Norbert Streitz, Thorsten Prante, Carsten Röcker, Daniel van Alphen, Richard Stenzel, Carsten Magerkurth, Saadi Lahlou, Valery Nosulenko, Francois Jegou, and Frank Sonder and Daniela Plewe

Smart artefacts as affordances for awareness in distributed teams

Book section

Original citation:
Originally published in Streitz, Norbert; Kameas, Achilles and Mavrommati, Irene, *The disappearing computer.* Heidelberg, Germany : Springer, 2007, pp. 3-29

Smart Artefacts as Affordances for Awareness in Distributed Teams

Norbert Streitz[1], Thorsten Prante[1], Carsten Röcker[2], Daniel van Alphen[3], Richard Stenzel[1], Carsten Magerkurth[4], Saadi Lahlou[5], Valery Nosulenko[6], Francois Jegou[7], Frank Sonder[8], and Daniela Plewe[9]

[1] Fraunhofer Institute IPSI, Darmstadt, Germany
[2] now at University of California, San Diego, USA
[3] now at Philips Design, Boston, USA
[4] now at SAP Research CEC, St. Gallen, Switzerland
[5] Electricité de France, Paris, France
[6] Russian Academy of Science, Moscow, Russia
[7] Solutioning Design, Brussels, Belgium
[8] Wilkhahn and Foresee, Bad Münder, Germany
[9] now at National University of Singapore, Singapore

1 Introduction

The manifolds of spaces and places we are entering, populating, transiently crossing and eventually leaving (only to immerse in another subsequent context) as part of our daily activities in our personal, public and professional lives are undergoing a dramatic change. Although this change is taking place we are aware of it only in a limited fashion due to its unobtrusive character as illustrated in the statement by Streitz and Nixon (2005): "It seems like a paradox but it will soon become reality: The rate at which computers disappear will be matched by the rate at which information technology will increasingly permeate our environment and our lives".

Due to the proliferation of information and communication technology we are encountering increasingly spaces that are being transformed into augmented and shared environments. Augmentation takes place via embedded technologies (e.g., sensing, networking) resulting in smart artefacts as the building blocks of smart environments at different levels and scales. While this development takes place in many areas of our daily live, we are focusing in this chapter in particular on office spaces and how to transform them into augmented shared work environments. The office environments we anticipate should be able to support communication and cooperation of individuals and teams, especially also taking into account the issues arising from distributed settings where people are not sharing the same architectural space. The associated problems do not only affect large organizations but also small companies and groups of people forming loose and temporary networks of collaboration.

Originally, "shared environments" denote work situations where people actually share architectural spaces and physical places in an office building. They share the same office; meet each other in the hallway or the cafeteria. These settings provide multiple opportunities for being aware of what is going on in the building and for engaging in spontaneous chance encounters with colleagues. They can be from the same or a different team or organizational unit, from a related or a completely different pro-

N. Streitz, A. Kameas, and I. Mavrommati (Eds.): The Disappearing Computer, LNCS 4500, pp. 3 – 29, 2007.

ject. People can gain and extend their knowledge about what is going on in the organization.

Successfully working together involves and requires more than exchanging only data and information. To act as a team, people have to develop commonalities on at least two dimensions. First, they have to develop and experience a common basis of understanding, i.e., a mental model of the task domain and the procedures that is shared by all team members. Second, they have to develop a common feeling as a team, the "corps d'esprit". Establishing the shared mental model and the common feeling is dependent on the type of communication channels and media available. They determine the social cohesion and other group processes. Our thesis is that this process of developing a common understanding can be successfully supported by information and communication technology if the enabling environments are designed and developed in a task-oriented and user-centered way.

In this chapter, we describe an example of enabling environments supporting team work and mobility and the development of smart artefacts as constituents populating what we have called earlier "cooperative buildings" (Streitz et al. 1998). The specific application scenario and the different smart artefacts were developed in the "Ambient Agoras" project (www.ambient-agoras.org) that was part of the EU-funded "Disappearing Computer" initiative.

The chapter is organized as follows. First, we describe the problem domain of supporting team work in the age of increased mobility and its implication for the design of future office buildings. Second, we introduce the Ambient Agoras project. Third, we argue for the notion of people-oriented and empowering smartness keeping the human in the loop. Fourth, we discuss - in the context of the disappearing computer paradigm - the role of affordances for interaction and experience design of smart artefacts constituting a social architectural space. Fifth, a brief characterization of ambient displays and privacy issues provides the basis for the development of the specific artefacts in the next sections. Sixth, after illustrating the specific "connecting remote teams" application scenario, we describe the development and implementation of three smart artefacts (Personal.Aura, Hello.Wall, and View.Port) and their functionalities. Finally, we report about their integration in a concrete test environment between Germany and France as well as its evaluation.

