Performing in Ambient Narratives: Supporting Everyday Life Performances with Technology

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Introduction

Ambient Intelligence (Aarts 2003) is a vision on the converging future of consumer electronics, telecommunications and computing in which devices and technology move into our surroundings until only their user interface remains. By moving devices in the background of our lives, the user performance and experience automatically move into the foreground. Ambient Intelligence takes a human-centric view on computing and aims to improve the quality of our life by creating the desired atmosphere and functionality via intelligent, personalized interconnected systems and services.

Several technological trends move this Ambient Intelligence vision closer to reality: First, increasing miniaturization of computer processors and storage have made it possible to put microprocessors not only in desktop and laptop computers but also in mobile phones, portable MP3 players and even tiny wearable sensors so small that they can almost completely disappear in the background (Weiser 1991). Advances in networking technology (wireless networking, Internet) allow these devices to talk to each other and work in concert on behalf of the user in an easy, unobtrusive way. New multimodal user interaction techniques make interacting with computers much more natural: Next to ordinary keyboards, mice or remote controls we may use voice, touch or gestures to control the devices that surround us. Finally, artificial intelligence and machine learning algorithms may help us to teach devices how to respond and interact with us.

The goal of Ambient Intelligence is to help people in performing their daily activities better, by making these activities more convenient and enjoyable: by introducing interactive media. Notice the word *performing* in this description. The word 'performing' is so commonly used in our language that we forget that performances are pervasive to every culture. Performances are not just seen in the theatre, music, dance and performance arts in general but also in our everyday lives: We perform the role of a father or son in our private lives but maybe

also that of a doctor, judge or police agent for example in our professions. In order to understand where and how Ambient Intelligence can be applied to support these performances, a better insight is needed into what performances are and what it means to perform.

The purpose of this article is to draw attention on these everyday life performances and show the possibilities and limitations of current Ambient Intelligence applications with real case studies.

The article is structured as follows: First, we discuss in more detail how understanding performance is important to us. Then we describe a number of examples in the home and professional environments and illustrate how ambient technologies can be applied to improve these performances. The advantage of the performance-centric approach towards Ambient Intelligence is that technology is really shaped and designed around specific user wants and needs. But there are also disadvantages. In the second part of the article we investigate the limitations of current Ambient Intelligence environments and argue for a different view where the final experience is not carefully planned and staged for each performer but the result of an active co-creation process between the performer that is free to make choices and the environment that imposes meaning, restrictions on him.

Everyday Life Performances

Because performances vary so widely from medium to medium and culture to culture, it is hard to pin down an exact definition for performance. Schechner (Schechner 2002) defines performance as "ritualized behaviour conditioned/permeated by play" or "twice-behaved behaviour". When people are performing, they show behaviour that is at least practiced once before in a similar manner. In traditional performance arts this behaviour can be detected easily: Actors in a theatre play, opera or movie rehearse their roles off-stage and repeat this behaviour when they are on stage. But this twice-behaved behaviour can also be seen in a priest conducting a wedding ceremony, a surgeon operating on a patient or a McDonald's service employee behind the counter. Even in our own homes, people show signs of this repeated behaviour. This happens for example during everyday rituals, like brushing teeth in front of a mirror in the morning, watching a soccer match with friends, or, coming home from work in the evening like in the example scenario.

Although many different perspectives on performance studies exist, they agree that people follow culturally specified social scripts that influence each other. These social scripts may differ from culture to culture and time to time but no culture exists without those scripts (Goffman 1959).

Viewing life as social theatre is interesting for us for two reasons: First, if people behave according to social scripts, we may succeed in codifying interactive media applications to support people in carrying out these scripts. Just as lighting and sound effects add to the overall drama of a theatre play, Ambient Intelligence may thus be applied to enhance the performance described by these social scripts. Second, positioning Ambient Intelligence in performance theory may open up a well-studied and familiar frame of reference for the design of Ambient Intelligence environments and the underlying technology, as we will discuss later.

