Ambient Intelligence: visualizing the future

Boris de Ruyter
Philips Research
Prof. Holstlaan 4
AA 5656 Eindhoven, The Netherlands
+31 40 2744982
boris.de.ruyter@philips.com

Emile Aarts
Philips Research
Prof. Holstlaan 4
AA 5656 Eindhoven, The Netherlands
+31 40 2744982
Emile.Aarts@philips.com

ABSTRACT
As technologies in the area of storage, connectivity and displays are rapidly evolving and business development is pointing to the direction of the experience economy, the vision of Ambient Intelligence is positioning the human needs central to technology development. Equipped with a special research instrument called HomeLab, scenarios of Ambient Intelligence are implemented and tested. As two examples of bringing real user experiences through display technology into the digital home, research on creating the feeling of immersion and the feeling of being connected, are discussed. Results from this work indicate that visual displays can indeed be used beyond simple information rendering but can actually play an important role in creating user experiences.

Keywords
Ambient Intelligence, HomeLab, user experiences

1. INTRODUCTION

1.1 Technology trends
Performance indicators of technologies in the area of processing power and wireless connectivity are increasing rapidly. Following the generalized Moore's law, these indicators double every 18 months (see Figure 1). In terms of storage capacity for example, we see the emergence of high capacity optical storage media (today up to 22 Giga Bytes) small enough to be integrated in many devices including portable systems. Connectivity is being supported by many different standards going from short-range wireless (low power) to full in-home networks for streaming high quality multimedia content.

With such technological developments, scenarios sketching ubiquitous access to digital content and supporting natural user – system interaction, have become reality.

1.2 Waves in business development
In their recent book Pine and Gilmore [1999] describe a new economy that they call the experience economy. They position this economy as the fourth major wave following the classical economies known as the commodity, the goods, and the service economy. This is probably best explained by means of the changing role of coffee in economy. Coffee first came in beans that were shipped all over the world as a commodity for which a certain prize per unit volume was charged. Next, people came up with the idea to roast, grind, and package the beans and sell them as goods, and prices per unit volume went up, which was the reason to do so. Next, people added hot water to the coffee and poured it out as a service, and again prices went up. Finally, if you have a cup of coffee at the top of the Eiffel tower you have an experience, and you pay some ten dollars.

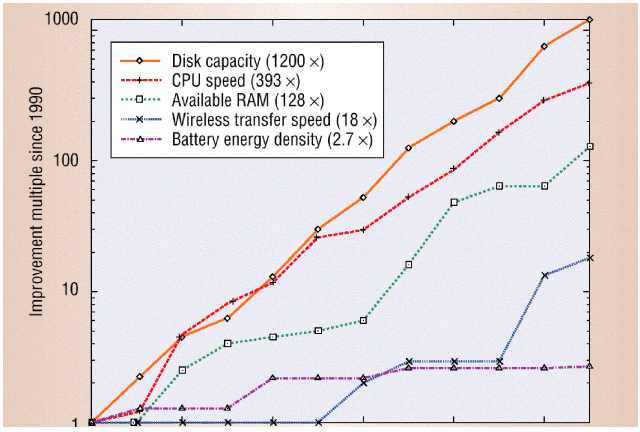

Figure 1: Generalised Moore's law for trends in storage, CPU, memory, wireless connectivity and battery technology (from IEEE Computer Magazine)

The general believe is that people are willing to spend money on having experiences, and the holiday economy indeed shows that this might be very well true.

1.3 The history of the vision
Ambient Intelligence refers to electronic environments that are sensitive and responsive to the presence of people. The notion of Ambient Intelligence was proposed in 1998 in a series of workshops that were organized within Philips, and that were commissioned by the board of the management [Zelka, 1998]. The workshops were aimed at developing different scenarios that would lead a high volume consumer electronic industry from the current world which was called fragmented with features into a world near 2020 with fully integrated user friendly devices supporting ubiquitous information, communication, and entertainment. Palo Alto Ventures, a US management consultancy company, acted as the facilitator, and they involved several Philips departments including Research, Design, and Global Brand Management.