2 Awareness in Distributed Teams

2.1 The Role of Communication

Within the last decades, the role of teamwork has gained significant importance. Besides an immense increase in the use of work groups within companies (Guzzo and Salas 1995; Sundstrom 1999; Utz 2000), also virtual teams, where team members collaborate from remote locations, become increasingly popular (Potter and Balthazard 2002). But successful teamwork involves more than just people working at the same project or in the same room. To act as a team, the team members have to experience a special relationship and attitude (the 'team spirit"), they have to take over responsibilities and work towards a common goal. It is essential to share knowledge, to make decisions and to coordinate the activities of all people working in the team. As a result, the relevance and amount of communication is constantly increasing.

In addition to explicit verbal communication, especially implicit communication in form of mutual awareness is an important requirement for a shared understanding and knowledge about ongoing and past activities within a team (Streitz et al. 2003). Mutual awareness usually leads to informal interactions, spontaneous connections, and the development of shared cultures, all important aspects of maintaining working relationships (Dourish and Bly 1992). Gaver et al. (1992) define awareness as the pervasive experience of knowing who is around, what sorts of things they are doing, whether they are relatively busy or can be engaged, and so on. Especially information about presence and availability of remote colleagues is of high value during the daily work process. This is also confirmed by the findings of Nardi et al. (2000), who evaluated the use of buddy lists. They showed that people found it valuable to simply know who else was "around", as they checked the buddy list, without necessarily planning to interact with anyone.

In a local work environment, information about presence and availability of colleagues is continuously available and picked up by those present. Teams, which are geographically distributed, by their nature, are denied the informal information gathered from a physical shared workspace (Kraut et al. 1990). Hence, it is particular important to support the need of distributed teams for informal interaction, spontaneous conversation and awareness of people and events at other sites (Bly et al. 1993).

In contrast to local work environments, where minimal or no effort is required to maintain awareness, the members of distributed teams have to communicate awareness information explicitly. The amount of information that is communicated is determined by the benefits users gain and efforts for providing the relevant information to their remote team members. This explains why traditional communication tools, like e-mail or telephone, are only of limited appropriateness for supporting awareness in distributed teams. Communicating relevant information requires a comparatively high effort and, therefore, will be used only for things, which are considered to be more important, like scheduling of meetings, task management or other work related subjects (Rohall et al. 2003; Bellotti et al. 2003; Gwizdka 2002).

2.2 Mobility: Local vs. Global

Since the introduction of office work in the beginning of this century, work environments are subject to a constant change towards higher organizational flexibility and personal mobility. Especially within the last decade, a continuous trend towards higher local mobility could be observed in most companies. Even if employees are within the office building, they spend considerable time away from their own desk, working in meeting rooms, other offices or in the hallway (Lamming et al. 2000; Huang et al. 2004). According to some estimates, white-collar workers spend between 25% and 70% of their daily working time in conferences or meetings with colleagues (Panko 1992; Eldridge et al. 1994; Whittaker et al. 1994). Bellotti and Bly (1996) studied local mobility in a design company and observed an even higher level of mobility with people being away from their desk for around 90% of the time.

To get a better understanding of the interdependency between mobility and teamwork, two forms of mobility are distinguished: "local mobility" and "global mobility”. The term local mobility refers to the mobility of an individual within a building or organization, which is mainly determined by the organizational structure and the design of the work environment in a specific building. In contrast, global mobility describes the fading linkage of employees to a fixed workplace as a result of globalization trends and technology trends like the availability of networked mobile devices. People are becoming increasingly part of distributed teams working at remote sites.

The advantage of local mobility, regarding the collaboration of team members, has to be seen in an increased awareness about activities and events in the surrounding of their own work place. Findings by Bellotti and Bly (1996) led to the assumption, that the relevant information is received passively, as soon as a team member is in physical proximity to the activity. They come to the conclusion, that local mobility is imperative for communication within teams and, at the same time, supports informal communication and awareness about local colleagues. Based on the work of Kraut et al. (1990), Whittaker et al. (1994) come to similar results and additionally stress the fact that informal communication plays a key role for the collaboration within companies.

Regarding the working methods of many teams, higher mobility seems appropriate and natural: creative processes cannot be initiated on command; they are independent of time and place. As a matter of fact, the most creative and inspiring ideas are usually not born while sitting at the office desk (Sonnentag 2001). Pelizäus-Hoffmeister (2001) argues in the same way, and sees the most important benefits of higher mobility in a broader wealth of experience and the additional opportunities for new relationships. So, there is no doubt that the increase of local mobility in workspaces affects teamwork.

Observing the prevailing developments, one has to assume that future office environments will allow a much higher level of personal mobility as today’s office concepts do.