Case Study: Tooth Brushing

Many social scripts are enacted at home. The home people live in can be seen as a stage on which they perform everyday rituals, such as brushing teeth, going to work or watching a soccer match. Figure 2 shows a cartoon projected on a Philips mirror TV (a one-way mirror with an LCD screen behind) that invites the small child standing in front of the mirror to brush his teeth for two minutes. The cartoon carries the child through this daily task. It would be too easy to say that we can create an optimal experience by making a task more effective or more entertaining. A better explanation of what an optimal experience is, is perhaps provided by psychologist Mihaly Csikszentmihalyi, who argues that happiness is not so much a result of finishing a task but more about being immersed and engaged in the process of performing the task. Only then do we get into a state of 'flow' (Csikszentmihalyi 1991) and optimal experience. In the mirror TV example, the cartoon shifts the attention of the child from achieving the end result to the process of getting there. The cartoon increases the flow of the activity by improving the level of engagement. Many children (and adults) love the demonstration and want to play along but it has yet to be proven whether the effect is also positive on the long term when the novelty of the cartoon wears off and people
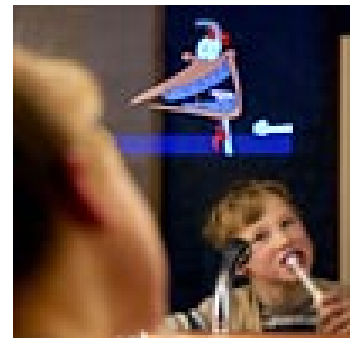

Figure 1: Enhancing everyday life performances with Ambient Intelligence

start to try out different things (e.g. what happens if I do not brush my teeth?).

At first glance there seems to be no audience present. But if we look closer at Figure 1 we see that the child is performing his act, the toothbrush performance, in front of the cartoon character. But we might also say that the cartoon character is performing in front of the child. It turns out that people are treating computer characters as real people and see these characters, perhaps on a subconscious level as an audience that watches their everyday life performances. The more computer characters represent real people, the more people expect that these characters to behave like real people. In the "Media Equation: How People Treat Computers, Television, and New Media Like Real People and Places" authors Nass and Reeves (Nass 1996) present a series of psychological experiments that show that people are polite to computers, react differently to male and female voices, and that large faces on a screen can invade a person's body space for example. The Media Equation tells us that we have higher expectations from a human-like virtual character that it will behave intelligently than for example from an animal-like virtual character. This teaches us that we must be careful to pick virtual characters that are believable as audience. People are more forgiving towards a virtual bird that often occasionally does not recognize a spoken sentence than a human-like virtual character.

Case Study: Examining Patients

The central role of performances is also reflected in business literature about services. Pine and Gillmore (Pine 1999) talk about an experience economy in which work is theatre and every business a stage. They argue that staged experiences are valued higher by customers than delivered services, manufactured goods or extracted raw materials. Experiences fulfil a larger subset of customer needs, so customers are willing to pay a higher price. Rifkin (Rifkin 2001) further argues that in this experience economy, culture itself is being pulled into the commercial sphere. Entertainment parks, themed shopping malls and organized tourist travel are just some examples where people no longer buy things, but pay to gain access to services and commoditised culture. Earlier research on service marketing by Fisk and Grove (Fisk 1992) discusses a theatre framework for service marketing, in which services are seen as performances, front-end service personnel as actors, the service setting as the stage on which the service is performed,

products used in the services as props and the business process of the service as the script. Empirical evidence suggests that the 'servicescape', the environment of the service, plays an important role in how people perceive a service encounter (Bitner 1992).

Figure 2: Enhancing a medical examination room with interactive, situated media

This suggests that Ambient Intelligence can also be applied in professional service encounters to enhance the atmospherics of a service encounter and thereby the perception or performance of a service in a positive way.

Consider for example a medical imaging room in a hospital. Many patients feel frightened by the bulky equipment in the examination room of a hospital. By enhancing this environment with immersive media, e.g. by projecting video clips on the walls and ceiling of the examination room, patients may feel more at ease, as illustrated in Figure 2. This immersion effect is much stronger than a picture against the wall at the dentist office for example. Philips Medical Systems demonstrated this concept together with Philips Design in the ambient experience pavilion at the Annual Meeting of the Radiological Society of North America (RSNA) in December 2003 where it received a lot of interest.