The first official publication that mentions the notion "ambient intelligence" appeared in a Dutch IT journal [Aarts & Appelo, 1999] and emphasized the importance of the early work of the late Mark Weiser who already for more than ten years was working on

a new concept for mobile computing which he called ubiquitous computing [Weiser, 1991]. From a technological point of view this concept has been very influential and it can be viewed as the starting point for several new developments including IBM's pervasive computing and Philips' Ambient Intelligence. From the point of view of industrial design we need to mention the work of Philips Design who through a number of large projects such as Vision of the Future and La Casa Prossima Futura managed to visualize persuasively a world in which the current demanding consumer products would be replaced with new products that support greater ease of use [Philips Design, 1996; Philips Design, 1999].

In the mean time the vision grew mature. Along with the build up of the vision for Philips, a parallel track was followed which was aimed at positioning the vision as an open initiative for the advancement of the innovation in information and communication technology in Europe. During a series of workgroups organized by ISTAG (Information Society and Technology Advisory Group) which serves as an influential advisory board to the European Community, the vision of ambient intelligence was adopted as the leading theme for the sixth framework on IST research in Europe [ISTAG, 2000]. This major achievement will result into a subsidiary European research program with a budget of 3.7 billion Euro over the forthcoming four years focused on research in the domain of ambient intelligence.

At the same time the vision was recognized as one of the leading themes in computing science by the Association for Computing Machinery (ACM), and as a result thereof a book chapter on ambient intelligence was invited to the book The Invisible Future [Aarts, Harwig & Schuurmans, 2001]. The book was published at the occasion of the ACM1 conference, which was aimed at providing the electrical engineering and computer science community of the world with new insights into the future of computing at large. In addition to the chapter on ambient intelligence the book contains a wealth of contributions from various renowned scientist in the world expressing their vision on a variety of subjects ranging from computer hardware and programming up to health, education, and societal issues.

The ambient intelligence vision has also been used by Philips Research to establish new and promising collaborations with other strong players in the field. In 1999 Philips Research joined the Oxygen alliance; an international consortium of industrial partners that collaborated within the context of the MIT Oxygen project. The Oxygen project is a joint effort of the MIT Computer Science Laboratory and the Artificial Intelligence Laboratory, and it aimed at developing the technology for the computer of the 21rst century. It allows multi-modal controlled handheld communication units to connect through environmental units to a broadband communication network, thus supporting ubiquitous information access and communication. Several technological results obtained in the Oxygen project have found their way to HomeLab. Examples are the Cricket location detection technology and speech and vision technologies. Another example of an international ambient intelligence based activity is the joint virtual laboratory that was established in 2000. The activity involves Philips Research, INRIA and Thomson Multimedia in a project called Ambient Intelligence Research and Development (AIR&D), and is aimed at developing software platforms for ambient intelligence applications in the home. Also this project has proved quite successful and first results have become available to HomeLab in terms of middleware supporting intelligent broadband services.

In the summer of 2002 a project was launched in a joint effort of Philips Design and Philips Research that was aimed at writing a book on ambient intelligence. The book should consolidate the position of Philips as the intellectual leader in the field of ambient intelligence. On March 1rst 2003 The New Everyday was published [Aarts & Marzano, 2003]. The book contains over 100 contributions on ambient intelligence on a broad range of topics ranging from materials science up to marketing and business models. Most of the contributions are from Philips authors, but about ten of them are from renowned specialists emphasizing various aspects related to ambient intelligence ranging from promising new applications to critical remarks that warn for the possible societal disorientation that might result from ambient intelligence. The books is a unique object because its covers the subject of ambient intelligence from a remarkably broad perspective, thus providing a solid basis for future discussions of the subject in all its relevant respects.

After its five years of steady development we can safely state that the ambient intelligence vision has reached a well-recognized status of maturity. It has been adopted by Philips as a strategy for the company, and it has been recognized by the European Commission as a research directive for the IST 6th Framework. Both inside and outside Philips the build up of the vision will continue and the HomeLab will play a prominent role in the studies on feasibility and usability aspects of ambient intelligence. We need to continue evangelizing the vision throughout Philips and Europe in order to make it come true.