3 Cooperative Buildings

In 1998, we introduced the concept of so called *Cooperative Buildings* (Streitz et al. 1998). Using the term “building” (and not “spaces”) was motivated by emphasizing that the starting point of the design of future office buildings should be the real, architectural environment. This was at a time when the discussion was pretty much dominated by the notion of virtual environments as the offices of the future. Calling it a “cooperative” building, we indicate that the building serves the purpose of cooperation and communication. At the same time, it is also “cooperative” towards its users, inhabitants, and visitors by employing active, attentive and adaptive components. This is to say that the building does not only provide facilities but it can also (re)act “on its own” after having identified certain conditions. It was part of our vision that it will be “smart” and be able to adapt to changing situations and provide context-aware information and services. In Streitz et al. (1998, 2001), we identified the following distinctions spanning three dimensions of what has to be taken into account when designing cooperative buildings:

- individual vs. group activities
- local vs. global contexts
- real vs. virtual worlds

In this chapter we report on how to incorporate these design dimensions for one of the application scenarios that were investigated in the Ambient Agoras project.

With respect to the third dimension, one can observe that the use of information technology has caused a significant shift: away from real objects in the physical environment as the sources of information towards computer monitors as "*the*" new interfaces to information and thus an increasing emphasis on virtual environments. Continuing the approach of our previous work, e.g., on Roomware® for cooperative buildings (Streitz et al. 1998, 1999, 2001), we argue also in this context now for returning to the real world as the starting point for designing future information and communication environments. It is our intention to design environments that exploit the affordances provided by real world objects and spaces, at the same time making use of the potential of computer-based support available via the digital or virtual world. Our thesis is to take the best of both worlds by combining and integrating real and virtual worlds resulting in hybrid worlds.

4 Ambient Agoras

The Greek *agora* (market place) was the guiding metaphor for our work in the Ambient Agoras project. We investigated how to turn everyday places into social market places of ideas and information where people can meet and interact. We addressed the office environment as an integrated organization situated in an architectural context and having specific information needs at the collective level of the organization, and at the personal level of the individual team member. The overall goal was to augment the architectural envelope creating a social architectural space to support collaboration, informal communication, and social awareness. This was achieved by providing situated services, place-relevant information, communicating the feeling of a place (*genius loci*) to users, enabling them to communicate for help, guidance, work, or fun. We promoted an approach of designing individual as well as team interaction in physical environments using augmented physical artifacts. In particular, we were interested to go beyond traditional support for productivity-oriented activities and rather focus on providing experiences via "smart" or augmented spaces. The goal was to take a closer look at activities and social processes in lounge areas, hallways, and other transient spaces (see Figure 1).

In order to be able to focus on the needs of potential users, we employed a scenario-based approach, starting out with a large number of so called "bits-of-life" (very short descriptions of functionalities, situations, events, …), aggregated them to scenarios and presented them, e.g., via video mock-ups to focus groups for user-feedback. This served, in combination with extensive conceptual work based on different theories in architecture (e.g., Alexander 1977) as the basis for the development of a wide range of smart artefacts and corresponding software so that their combination provides smart services to the users.

Design, development, and evaluation followed an iterative and rapid prototyping approach. For the Ambient Agoras environment, we addressed several interaction design objectives (disappearance and ubiquity of computing devices) with different sensing technologies (active and passive RFID) which resulted in the development of several smart artefacts.

Fig. 1. Vision scribble of a lounge area in future office environment

In this book chapter, we focus on the specific application scenario of coordination and collaboration between remote sites of distributed teams and the corresponding subset of ambient displays and mobile devices that we developed for it. One important aspect was the combination of more or less static artefacts integrated in the architectural environment with mobile devices carried by people. At the same time, we addressed issues of privacy in sensor-based environments.

5 Smart Environments

The availability of information technology for multiple activities is one important step but it is not sufficient for achieving the objectives indicated above. It is to be followed by the integration of information, communication and sensing technology into everyday objects of our environment in order to create what is called "Smart Environments". Their constituents are smart artefacts that result from augmenting the standard functionality of artefacts thus enabling new quality of interaction and "behaviour" (of artefacts). Work on Ambient Intelligence (ISTAG 2001) addresses similar aspects but we prefer the term "smart" over "intelligent" in order to avoid a too anthropomorphic association. Without entering into the philosophical discussion of when it is justified to call an artefact "smart" or what we consider "smart" or "intelligent" behaviour in general, the following distinction is useful (Streitz et al. 2005b).

