is created through intensive, if intermittent, involvement with technology. This means that a sense of control is created only if there are extensive possibilities of personalizing the functions of the technology. As noted above, this requirement for personalization is not easily combined with that of consistency. However, in the case of the

early adopters the apparent contradiction between these goals is resolved when we note how awareness and the related skills and emotive contents are embedded. Personalization means, in effect, the embedding of skills and contents into practices and physical settings through use. This is a much wider phenomenon than "setting the preferences" of a piece of software, for instance. In the early-adopter context an experientially acceptable awareness is created only if control and personalization can be extended to forms that border on misuse. This is, of course, in stark contrast with other possible contexts of use.

The embedding of awareness entails that control is multi-layered, existing at various levels. For an early adopter culture, control means potential for invasive changes both in how the proactive technology functions and in how it affects the other routines of the home. It is not enough to be able to shut off or override all proactive technology at will. Personalization *is* control. Control is created through personalization on many levels: the physical setting of the technology, its use, adapting it through technological, physical and social changes in the home, etc.

Accordingly, consistency is multi-layered, too. The technology has to be consistent not only in its responses to commands, in its affordances and its signals of its internal states; it also has to be socially consistent with the expectations of the early adopter culture. Consistency means different things and is designed through different means on these levels. One design principle needs special attention here. Because the home is essentially a personalized space and because autonomy and self-determination are to be desired, one must design also for non-intended use (or misuse) of proactive technology. The social "whys" of a proactive technology cannot be entirely foreseen. Rather, it is to be expected, as always, that especially early-adopter cultures will creatively find non-intended uses for the technology, even uses that may be more widespread than the intended ones.

Our second user case, elderly people and other special groups, have begun to attract increasing attention as the potential users and subjects of proactive technology. The duality of the term "subject" is particularly instructive here, as the elderly are both perceived as actors or users of the technology, but also as subjects of its operation in a subordinate and dependent sense. An obvious example is the proactive systems designed

to augment failing memory by various assisting techniques. As an addition to (or, more worryingly, as a substitute for) personal human care, help with the problem of forgetting to take one's medication can be designed through technological solutions. A "strong" proactive design would consist, for example, of a medical pump that operates automatically, in the fashion of contemporary insulin pumps. In contrast, more within the ethos of weak proactivity, some research projects are looking into developing computer systems that would prompt the user by providing reminders based on time, location, activity or some other monitored condition. Rather than totally overruling or replacing the subject's imperfect cognitive skills, the prompting designs of proactive technology aim to empower the user in order to prolong independent living, and integration to existing social networks and caregiving patterns (see, e.g., MAPS 2003; Intille 2002). A strong design of complete dependency with a totally automatic solution would have a much higher acceptance threshold, as the potential consequences of a failure situation would also be more serious. The more powerful and autonomous the design of e.g. a medical technology, the higher are the demands for its robust and totally fail-safe operation.

Designing the Future: A Proactive Utopia

There are short, medium, and long term consequences and questions related to the development of proactive technologies. Above, we have mostly looked at the short and medium term issues of "weak" proactivity, where the existence of powerful Artificial Intelligence, nanotechnology or some other advanced forms of manipulating matter and energy are not yet available. However, scenarios of civilisations based on very advanced technologies can be illustrative as test cases that help in mapping and examining expectations and attitudes towards future technology.

In his series of Culture novels, the science fiction author Iain M. Banks describes a future space-faring civilization that exists in a post-scarcity state in close co-operation with artificial intelligences called "Minds." In a logical extension of their almost total mastery of matter, most of the members of the Culture are mortal only because immortality is considered to be bad taste. In the novel *Look to Windward* (2000),

Banks portrays a planet that is essentially a proactive utopia. The whole planet down to its least physical aspects is controlled by Minds. Humans are completely protected by the Minds if they so choose. They are usually accompanied by Mind-controlled drones glowing in different colours according to the mental state of the drones. In the event of danger, or if the human wishes for something, the drone or the other Minds it is in contact with can usually eliminate the danger or fulfil the wish, if not otherwise then through virtual reality that is indistinguishable from reality. Even reality is virtual in the sense that involuntary death is next to impossible, as in an ultimate danger a Mind can restore a human whose mind has been preserved in a "Soulkeeper."