1.4 Ambient Intelligence research

Conducting research in the area of Ambient Intelligence requires different research methods and tools: since the emphasis is on creating user experiences through environments that are perceptive and intelligent, there is a need for more holistic user – system interaction research. Traditional usability engineering methods and tools fail to deliver here. Established organizations such as the Usability Professional's Organization have recognized the need for new approaches to usability testing [Branaghan, 2001].

In 2000 first serious plans were launched to build an advanced laboratory that could be used to conduct feasibility and usability studies in ambient intelligence. After two years of designing and building HomeLab was eventually opened on April 24, 2002 by Gerard Kleisterlee, the president of Philips Electronics. On the occasion of the opening an international technology seminar was held and a booklet was published explaining the purpose and the ambition of HomeLab [Aarts & Eggen, 2002]. The opening event officially marks the start of the ambient intelligence research in HomeLab. Since then HomeLab attracted much attention from the

press. In less than a year there were over 25 coverages of the subject appearing on television including Discovery Channel and more than 100 press articles have been published in a large variety of journals ranging from Focus to The Wall Street Journal. More than 150 visits to HomeLab were organized and frankly speaking it has become a real challenge to see to it that HomeLab adheres to its original objective of being a research facility because there is a continuous and natural pressure to turn it into a showcase.

2. HOMELAB

The HomeLab is build as a two-stock house with a living, a kitchen, two bedrooms, a bathroom and a study. At a first glance, the home does not show anything special, but a closer look reveals the black domes at the ceilings that are hiding cameras and microphones.

Figure 2: the HomeLab living room

Adjacent to the Home there is an observation room. From this room you have a direct view into the home. The signals captured by the cameras, can be monitored on any of the 4 observation stations. Through an observation leader post (see Figure 3) signals can be routed to these observation stations. The observation leader modifies camera set-ups, routes video and audio signals, and monitors the capture stations. Each observation station is equipped with two monitors and one desktop computer to control the cameras and to mark observed events. The marked events are time-stamped and appended to the video data. All captured signals and marked events are recorded by means of the four capture stations.

Broadband Internet facilities enable various ways to connect parts of the HomeLab infrastructure to the Philips High Tech Campus network or even to the outside world. A wireless Local-Area Network (LAN) offers the possibility to connect people in HomeLab without running cables. However, if cables are required, double floors provide nice hiding places. Corridors, adjacent to the rooms in HomeLab, accommodate the equipment that researchers and developers need to realize and control their systems and to process and render audio and video signals for the large flat screens in HomeLab.

A power control system features remote controllable light settings and power switches. But it still leaves the possibility for participants to simply turn on and off the lights by using 'ordinary' switches. Future intelligent systems that aim to enhance people's emotions and experiences by means of lighting will be able to interface with the HomeLab power control system.

Figure 3: the observation leader post

When setting up an experiment in HomeLab, the researcher designs a coding scheme for the observation session. A coding scheme lists all prototypical behaviors that are expected to be observable during the session. The occurrence of these behaviors is marked during the observation session. Further analysis of this data can consist of a simple frequency analysis up to a sophisticated data mining analysis for finding hidden patterns in the data set. This latter technique has been adopted in other research areas and is now being deployed in the area of user – system interaction research [Jonsson, G.K., Bjarkadottir, S.H., Gislason, B., Borrie, A. & Magnusson, M.S., 2003].

2.1 CASE STUDIES

In traditional user – system interaction research, displays are positioned as rendering devices for huge amounts of information. In fact, research into information visualization is continuously investigating new techniques for increasing the multitude of information that can be presented to users with the aim of increasing efficiency in human information processing. In our work we will highlight some concepts that are developed to go beyond the rendering of huge amounts of information. The focus is on the creation of user experiences by means of display technology.

2.1.1 The feeling of being together

The introduction of advanced technologies such as interactive TV has not resulted in the expected behavioral change of consumers. We contend that one of the most important causes for this has been the absence of sufficient content to offer attractive user benefits. Consequently our research in the Philips HomeLab explores the potential user benefits from interconnected CE devices.

One such benefit is social presence, which refers to the sensation of 'being together' [IJsselstein, de Ridder, Freeman & Avons, 2000] that may be experienced when people interact through a telecommunication medium. As connectivity permeates our daily lives we expect that network infrastructures will become enablers for social interactions. While communication media such as e-mail, telephony, text messaging services for mobile phones, etc., are common, there is more to system-mediated communication than exchanging information.