5.1 System-Oriented, Importunate Smartness

An environment is to be considered "smart" if it enables certain self-directed (re)actions of individual artefacts (or by the environment in case of an ensemble of artefacts) based on previously and continuously collected information. For example, a space or a place can be "smart" by having and exploiting knowledge about which people and artefacts are currently situated within its area, who and what was there before, when and how long, and what kind of activities took place. In this version of "smartness", the space would be active, (in many cases even proactive) and in control of the situation by making decisions on what to do next and actually take action and execute them without a human in the loop. For example, in a smart home, we have access control to the house and other functions like heating, closing windows and blinds are being done automatically. Some of these actions could be importunate. Take the almost classic example of a smart refrigerator in a home analyzing consumption patterns of the inhabitants and autonomously ordering depleting food. While we might appreciate that the fridge makes suggestions on recipes that are based on the food currently available (that would be still on the supportive side), we might get very upset in case it is autonomously ordering food that we will not consume for reasons beyond its knowledge, such as a sudden vacation, sickness, or a temporal change in taste.

5.2 People-Oriented, Empowering Smartness

In contrast, there is another perspective where the empowering function is in the foreground and which can be summarized as "*smart spaces make people smarter*". This is achieved by keeping "the human in the loop" thus empowering people to make informed decisions and take actions as mature and responsible people being in control. In this case, the environment will also collect data about what is going on but provides and communicates the resulting information - hopefully in an intuitive way so that ordinary people can comprehend it easily - for guidance and subsequent actions determined by people. In this case, a smart space might also make suggestions based on the information collected but the people are still in the loop and in control of what to do next. Here, the place supports smart, intelligent behaviour of the people present (or in remote interaction scenarios people being away "on the road" but connected to the space). For example in an office scenario, the smart space could make recommendations to the people currently in the room that it would be useful to consult other people that were there before and worked on the same content or to take a look at related documents created in this room before.

There is no doubt that these two points of view will not exist in their pure distinct form. They rather represent the end points of a dimension where we can position weighted combinations of both somewhere in between. What kind of combination will be realized is different for different cases and depends very much on the application domain. It is also obvious that in some cases it might be useful that a system is not asking for user's feedback and confirmation for every single step in an action chain because this would result in an information overload. The challenge is to find the right balance. The position we propagate here is that the overall design rationale should be guided and informed by the objective to aim at having the human in the loop and in control as much as possible and feasible.

6 From Information Worlds to Experience Worlds

An important aspect of our work is to go beyond traditional support for productivity-oriented tasks in the office and focus on designing "experiences" with the help of smart or augmented spaces (Streitz et al. 2005a). The goal is to design smart artefacts that enable us to interact with them and the overall environment in a simple and intuitive way or just being exposed to it and perceive indicators in the environment that indicate events and changes. This includes extending the awareness about our physical and social environment by providing observation data and parameters that - in many cases - are "invisible" to our human senses and therefore enable new experiences.

The general idea of capturing and communicating "invisible" parameters is known, e.g., in physics where radioactivity is indicated via the sound of a Geiger-Müller counter, and can be applied to existing activity contexts as well as for situations and settings that are newly created. Previous examples in the ubiquitous computing domain included pollution data or computer network traffic data (e.g., Wisneski et al. 1998) that are usually not directly noticeably with our standard human senses. Presenting these data in a format that provides new experiences enables people to get a feeling of what is currently going on around them, i.e., the world around us becomes the interface.

In this paper, we present an application of the general idea of designing these experiences via calm technology (Weiser and Brown 1995) and focus on the creation of an augmented social architectural space in office settings.

7 Interaction Design and Affordances

Developing and having the technology (e.g., sensing) and infrastructure (e.g., wireless network) available is an important ingredient of creating smart environments. Designing the interaction with smart artefacts constituting these environments is another challenge. For our design approach, we found the notion of *affordances* very helpful.

7.1 Different Approaches to the Concept of Affordances

The concept of *affordances* was first introduced by Gibson (1979) who also coined the term. His notion of affordances highlights the function of properties of the environment that enable possible actions available in the environment, independent of the individual's ability to perceive this possibility. He concentrated especially on the relationship between actor and environment.

Norman's (1988) initial treatment of the issues, later on revisiting them again (Norman 1999), made the term popular in the HCI community. In his interpretation, affordances are understood as design aspects of an object which suggests how the object should be used. The concept was widely adopted but with the emergence of complex software and the variety of interfaces these definitions were not elaborate enough. It was Gaver (1991) who proposed a catalogue of "technology affordances" and introduced the concepts of nested affordances and sequential affordances. For a detailed history of the affordance concept see McGrenere and Ho (2000).

Alexander (1977) does not explicitly use the term "affordances". Still, we consider part of his work as an approach to classify "affordances of spaces". As an architect, Alexander observed that in all environments archetypical problems occur to which certain solutions have emerged. One can consider these solutions as providing affordances of spaces. Alexander analyzed existing solutions, extracted the underlying principles and organized them in a so called "pattern-language" (Alexander 1977).

The result is a collection of over 250 hierarchically grouped patterns concerning the affordances of spaces.

Similar to our goal of developing a social architectural space (see below) Alexander aims at an "alive space" characterized by various patterns as communicative, lively and offering various opportunities for exchange.