In practice, it turns out that patients go much faster under the medical imaging device and feel less anxious with this ambient experience than without it.

In this case the performance is not intensified as in the tooth-brushing example by putting extra focus on tooth brushing. Ambient technology is used here to draw attention *away* from the process: The patient is given something pleasant or personal (e.g. family pictures) to focus on. By choosing the atmosphere of the imaging room the patient has regained some control in a situation where he must give control completely away.

Case Study: HomeLab

The medical examination room and bathroom mirror TV cases are clear examples of media-enhanced environments that

are designed to support everyday life performances in private or public spaces but there are many more of such examples of Ambient Intelligence. At Philips Research, everyday life performances can be monitored in a controlled environment. HomeLab (Figure 3) is a normal house with a living room, kitchen, bedrooms and a bathroom but is equipped with many microphones and video cameras in the walls and ceilings. These microphones and cameras allow researchers to study how people perform, how they interact with new ambient technology in a natural environment. The first prototypes of Ambilight TV (Ambilight) have been evaluated in HomeLab with real users to see if users were interested in the concept. Users were invited to HomeLab and asked to watch a movie with and without Ambilight. Most users felt the feature was really adding something to the TV viewing experience. The positive comments and user feedback afterwards have helped to shape the concept further and transfer it to the business. Another example of technology that was evaluated in HomeLab is the Mirror TV in the toothbrush case we described earlier. In experiments and HomeLab tours we notice that people often forget the presence of the observers and the microphones and video cameras that surround them. Informal interviews after tours and experiments often confirm this.

Figure 3: Observing how people perform in HomeLab

One possible explanation could be that we are getting more and more used to the idea that we can be watched. Today, we can chat online and see each other with webcams. We can take and send photos anytime and everywhere with our mobile phones with built-in cameras. After 9-11 and the bombings in Madrid and London security cameras have also become ubiquitous. Perhaps we are starting to accept cameras and microphones in our home. Are the visions of Foucault, Orwell and many other thinkers becoming a reality? Are businesses and technology taking over our lives and disciplining us to the maximum? The reverse seems to be happening. Companies have gotten out of touch with their customers and consumers now have the ability, means and motivation to take interaction with companies in their own hands. Business and (ambient) technology will have to move in a

supporting role. Another explanation is that people are so immersed in the experience (the visit of HomeLab and seeing new exciting technologies at work) that they forget there are cameras and microphones recording them.

Ambient Narratives

The advantage of the performance-centric approach towards Ambient Intelligence in HomeLab is that technology can really be shaped and designed around specific users. But there is also a downside to this approach: The development of technology from a user point of view leads to solutions that are often hard to reuse. The effort spent to create a new application remains high. For examples such as Ambilight and Mirror TV this poses no real problems because they provide the same experience to everybody, but this is not true for Ambient Intelligence in general. To meet the needs and wants of many people, we need technology that allows us to customize these smart environments on a mass, low cost basis. Therefore a different is needed. In the next sections we will show how a mass customization approach can be implemented in the ambient narrative concept. Before we discuss the concept of ambient narratives in more detail, we first give an example to illustrate the concept.

Example

Solana comes home after a busy day at work in her apartment in Madrid. Solana switches the electronic window to a panoramic view on Paris, the city where she grew up. Immediately the sounds of Paris flood the room. After a while she sees a message appearing on the screen. "Hi, it is me, Ernesta. I am not feeling too well today. Can you call me back?" Solana recognizes the voice, it is Ernesta her virtual