Our research on the feeling of being together has been focusing on the potential of attaining social presence by maintaining a peripheral awareness of a connected person or group of persons, when consuming content such as a broadcasted program [De Ruyter, B., Huijnen, C., Markopoulos, P., Ijsselstein, W., 2003]. This research assesses affective benefits that arise out of this interconnection and illustrate the positive impact of awareness on social interactions.

When developing the concept for creating this user experience, special attention was paid to: (i) safeguarding the privacy of the home environment, (ii) minimizing the shift of user attention away from the actual content being consumed and (iii) creating the feeling of being connected when consuming content over different locations.

This concept is embodied by means of presenting sketch like visualizations of the physical activities in the remote location.

Figure 4: augmenting content by sketch like visualizations

2.1.1.1 The user study

In total 34 participants, all Dutch males, participated in the experiment. They were recruited as groups of friends who enjoy watching soccer games. The groups were split (2-1) and the participants were placed in two different rooms. During the experiment all participants watched the same soccer game. Although they knew they were watching the same soccer game they did not know that they were in the same building.

The amount of visual information the subjects received about their friend(s) was varied over the different conditions and would range from: no visual information, a sketch like visualization representing physical movements of the people at the remote location (see Figure 4) and a full motion video of the remote location. Social presence and Group Attraction were measured after each condition by use of standardized psychometric instruments available in literature.

2.1.1.2 Results

The results from this study indicate that a low bandwidth visualization of the physical activities from remote locations is capable of establishing a sense of social presence. Furthermore, the feeling of being part of a group (i.e. group attraction) was increased.

When compared with the full motion video, the sketch visualization gave participants not so much the feeling of being observed by the remote location. This latter aspect of the sketchy visualization could be of great importance to create social presence enabling systems for the home environment: earlier research has shown that privacy considerations are a major obstacle for the acceptance of video communication at the home.

Test participants indicated that they would prefer different levels of social presence for different kind of programs. People prefer to watch sports and movies in presence of others, whereas they prefer to watch news and documentaries alone. They do not want to be disturbed while concentrating on more serious programs. For entertaining programs, viewers enjoy making a cozy atmosphere and to experience other person's reactions.

2.1.2 The feeling of being immersed

A favorite leisure activity of many is watching movies, either in the cinema, or at home. The way we watch movies at home has changed much since the first television was introduced: from black-and-white to full color, from mono to stereo to surround sound. In their research on creating immersive experiences, Elmo Diederiks and Jettie Hoonhout developed and tested the Living Light concept in the Philips HomeLab. The Philips Living Light system can be considered as the next step in the Home Cinema Experience. It offers light ambiances and light effects for film and music.

The system comprises four LightSpeakers (left-right front-back), a CenterLight and a SubLight, which is situated underneath the couch. Light scripts for selected pieces of film and music have been developed in conjunction with light designers, theatre lighting experts, filmmakers and musicians. This system has been installed in the living room of HomeLab, to provide the right context for experiencing this concept.

2.1.2.1 The user study

The concept has been evaluated with specified user groups, primarily to determine its appeal in terms of acceptance, usability, and excitement.

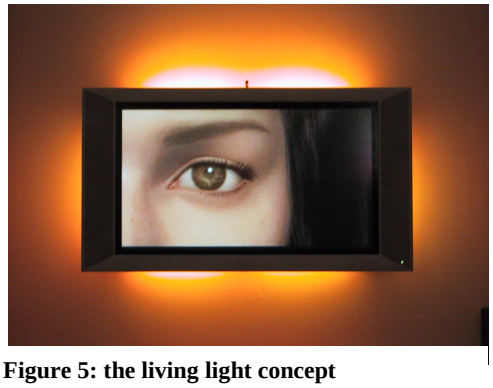

Figure 5: the living light concept

The secondary purpose was to collect additional information on possible improvements of the concept from a user point of view. Also, participants' opinions were collected regarding the appropriateness of the light settings that were presented. The 32 participants were representative for the target group: they had a keen interest in watching movies or listening to music at home. Half of the participants were shown film and the other half were asked to listen to music, both were enhanced by light ambiance settings and light effects provided by the Living Light system.