Against the background of the various concepts of affordances, we adopt the following notion for our work:

> *Affordances* are available elements in the perceived environment that trigger, facilitate, and support certain activities, especially when interacting with artefacts. From the perspective of the design process, the notion of affordances is used to constrain the space of possible interactions with an artefact and to suggest intended and/or possible interactions to the user.

Another related assumption is that users are familiar with the "meaning" or "effect" of affordances provided by "classical" interfaces of artefacts and are able to transfer their previous experiences to the new artefact.

7.2 Interacting with Disappearing Computers

With the trend of the "disappearing computer" new challenges arise. Computers used to be primary artefacts, now they become "secondary" artefacts which move in the background in several ways. They disappear from the scene, become invisible and - in consequence - disappear in the perception of the actors. Therefore, new issues with regard to the notion of affordances arise: how can people interact with disappearing computers? How can we design for transparency and make users "understand" the interface? How can people migrate from explicit interactions and interfaces towards implicit interactions and interfaces? And how can we fulfill the occurring needs for privacy?

Our approach is mainly characterized by returning to the real world as the starting point for design and trying to exploit the affordances that real-world objects provide.

7.3 Social Architectural Space

Once we go beyond individual artefacts to collections of artefacts and their placement in space, we have to extend the notion of affordances. Architectural spaces are coupled in our minds with meaning, memories, associations and previous experiences. If one wants to differentiate between spaces and places, one could say "a place is a space with meaning". A "successful" experience of a place is the result of (re)acting "appropriately" on the affordances offered and using the context with appropriate knowledge. People perform better in known and familiar spaces. Therefore, enriching spaces with an additional interpretative layer via appropriate affordances transforms them into places and can result in a better and more comfortable experience.

Collections of artefacts with corresponding affordances constitute what we call "a social architectural space". A social architectural space is an (office) environment, which supports collaboration, social awareness, thereby acknowledging the role of informal communication and social awareness for creativity and innovations in organizations. This is in line with emphasizing activities requiring support that go beyond the PC-based workplace and traditional productivity tools. The social orientation also takes into account the increase of temporary project teams with irregular presence in the office building, possibly leading to a deficit of social coherence. To counter this, transparency of relationships and light-weight means for communication are needed.

The position of an artefact within an environment influences its affordances. Spaces themselves have properties that support or inhibit certain activities. Inspired by Alexander (1977), we introduce some considerations about spaces which support our goal of designing a social architectural space. To this end, we reference certain patterns and use his classification and numbering scheme.

Meeting our emphasis on informal communication, Alexander (1977) states: "No social group - whether a family, a workgroup or a school group – can survive without constant informal contact among its members." (Pattern Number #80 "Self-governing Workshops and Offices", p 398) In his pattern language, Alexander introduces various patterns that enhance this kind of "intensity of action".

From his notion of "Activity Pockets", we adopt that places need to provide shelter and allow frequency at the same time. "Surround public gathering spaces with pockets of activity – small, partly enclosed areas at the edges, which jut forward into the open space between paths, and contain activity pockets which make it natural for people to pause and get involved." (Pattern # 124 "Activity Pockets", p 602).

According to Alexander, in many modern buildings the problem of disorientation causing mental stress is acute. "An environment, that requires that a person pays attention to it constantly, is as bad for a person who knows it, as for a stranger. A good environment is one which is easy to understand, without conscious attention." (Circulation Realms, #98, p 482). Here, especially large scale artefacts can contribute to create landmarks. The locations may be discernable by their varying atmospheres.

This was reflected in our design of the large ambient display Hello.Wall (to be described later on) that meets the landmark aspect as well as the request "to be understood without conscious attention".

7.4 Disappearing Computers and Inherited Affordances

One of Weiser's (1991) central ideas is the notion of the *disappearing computer* being part of designing *calm technology* (Weiser and Brown 1995). It is best captured in his statement "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." The notion of the disappearing computer gives rise to a new discussion of the role of affordances. In this context, it is helpful to revisit the distinction of two types of disappearance we introduced some time ago (Streitz 2001):

- *Physical disappearance* is achieved by the miniaturization of computer parts that allows convenient and easy integration into other artefacts, mostly into "close-to-the-body" objects, so that the result can fit in your hand, can be integrated in clothing or even implanted in the body, etc. As a result, features usually associated with a computer are not visible anymore and the interaction happens via the compound artefact in which the computer parts disappeared.

- *Mental disappearance* of computers is achieved by becoming “invisible” to the “mental” eye of the users. This can happen by embedding computers or parts of them in the architectural environment (walls, doors) or in furniture (tables, chairs, etc.) or other everyday objects. Then, computers are not perceived as computers anymore – although the artefacts can be quite large – but as adding interactive, communicative, and cooperative aspects to traditional everyday objects (e.g., an interactive wall or an interactive table is a “table”, a “wall” that is interactive and not a computer built into a table or the wall).