Figure 5: Performing in Ambient Narratives

twin-sister. Solana calls the number and Ernesta appears on the window. She does not look too happy. "My boyfriend just broke up with me. I need somebody to talk to." "Do you want to tell me what happened while we do our workout?" Solana replies. Ernesta smiles and gets ready for the workout programme. Ernesta tells her story and
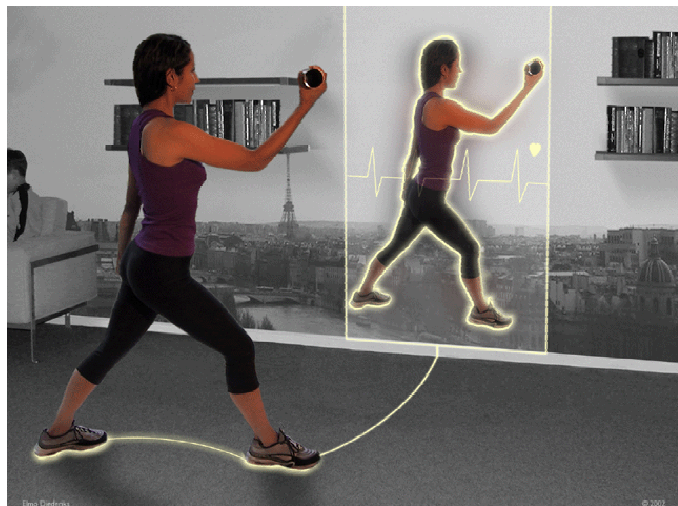
Solana listens as they work out. After the exercise Ernesta looks somewhat happier and the clouds over Paris are breaking up. The lights in the room turn yellow. Solana feels better.

Mass Customization in Ambient Narratives

If we take a closer look at the example we see that by making choices in her environment, by performing, Solana creates an experience, which carries a lot of meaning for her. Solana is not just working out for herself; she is helping her virtual twin-sister too. The example reveals two important elements of *ambient narratives* that will be analyzed in more detail: Participation and meaning.

In relation to meaning it is interesting to briefly consider the meaning of the word 'experience'. In German (and Dutch) there are two distinct words for the English word experience (Boswijk 2005). Experience can mean an 'Erlebnis' or an 'Erfahrung'. An 'Erlebnis' is any ordinary event that we witness such as a lamp that goes on when we enter a room. An 'Erlebnis' can become an 'Erfahrung' if the event marks a turning point in our life. These events can be personal events such as a wedding or the sudden death of a close relative or they can be historical events like 9-11. Current Ambient Intelligence thinking is focused on enhancing functionality with technology, on experiences as in the word 'Erlebnis'. The Solana example and to a lesser degree the use cases on the other hand are much more aimed at creating a more meaningful and memorable experience, on experience as in the word 'Erfahrung'. The workout session Solana experiences, has a strong narrative component that turns the 'Erlebnis' in an 'Erfahrung'.

The meaning carried in the narrative is one important element, participation or interactivity is another. To understand the element of participation it is helpful to analyze the experience creation process. If we look at how experiences are formed it becomes clear that experiences are formed in a subject-determined, reflexive and involuntary way (Schulze 1992): We may choose the situation we are in (e.g. you decided to read this article) but we cannot control how the situation will affect our inner mind. We can reflect back on the experience and notice that it happened involuntary. Since we are always both subjects and objects (exposed to environments that generate meaning) at the same time, both the subject-oriented approach of performance studies and the object-oriented side of traditional literature

studies and semiotics can provide a deeper understanding in this process of experience formation.

To create natural and memorable experiences a balance is required between the freedom to interact when we perform and the structure that is imposed on us by our environment. This tension is well known in interactive narrative or interactive drama (Murray 1998) where readers or performers can change, alter or otherwise affect the story told. Too much interactivity and we feel lost in a graphical computer adventure game; too much structure and we feel as if our choices do not matter anyway. Well-designed interactive narratives carefully balance these two views.

When most people think about interactive narratives they think about electronic text (hypertext) or adventure games. If we stretch our definition of what text is and what reading is, we can see many more forms of interactive narrative. Consider paintings. Perspective is often used as a technique to convey different stories to people. Figure 4 (left) shows the famous painting of Spanish Surrealist Salvador Dali, Apparition of Face and Fruit Dish on a Beach (1938). If you look closely at this painting you'll see four different stories: A dog, fruit in a dish, a face and a desert landscape with the sea in the background. Depending on the way you look at this painting, a different story is told to you. Architecture is another example of interactive narrative. Depending on the way you walk through the Rijksmuseum in Amsterdam (right) for example a different history is told to you through the paintings and text on display.