In a setting like this, the awareness and experience of a sentient being is radically transformed. The distribution of cognitive, emotive and volitional skills and contents is much more intertwined with the proactive technology than in the society that we are familiar with. Consider a scene from the aforementioned novel, where a visitor to the Culture planet, an ambassador, while attending a party, slightly puzzled by the technological sophistication of the system overinterprets the possibilities, and after picking up something from a nearby table asks the object: "Are you edible?" The object does not answer, but the Mind controlling the orbital – overhearing everything, of course – contacts another guest at the party and so arranges help to the ambassador. In our view, there are two important points in this small anecdote from a possible future. First, coming from a different background, the interprettation, the "reading," of a highly proactive environment is bound to lead to misinterpretations, and the proactive system has to be able to deal with this. Second, and even more importantly, a highly proactive environment by its very nature prompts a change in "human" nature and the awareness that co-exists with it. The malleability and responsivity of the world in such a utopia creates a situation in which the necessary cognitive skills are quite different compared to those needed for survival in a harsh environment. Interestingly enough, in his novels Banks emphasises how the citizens of the Culture are acutely aware of and extremely skilled in social gaming, taking pleasure in the cultivation, intensification and sophistication of human (or, more generally) sentient relationships, be they intellectual, camaraderial, or sexual.

Disregarding for a moment the question of whether this kind of super-civilisation will ever be achievable, we should analyse here how the surrounding advanced proactive technology is supposed to affect the lives of individuals and society at large. An earlier Culture novel, *The Player of Games* (1988) focuses on the life of a professional game player named Jernau Morat Gurgeh. The Culture lifestyle where technology takes care of all that is non-interesting to a human mind, is well captured by the description of Gurgeh's life:

> *He took dinner on the terrace, the terminal screen open and showing the pages of an ancient barbarian treatise on games. The book – millennium old when the civilisation had been Contacted, two thousand years earlier – was limited in its appreciation, of course, but Gurgeh never ceased to be fascinated by the way a society's games revealed so much about its ethos, its philosophy, its very soul. Besides, barbarian societies had always intrigued him, even before their games had.*
>
> *The book was interesting. He rested his eyes watching the sun going down, then went back to it as the darkness deepened. The house drones brought him drinks, a heavier jacket, a light snack, as he requested them. He told the house to refuse all incoming calls.*
>
> *The terrace lights gradually brightened.* (Banks 2002/1988, 30)

The design of home environments based on a strong interpretation of proactivity has to take into account the development of strong AI. Banks's Culture civilisation is based on a symbiotic relationship with high technology, embodied and personalised in interactions with the Minds. Each technological entity, like a home, spaceship or entire Orbital (a giant space-bound living environment) has a personality and intellect of its own; this could be called the design *principle of animism* for advanced proactive functions and services. During their evolution, humans have adapted to consider each subject or actor as a social persona with reactions and feelings, whether technically alive or not (as evidenced, e.g., by studies reported in Reeves & Nass 1996). The easiest and most natural way to interact with a proactive home would be to treat it as if it had some kind of persona or other social interface of its own. Such an attitude of infusing inanimate environments with a sense of life

and purpose has, in cultural anthropology, been termed animism. In the above quote, Gurgeh converses with his house and commands its services (embodied in small drone robots) using natural language.

Talking about the philosophical, political and historical vision guiding the design of the future scenario of the Culture civilization, Banks (1994) has written that in the collaboration between Culture's AI Minds and humans, "at first the struggle is simply to survive and thrive in space; later – when the technology required to do so has become mundane – the task becomes less physical, more metaphysical, and the aims of civilisation moral rather than material." Most of the functions of his proactive living environment are trivial to Gurgeh; the lights of the terrace adapting to help him read in the darkness, for example. A more fundamental consequence of the strong AIs and proactive technologies is that Gurgeh and other people of this proactive utopia are able to dedicate their time to areas that are really satisfying – in Gurgeh's case to the history and practice of games. In Banks's words, Culture "is essentially an automated civilisation in its manufacturing processes, with human labour restricted to something indistinguishable from play, or a hobby" (Banks 1994). This can be identified as the second design principle for an advanced proactive environment: *design for play*.

The design community has started to question the universality of the principles of "experience design," where the strong and imposing orchestration (or manipulation) of experiences is at the forefront. Liz Sanders, for example, has written that collective creativity and user participation are much more desirable design goals: "If you think of products, interfaces and spaces as being scaffolds on which ordinary people can create their own experiences, the design challenge changes" (Sanders 2001, 6). It is our belief that some of the most useful applications for proactive technologies in homes are in the areas of proactively supporting social interaction, in helping and encouraging people to relax, enjoy their lives and be creative without the increasing pressures of contemporary working life. Believing play behaviour to be the free expression of people of all ages expressing their fundamentally human, creative and social impulses (cf. Huizinga 1971/1938), we propose that a major part of proactive technology research be directed towards studying new kinds of creative interactions and user-defined emergent behaviours

that are facilitated by the "semi-alive" living environment of the future. Following the work of Djajadiningrat and others (Djajadiningrat, Overbeeke & Wensveen 2002; Ferris & Bannon 2001; Ishii & Ullmer 1997) we suggest that the principle of open-ended tangible designs, where proactive services are joined to physical objects which afford multimodal, sensory-rich interactions, will provide usable and aesthetically pleasing interactions for future homes. Situating interactions with proactive systems in this kind of novel objects will help occupants identify the presence of these new functionalities, and orient their interactions with these consistently coded properties. An example of this is how, in the Culture novels, the drones are provided with colourfully glowing fields that are used for communicating emotional states with humans.