Based on the notion of mental disappearance, we introduce the concept of “inherited affordances”. The affordances of a well established object help to focus on interacting with the hidden affordances of the digital application. An example is to use real world furniture with well-known ways of interaction facilitating the communication of affordances for interacting with the disappeared computer, because users basically know how to interact with a chair or a table. Everyday objects provide simple affordances guiding the user to the nested and/or sequential affordances of the application enabled by the “invisible” computer.

In analogy to the discussion of the pros and cons of natural world metaphors one may argue, that applying metaphors helps the user initially to learn some basic interactions but later on possibly inhibits transcending the functionality of real-world artefacts – which, of course, is the reason for the existence for any new device. This general problem has already been extensively discussed many years ago in the context of introducing the desk-top metaphor for personal computers. (see, e.g., the notion of mental and conceptual models, Streitz 1988).

7.5 Ambient Displays

Inspired by the discussion on affordances (see above) and selected design patterns proposed by Alexander (1977), we found that a calm and ambient technology implementing the ideas of the disappearing computer would be very well suited to support the informal social encounters and communication processes we have in mind in our Ambient Agoras environment. In contrast to mechanism like open video channels (Bly et al. 1993; Fish et al. 1992), we decided to implement “ambient displays” for our approach.

They go beyond the traditional notion of “display” encountered with conventional graphical user interfaces (GUI) found on PCs, notebooks, PDAs. The design of ambient displays is often based on observations in nature or employing corresponding metaphors. They are designed to display information without constantly demanding the user’s full attention. Usually, this is achieved in a more “implicit” way by being available in the periphery compared to traditional “explicit” GUIs. Ambient displays are envisioned as being all around us and thereby moving information off the conventional screens into the physical environment. They present information via changes in light, sound, movement of objects, smell, etc. Early examples are described in Ishii et al. (1998), Wisneski et al. (1998), Gellersen et al. (1999), and ways of evaluating them by Mankoff et al. (2003).

Applying the concept of ambient displays for our purposes is in line with our observations that social affiliations can be strengthened via additional awareness of people’s activities. Ambient displays can be used to trigger the attention of team members in a subtle and peripheral way by communicating the atmosphere and thus providing a sense of a place.

Ambient displays are one aspect of the implementation, sensing people and collecting parameters relevant for achieving the goal of providing location- and situation-based services are others. They will be discussed in the context of the artefacts and the application scenario. We will describe later on three types of artefacts that were developed for populating the Ambient Agoras environment: Personal Aura, Hello.Wall, and ViewPort.

8 Privacy in Sensor-Based Environments

Smart objects and environments that support us unobtrusively and intelligently have to gather large amounts of information about almost every aspect of our lives—our past preferences, current activities, and future plans—in order to better serve us. Five characteristics make such systems very different from today's data collections (Langheinrich 2001):

- First, the unprecedented coverage of smart environments and objects present in homes, offices, cars, schools, and elderly care facilities.
- Second, the data collection will be practically invisible: no more card swiping or form signing, as sensors in walls, doors, and shirts silently collect information.
- Third, data will be more intimate than ever before: not only what we do, where we do it, and when we do it, but also how we feel while doing so (as expressed by our heart rate, perspiration, or walking pattern).
- A fourth difference concerns the underlying motivation for the data collection—after all, smart objects are dependent on as much information as they can possibly collect in order to best serve us.
- Lastly, the increasing interconnectivity allowing smart devices to cooperatively help us means an unprecedented level of data sharing; making unwanted information flows much more likely.

Together, these characteristics indicate that data collections in the age of ubiquitous computing would not only be a quantitative change from today, but a *qualitative* change: Never before has so much information about us been instantly available to so many others in such a detailed and intimate fashion.

Surveys since the 1970s show that the loss of privacy is associated with the quantity of personal information collected, and that fear of privacy infringements constantly increases with the integration of computers in everyday life (Robbin 2001). When boundaries between public and private spaces blur, users feel uneasy because they do not know what information they actually share with whom, often triggering substantial privacy and security concerns about the technology. Making technology invisible means that sensory borders disappear and common principles like "if I can see you, you can see me" no longer hold. Because collecting and processing of personal information is a core function of smart environments, privacy and ubiquity seem to be in constant conflict.

Within the Ambient Agoras project, we decided to pay considerable attention to the privacy issues and make them part of the overall design rationale. In this context, a subgroup of the project team produced the *European Privacy Design Guidelines for the Disappearing Computer* (Lahlou and Jegou 2003). It is beyond the scope of this chapter to describe them in detail but they provided a conceptual framework within which the smart artefacts were developed; a particular example is the “Personal Aura”.