Figure 4: Other forms of interactive narrative

If we strip the perceptual characteristics of these examples of interactive narrative, what essentially remain are complex, interrelated sign systems. These signs and symbols can be interpreted or read as text. If

we superimpose these different interactive narrative forms on each other, a single, interactive *ambient narrative* emerges.

An ambient narrative has the following characteristics:
- Interactive: Readers can create their own experience, their own story by making choices in the ambient narrative. Their actions change, alter or otherwise affect the story told.
- Situated in mixed reality: An ambient narrative is neither fully virtual nor physical, it combines the virtual and real world. A reader may trigger a music or video fragment by standing in front of a painting or change the light atmosphere by walking into the room for example.
- Designed to support everyday life performances. Enhancing the performance of everyday life performances may not necessarily mean increased functionality. In many situations the goal will be to create more meaningful and memorable experiences.

We can look at ambient narratives from a reader's or a writer's point of view. From a reader's point of view interacting with the ambient narrative creates a personal experience, a personal story, the workout experience in our example. Ambient Intelligence is a part of this experience. More precisely, it is that part of the experience that is conveyed through the devices that surround the reader/performer. From a writer's point of view, an ambient narrative consists of many possibilities, storylines that readers such as Solana can explore. The experience designer who composes the ambient narrative must create a place that supports *story making* and that will last a memorable experience in the minds of the people who visit it. This requires a holistic view towards (landscape) architecture, interior and product design, human computer interaction and performance. Each of these disciplines can be of great help to support everyday life performances, but they need to work in concert to create the most memorable and meaningful experiences and transformations. Ambient narratives can perhaps be regarded as a form of Alternate Reality Games (McGonigal 2003). But while most Alternate Reality Games seem focussed on entertainment, we believe this is only one possible genre for ambient narratives.

It will be clear that the concept of ambient narratives implements a mass customization strategy because end-users can customize their own product, their own ambient intelligent experience by making choices in the ambient

narrative that have been designed in advance by the designer of the ambient narrative. However, we may go a step further as we discuss next.

Co-creation in Ambient Narratives

Often there exists a clear separation between readers and writers of ambient narratives. When we visit a theme park or themed shopping mall, we can interact with an environment that has been designed in advance by the designers of the theme park or shop. In our example, Solana can have the impression that she creates a unique story, but in reality she may be choosing between different story lines written in advanced by the designer of the ambient narrative. The plot structure is fixed and does not evolve.

This separation of readers and writers, of consumers and producers does not have to be fixed however. Weblogs and Wiki sites, Podcasting, live action or massive multiplayer on-line role-playing games are just some of the many examples where individual people are not just reading the interactive narrative but are also adding and removing material, i.e. writing text by their performance. In our case, Solana may have written that she has broken up with a boyfriend a few months ago and that she grew up in Paris. This information could have *generated* the plot structure Solana is exploring and experiencing now. If Solana had been in the same situation as Ernesta, the experience could be so much more rewarding and meaningful to Solana.

The more we can participate in such an experience co-creation process, the more realistic and life-like the final experience becomes. In our everyday life we are both readers and writers at the same time: Interaction with our environment changes us but at the same time we affect and alter the environment. Our actions do not only create new stories, they also affect the possible stories that can be made by ourselves and others. In this process of reality making, possible futures ready to be explored are being made and destroyed all the time.

The more we participate in this co-creation process, the more we also seem to change from readers into performers: The object-oriented view on the individual that is exposed to environments that impose meaning upon him, moves into the background while the subject-oriented view becomes more important. There does not appear to be a clear line between reading in an interactive narrative and performing in an interactive drama. The more we

create text as performers in the interactive narrative/drama, the more authority we may have and the more visible the author becomes in the performer.