2.1.2.2 Results

The evaluation of the concept points out that Living Light is a potential winner concept as participants highly appreciated the concept. The concept truly appealed to the participants, especially in case of film. Participants indicated that the lighting made watching movies or listening to music a very enjoyable and a more immersive experience.

In addition, participants indicated that they would like use such a system to create the right Ambiance in the Home, e.g. when having friends over for dinner, or for enjoying an evening at home with the family. Light is seen as a key factor in creating the right setting and ambiance at home. Current technologies do not provide sufficient and easy to use means to create the desired light settings. The fact that the Living Light system offers possibilities to manipulate for example color temperature and intensity was therefore highly appreciated. These findings provided additional directions for future research: lighting concepts that offer solutions that take away the hassles of setting up appropriate lighting, and in addition provide extra means to enhance activities and create enjoyable ambiances.

3. Conclusion

While technologies are evolving rapidly the importance of creating user experiences in user – system interaction is observed. Using the HomeLab two examples of creating user experiences through display technology have been discussed. The research results of this work suggest that user benefits such as the *feeling of being together* and the *feeling of immersion* are highly appreciated by end users.

4. ACKNOWLEDGMENTS

Building the vision has involved many people, realizing this vision involves even more people. Special acknowledgements to the many researchers involved in HomeLab projects.

5. REFERENCES

[1] Aarts Emile, and Lisette Appelo (1999), Ambient intelligence: thuisomgevingen van de toekomst,

[2] IT Monitor 9/99, pp. 7—11, (in Dutch).

[3] Aarts, Emile, Rick Harwig, and Martin Schuurmans (2001), Ambient Intelligence, in: P. Denning, The Invisible Future, McGraw Hill, New York, pp. 235—250.

[4] Aarts, E.H.L., and B. Eggen (editors) (2002), Ambient Intelligence in HomeLab,Neroc, Eindhoven., The Netherlands.

[5] Aarts, Emile, and Stefano Marzano (editors) (2003), The New Everyday: Vision on Ambient Intelligence, 010 Publishers, Rotterdam, The Netherlands.

[6] Bowman, B., Debray, S. K., and Peterson, L. L. Reasoning about naming systems. *ACM Trans. Program. Lang. Syst., 15*, 5 (Nov. 1993), 795-825.

[7] Branaghan, R.J, (2001). Design by people for people: essays on usability, Usability Professional's Association.Dertouzos, M (1999), The Future of Computing, Scientific American 281(2), 52-55.

[8] De Ruyter, B., Huijnen, C., Markopoulos, P., Ijsselstein, W., (2003). Creating social presence through peripheral awareness, HCI International 2003, Crete June 22-27, Greece.

[9] IJsselsteijn, W.A., de Ridder, H., Freeman, J., & Avons, S.E. (2000). Presence: Concept, determinants and measurement. Proceedings of the SPIE, 3959: 520-529.

[10] ISTAG (2001), Scenarios for Ambient Intelligence, European Commission, www.cordis.lu/ist/istag.html.

[11] Jonsson, G.K., Bjarkadottir, S.H., Gislason, B., Borrie, A. & Magnusson, M.S. (2003). Detection of real-time patterns in sports: interactions in football. L'éthologie appliquée aujourd'hui. (C. Baudoin, ed), Volume 3 - Ethologie humaine. Levallois-Perret, France: Editions ED. ISBN 2-7237-0025-9.

[12] Philips Design (1996), Vision of the Future, V+K Publishing, Bussum, The Netherlands.

[13] Philips Design (1996), La Casa Prossima Futura, Philips Design, The Netherlands.

[14] Pine, J. & Gilmore, J.H. (1999). The Experience Economy - Work Is Theatre & Every Business a Stage, Harvard Business School Press, April 1999.

[15] Weiser, M. (1991), The computer for the twenty-first century, Scientific American 265(3), 94 -104.

[16] Zelkha, E. (1998), The Future of Information Appliances and Consumer Devices, Palo Alto Ventures, Palo Alto, California, (unpublished document).