These guidelines are meant to help system designers implement privacy within the core of ubiquitous computing systems. Designing for privacy is difficult because privacy is often a trade-off with usability. The guidelines state nine rules that not only reinterpret some of the well-known fair information practices (OECD 1980) in light of disappearing computers, such as openness and collection limitation, but also add new rules that specifically deal with the privacy challenges introduced by such invisible and comprehensive data collection. For example, applying the “privacy razor” (rule number four) in design means listing everything the system knows about the human user, and cutting out what is not “absolutely necessary” to provide the service; for example, personal identification. The guidelines are available at www.rufae.net/privacy.html. While these rules still require more feedback from real-world deployments, they nevertheless present an important first step for building privacy-aware ubiquitous computing systems that European citizens can trust (Lahlou et al. 2005).

9 The Ambient Agoras Application Scenario

The initial analysis of working conditions for team collaboration and communication and the implications of increased mobility (local as well as global) in the beginning of this chapter defined the overall problem domain for our research. The goal was to develop computer-based support for informal communication, coordination and collaboration at local and between remote sites of distributed teams. A sample setting of the situation is depicted in Figure 2.

In addition, we set us a second complementing goal in terms of the character of implementation. It should correspond to and be compatible with the nature of informal communication, social awareness, team cohesion, etc. In order to explore the user

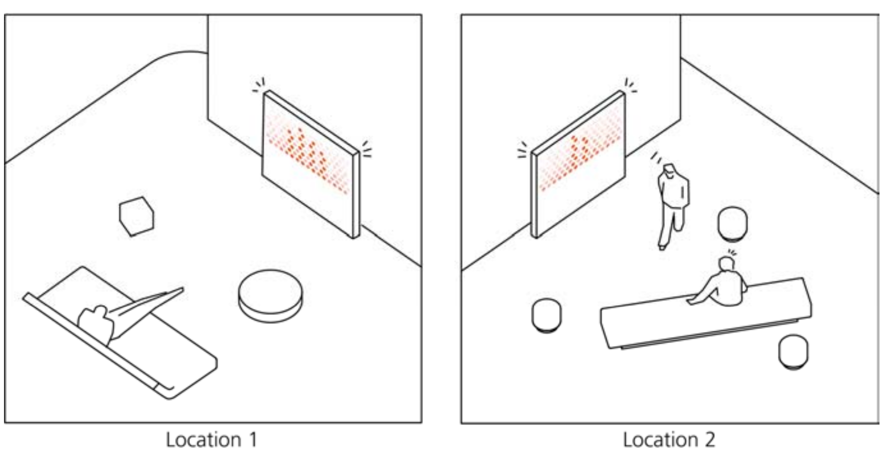


Fig. 2. Vision scribble of two remote locations connected via an ambient communication channel

requirements, we conducted focus groups and interviews in the project. The combination of our conceptual analysis and these results showed that the traditional ways of communicating information using standard tools and monitors of desktop computer did not achieve this goal and would not meet the expectations of the potential users. Therefore, we took a different route based on the notion of ambient displays and lightweight support with mobile devices to be described in the following sections.

The specific development was guided by three objectives. First, it was aimed to develop "lightweight" awareness devices that help members of a distributed team to communicate in a natural way. As mentioned before, awareness should be provided via a natural communication channel that enables people to be aware of each other, in a subtle, warm and expressive way, which can be easily and intuitively perceived without having to deal very explicitly with technology components.

Second, the interfaces should be adapted to the changing requirements of emerging office concepts as well as to the increased mobility of employees within the work environment. Hence, the conceptual system design aimed to support awareness and informal communication between remote team members through natural interaction in public areas, using intuitive interfaces integrated into an open office landscape implementing the affordances of a social architectural space.

Third, we wanted to integrate a privacy concept that would allow people to be in control of determining if they are being sensed and, if yes, that each person could then select and adopt different roles in such a sensor-augmented smart environment.

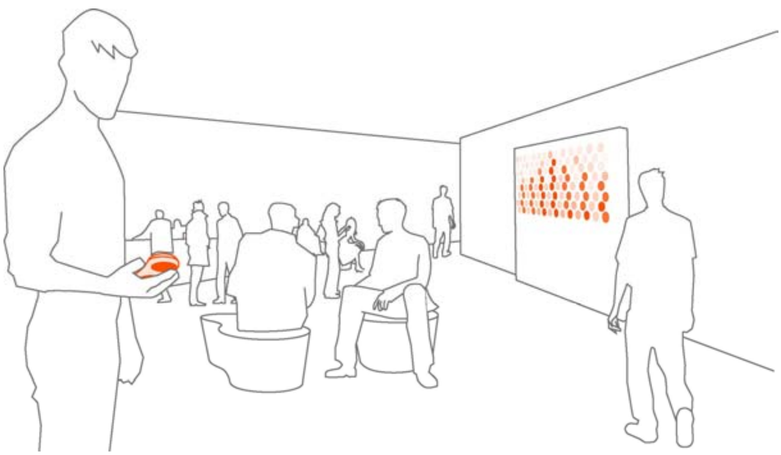


Fig. 3. Vision scribble of the artefacts and their integration into the environment

These objectives were achieved by combining various artefacts integrated into a smart office environment (see an example of a lounge area in Figure 3) and tailored to the needs of distributed teams. Ambient displays and sensors are embedded into the physical surrounding to communicate information and support implicit interaction mechanisms. These stationary artefacts are complemented by personal mobile devices, that help users to preserve their privacy in public space and access personalized information.