Conclusions

Much of the criticisms and apprehensions regarding "intelligent homes" are reasonable; in our analysis, a home is an intimate and personal space that, in order to fulfil its functions as a home has to be both robustly reliable and universal in its basic infrastructure, while simultaneously offering opportunities for highly idiosyncratic and personalised operations and contents.

To consolidate the two fundamental design principles, the *principle of consistency* and the *principle of personalization*, we proposed a matrix that identifies areas in both public and private environments where both these principles are effective, but to different degrees. The home can be mapped to contain various different functional zones for different people, several of them overlapping and sometimes also conflicting with the uses and interpretations of the same physical space for other people.

Looking at the challenges for ubiquitous computing in homes (as identified by Keith Edwards and Rebecca Grinter), we propose the use of an *embedded media interface*, which combines features from multimodal and ubiquitous interfaces with those of interpersonal and mass media. One of the most challenging tasks that emerges for the home proactive technologies is helping the occupant to control the boundaries of the home towards communications and media contents that are constantly, in a stimulating, welcome and/or irritating and stress-inducing manner, penetrating the limits of this private space.

Since there are several ethical concerns that have been brought forward in the context of proactive and pervasive computing, we took a closer look at this aspect of proactive technologies for two user groups: early adopters and elderly people. Evaluated according to the two principles consistency and personalization, these technologies appear to hold different potentials and risks for these two groups. The ability of technologically savvy early adopters to personalize these services makes it a natural extension of their personal tastes and preferences. The second group, elderly people and special groups (e.g., small children, people with various disabilities) confronts designers and developers, and also policy makers, with much more sensitive issues and challenges. Paradoxically, in some cases it might be preferable to refrain from the application of proactive technologies, as they always have the potential of inducing dependence. In many cases, the ethically most problematic view is the one that perceives social, psychological or health-related problems in unilaterally technological terms. Calm awareness and control can be designed by starting from the entirety of the social networks of the individuals and groups in question. Proactive systems should integrate the fabric of human relations, strengthening it, rather than the opposite.

Looking at the possible futures of proactive technology, we turned to science fiction, using Iain M. Banks's Culture novels as our source of inspiration. Relating to a world where true artificial intelligence is an omnipresent reality, these scenarios of future civilisation point towards some expectations of how the intelligent environments should be operating. These can be crystallised into three design principles:

1. *animism* (creating lifelike objects, services and interfaces to which occupants can socially and emotionally relate)
2. *design for play* (using proactive technology to support and encourage social interaction, relaxation and creativity)
3. the principle of aiming at open-ended tangible designs (multifunctional objects and materials aesthetically communicating the presence and interaction potentials associated with proactive functionalities).

Frans Mäyrä has studied the relationship of culture and technology since the early nineties, and currently works as the Research Director of the Hyper-media laboratory, University of Tampere. He has specialised on the conflicting and heterogeneous elements in culture, and published on topics that range from science fiction and fantasy to the demonic tradition, identity and role-playing games. He is currently teaching and heading numerous research projects in the development and examination of games, new media and digital culture, and is also the President of the Digital Games Research Association, DiGRA.

Publications: Koneihminen *(*Man-Machine*; ed., 1997),* Demonic Texts and Textual Demons *(1999),* Johdatus digitaaliseen kulttuuriin *(*Intro-duction to Digital Culture*; ed., 1999),* CGDC Conference Proceedings *(ed., 2002).*

Email: frans.mayra@uta.fi

Web page: http://www.uta.fi/~tlilma

Tere Vadén works as an Assistant Professor in the Hypermedia laboratory, University of Tampere, Finland. He has published papers on philosophy of mind and contemporary art and culture, including a recent book with Mika Hannula, Rock the Boat: Localized Ethics, the Situated Self and Particularism in Contemporary Art. *Köln: Salon Verlag, 2003.*

E-mail: tere.vaden@uta.fi

Web page: http://www.uta.fi/~fiteva

Notes

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