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Living in Metamorphosis - Proactive Computing in the Home Environment

The Finnish Academy of Sciences is funding a three year research programme [1] on proactive computing. The programme integrates technological innovations in hardware and software with psychological and social science research. The fourteen funded projects span the wide field of proactive computing ranging from modelling the user's behaviour to proactive health care systems to controlling the environment via a direct brain interface. The programme is organised in co-operation with the National Technology Agency of Finland and the French Ministry of Research.

Proactive systems or proactive computing is a new approach to help in understanding how intelligence should be embedded into the everyday environment [2]. It is closely related to e.g. ubiquitous computing, autonomous computing and ambient intelligence, which all deal with different aspects of the same domain of study. Proactive computing connects embedded systems and sensor technologies with a user-centric view on design, which necessitates research into which activities should be automated and which should be left to the human operator. On the other hand proactivity in its full "strong" form is an ability of the system to anticipate the needs of the user, and on the other an ability to take control of the situation whenever the user is unable or unwilling to act appropriately.

Morphome project

The research project examines the interface, engineering, design and acceptance issues related to proactive applications in a social and material, everyday environment. New solutions are needed for controlling intelligent objects and services, and for mediating awareness of their capabilities and internal state to the users. Environments that contains proactive functionalities often calls for different kinds of attitudes or actions from their users or inhabitants as compared to their non-enhanced counterparts. Proactive systems thereby require social and cultural, as much as technical research to make them successful in everyday life.

The main research problem of the Morphome project is: How the distributed, non-intrusive access and input can be designed and implemented so that it facilitates adaptive control and awareness in a proactive home environment?

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 proactive implementations embedded into its fabric. Home is an important and challenging research area: all kinds of people need to be served by the applications implemented in homes. People's primary aims there are in the areas of relaxation and social interaction. It is particularly important that people's focus should not be diverted and encumbered by system control functions in homes. Proactive technologies therefore face both great promises but also particularly tight challenges in home environments.

Very small communicating processors are embedded into every imaginable object forming a very fine grained parallel multicomputer with a user interface spread across the whole environment

The problem in studying how people understand proactive technology is similar to any advanced technology. Since people have no experience of this technology, they cannot formulate their opinions about it realistically. We build a series of "mini-designs" (the term is used in Philips Design and Technical University of Eindhoven, the Netherlands) to give people experience needed in reflecting not just technology, but also design issues involved. Mini-designs are in technological terms less advanced than prototypes, but their design is polished and aims at realism. The first mini-design, aimed primarily at studying wireless communication, power consumption, and durability in the hands of children was

a cushion implemented with RFID technology. The second design was an IKEA-style lamp: its latest version reacts to changes in sound levels. The final mini-design will be a lighting system combined with a mixed media environment. Combined with scenario-based interviews probing more advanced technological possibilities, these mini-designs helped us to give people experiences for interviews that were not based on negative stereotypes of technology.

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The information derived from the research has been relevant to all three areas: proactive technology research, research into the design of home as a material as well as social environment, and thirdly on the general design and research principles guiding the introduction of new technology into everyday life environments.

Some of the key principles suggested and supported by our research involve:

- principle of consistency (new, "invisible" and intelligent functionalities should be consistently implemented and communicated to users),

- principle of personalization (in home environments it is particularly important to provide room for individual taste and preference),
- design for play (as the guiding principle for making proactive environments supportive of relaxing social interaction),
- principle of open-ended tangible designs (to support making a proactively-enhanced home of the future also reassuring and manageable),
- principle of animism (to guide easily approachable design of places and objects that show characteristics of being alive or intelligence).

Technical interpretation of proactivity

When electronics penetrate to the everyday environment digital convergence [3] gets a new form. Besides computing, communication, and digital content there is digitalized real physical world. Real objects are controlled by computers, they can communicate with other objects digitally, they create new content to the global network by measuring the environment, and besides their traditional properties they have new functions enabled by the digital content and services. The emphasis is no longer in the information processing but rather in the events in the real environment.

((picture missing))

The second design was an IKEA-style lamp: its latest version reacts to changes in sound levels

The structure and behavior of a proactive system can be seen as a control system. Important research questions rise from the need to model the highly dynamic environment so that it can be measured and controlled in an intelligent way.

The state of the system can be described by a set of state variables describing the properties of some physical entities in the environment. In order to understand how the state of the system developes through time, a model of the behavior is needed. Most industrial processes can be described in detail using the state variables but the situation in a normal every day environment is much more complex and the number of state variables which could describe the state of the system is huge. Furthermore the relations between the state variables are not known and they change in time.

The Oxford Dictionary of American Usage and Style in English Language Reference gives two different meanings for the word proactive:

> *Proactive = (of a person, policy, etc.) creating or controlling a situation by 1) taking the initiative or 2) anticipating events; ready to take initiative, tending to make things happen.*

Thus the first meaning can be interpreted technically as the ability of the system to act autonomously without the user taking part in the control loop. The reasons why the user shoud be left out from the control loop are manifold. The requirements may be too tight and the human controller is not able to control the system accurately enough, the evolution of the system may be so slow that the user can not stay in control for such long time periods and slow changes are difficult to perceive, the evolution of the system state is too fast for a human to react correctly, or the control task is so complicated that comprehending all interactions is too difficult for a human operator.

The second interpretation is somewhat meaningless in the case of closed control systems where the future of the system is predetermined i.e. all future states of the system can be calculated given the initial state of the system. In a sense time and predicting loses their common meaning and the ability of a control system to be proactive in the sense that the system is able to predict and prepare for the future events is a built-in feature. The situation changes if the values of the control variables are changed as an external input to the system. Then the system is not closed and its future bahavior is known only until the next control action takes place. In an open system like the proactive everyday living environment the second meaning could then be interpreted as the ability of the system to anticipate the user goals on the basis of scarce and imprecise measured information.

Conclusions

How people will see the effect of the Moore's law in the future is not in the high-end supercomputers doing spectacular things, but rather in the very small communicating processors embedded into every imaginable object forming a very fine grained parallel multicomputer with a user interface spread across the whole environment. Personal computer, internet and mobile communication have all been large scale technological infrastructure developments that have produced large industrial branches and changed the way we are living. The interesting question is weather ambient intelligence in some of its form will do the same.

[1] The home page of the Morphome project is in

http://www.uta.fi/hyper/projektit/morphome/index.html

[2] Tennenhouse, David (2000) "Proactive Computing". Communications of The ACM 43:5 (May 2000), 43-50.

[3] Negroponte Nicholas, Being Digital. Vintage, New York, 1995.