The inseparability of reading and writing has many consequences for technology and business. Technology must be designed in a very specific way to support this form of co-creation. Pogo (Decortis 2002) is an example of an environment that supports storytelling for children. Media Fabrics (Davenport 2004), a project at MIT Media Lab is another example of an environment where creators, editors and audience blend into one. Companies need to organize their marketing and production functions differently to cope with this new reality. Prahalad and Ramaswamy argue for a new form of value creation, experience co-creation in which value is not created in the firm and then exchanged with the customer, but in which value is co-created by the firm and the consumer (Prahalad 2004).

Towards Ambient Narrative Technology

The notion of ambient narratives is helpful for us for two reasons: First, it allows us to view Ambient Intelligence no longer as only a technological phenomenon. We feel the concept of ambient narratives will help us to deepen our understanding of the social, economical and cultural aspects of digital environments that react and adapt to individual user needs a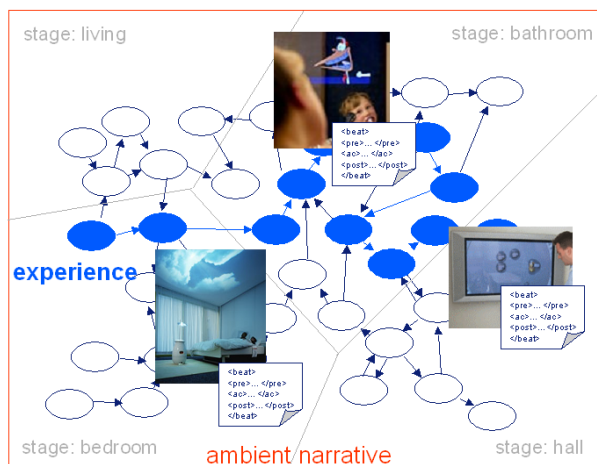nd wants. Second, it helps us in our search for a system architecture that enables the mass customization of Ambient Intelligence environments.

Figure 5: Ambient Intelligence experience as an emerging story in an ambient narrative

We can derive a more concrete definition of ambient narrative that helps system architects and software engineers to design a working system. Basically, we can represent an ambient narrative by a hypertext network where each node, electronic hypertext document, represents a description of an interactive media application, possibly distributed over many devices simultaneously. The examples of the enhanced tooth brushing performance and medical examination room could

be considered as nodes in an ambient narrative (one at home, the other in a hospital). Links between nodes represent transitions from one application into another. By interacting with the ambient narrative performing readers create their own personal story, their own ambient intelligence experience (see Figure 5). Reading and interacting should be considered in the broad, post-structuralist sense: Every change that occurs in context of the user can cause a transition to another application; e.g. a click on a button on a screen, touching a lamp, walking from one room into the next etc. The room becomes the browser you might say. Recent hypertext literature (e.g. Romero 2003) describes ubiquitous hypermedia and physical hypertext systems but these publications are mostly concerned about the possibilities and limitations of the technology and do not consider the larger context.

From a system point of view, users give feedback through the devices, sensors in their surroundings. This feedback is finally collected by an ambient narrative engine and used to determine what the next episode or episodes are in the ambient narrative (many users may be involved in many activities simultaneously so at any given point in time there may be multiple nodes active). After the ambient narrative engine has determined which nodes must be activated it instructs the devices to render a node (or part of a node). This process repeats itself for as long as the user or the environment changes.

Current and Future Work

Currently we are working on an ambient narrative prototype system. The system consists of a browser platform to which devices (screens, speakers, lights) and sensors (touch and pressure sensors) can connect and a storytelling engine (the ambient narrative engine). Today, we write our own episodes in a so-called beat mark-up language. This assumes that there is an experience designer that designs an ambient narrative in which performing readers can make choices but not really add or remove plot material. In the future we hope to empower performing readers to create their own ambient beats and add those to the ambient narrative. We believe this form of co-creation leads to a more engaging and natural experience because this is the way everyday life experiences are formed. Moreover, in an increasingly demand-driven experience economy, consumers often want more than just choice; they demand active participation at every stage during the production process.

Conclusions

Ambient Intelligence is a vision on the future of consumer electronics, telecommunications and computing that by moving technology in the background and the user experience in the foreground aims to improve the quality of our life.

Performance plays an important role in Ambient Intelligence. We argue that performances are not just seen in performance arts in general, but can be seen all around us in our daily lives. We perform the role of a father or son in our private lives but maybe also that of a doctor, judge or police agent for example in our professions. In order to understand where and how Ambient Intelligence can be applied, a better insight is needed into what performances are.

If we look at how experiences are formed it becomes clear that experiences are formed in a subject-determined, reflexive and involuntary way. We may choose the situation we are in, but we cannot control how this affects our inner mind. To create memorable experiences a balance is required between the freedom to act and the structure that is imposed on us by our environment. Too much interactivity, too much freedom to choose and we feel lost, too much restriction imposed on us and we feel our actions do not matter. This balance is well known in interactive narrative and drama. Hypertext novels and computer games are obvious examples of interactive narrative but if we look closer we can see interactive narrative structures in paintings and architecture as well. If we superimpose these interactive texts, we could see the result as an *ambient narrative.*

The ambient narrative concept moves us away from personalized ambient intelligence applications written for individual people to environments that support experience co-creation or collaborative story and meaning making. The traditional difference between readers and writers, consumers and producers of text disappears. Readers and writers transform into performers that together co-create the experience and the text that becomes written in our memory. The ambient narrative concept is not just theory; it can be translated in real systems and products. Currently, we are working on a prototype hypertext-based system but that is another story.

Acknowledgements

References

Aarts E. and Marzano S. (editors), *The New Everyday: Views on Ambient Intelligence,* 010 Publishers, 2003.

Weiser M., *The Computer of the 21st Century*, Scientific American, 1991.

Schechner R., *Performance Studies: An Introduction*, Routledge New York, 2002.

Goffman E., *The Presentation of Self in Everyday Life*, Doubleday: Garden City, 1959.

Csikszentmihalyi M., *Flow: The Psychology of Optimal Experience*, Perennial, 1991.

Nass C. and Reeves B., *The Media Equation: How People Treat Computers, Television, and New Media Like Real People and Places,* Cambridge University Press, 1996

Pine J. and Gillmore J., *The Experience Economy*, Harvard Business School Press, 1999.

Rifkin J., *Age of Access*, Tarcher, 2001

Fisk R. and Grove S., *The Service Experience as Theatre,* Advances in Consumer Research, 19:455-461, 1992.

Bitner, M. J. *Servicescapes: The impact of physical surroundings on customers and employees*. Journal of Marketing, 36(2), 57-71, 1992

HomeLab, *Ambient Intelligence and HomeLab*, http://www.research.philips.com/technologies/misc/homelab

Ambilight, *Simplicity Showcase,* http://www.simplicity.philips.com

Boswijk A., Thijssen T. and Peelen E., *Een Nieuwe Kijk op de Belevenis Economie: Betekenisvolle Belevenissen,*

Pearson Prentice Hall, 2005 (English version to appear in 2006)

Schulze G., *Die Erlebnisgesellschaft: Kultursoziologie der Gegenwart*, Frankfurt Campus, 1992

Murray J., *Hamlet on the Holodeck: The Future of Narrative in Cyberspace*. MIT Press, 1998.
McGonigal J., 'This is Not a Game': Immersive Aesthetics and Collective Play, Digital Arts & Culture Conference, Melbourne, Australia, 2003

Decortis F. and Rizzo A., *New Active Tools for Supporting Narrative Structures*, Personal and Ubiquitous Computing Personal and Ubiquitous Computing, 6:416-429, December 2002

Davenport G. et.al., *MediaFabrics – A Process-oriented Approach to Media Creation and Exchange*, BT Technology Journal, 22:4, 2004

Prahalad C. and Ramaswamy V., *The Future of Competition: Co-creating Unique Value With Customers*, Harvard Business School Press, 2004.

Romero L. and Correia N., *HyperReal: A Hypermedia Model for Mixed Reality,* In Proceedings of the 14th ACM Conference on Hypertext and Hypermedia, Nottingham, UK, 2003. ACM.