10 Implementation

Corresponding to the three objectives, the conceptual model was implemented by developing three different artefacts, which use a common communication infrastructure.

10.1 Personal.Aura

To enable user-controlled identification processes as well as personal role management, a mobile control device called *Personal.Aura* was developed (see Figure 4). The *Personal.Aura* is a mobile device enabling users to control their appearance in a smart environment by deciding on their own, whether they want to be “visible” for remote colleagues, and if so, in which “social role” they want to appear. The guiding design principle here was to have a physical artefact and physical actions for providing control to the user.

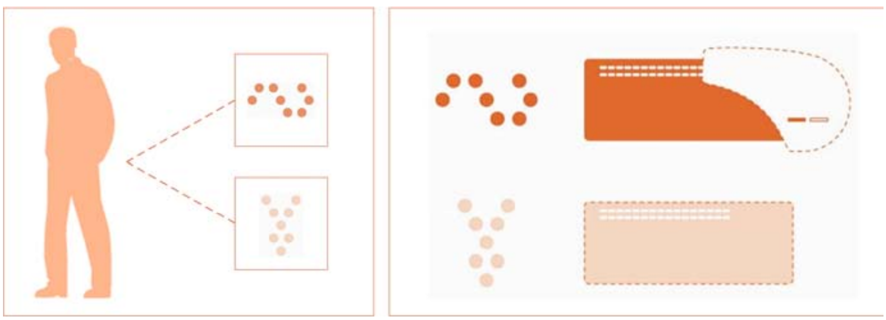


Fig. 4. The Personal.Aura concept for individual identification and role management. Each user has different virtual roles represented by a personal sign. With the Personal.Aura artefact users can activate different roles and thereby control if and how they are identified by the environment. Different patterns (e.g., displayed on the Hello.Wall see Figure 9 below) correspond to different social roles

The *Personal.Aura* is a compound artefact consisting of a *Reader Module* and several complementary *ID Sticks* (see Figures 5 and 6). Every *ID Stick* symbolizes a different social role and contains a unique identification code. Besides the identification information, the *ID Stick* contains additional memory to store personal information or user preferences. The *Reader Module* comprises the power supply, antenna and input/output controls. It decodes the identification stored on an *ID Stick* and transmits the data to a smart environment. More details can be found in Röcker (2006).

To give users the possibility to change their social role or identity, it is important that they have control over the information transmitted to the environment. If people want to signal their presence to remote team members, they can do so by simply connecting a specific *ID Stick* to the *Reader Module*. As soon as both parts are physically connected, the user is identified with the digital profile linked to the specific *ID Stick*. Disconnecting both parts immediately stops the identification process.

To enhance the users' awareness for tracking and identification events, visual and acoustic feedback mechanisms are implemented. While all prototypes use visual feed

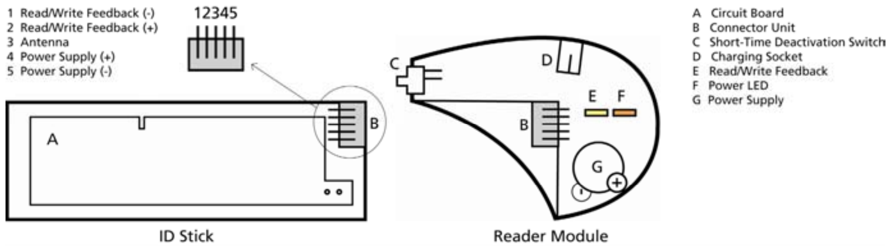


Fig. 5. Technical concept of the Personal.Aura artefact

Fig. 6. Activation of the Personal.Aura artefact by connecting an ID Stick to the Reader Module

back to signal their operating state, both, acoustical and visual feedback mechanisms, are tried to inform users about data transfer between the artefact and the environment. Half of the prototypes are equipped with an additional LED to signal data access, the other half provides feedback via a bleeper. Providing acoustic feedback enhances peripheral awareness, even if the artefact is not constantly in the user's field of vision.

To enable users to temporarily interrupt the identification process, the *Personal.Aura* can be switched to a "privacy mode". While in privacy mode, users are invisible for all others. A status change to privacy mode is done via a switch on the side of the artefact. While disassembling the artefact provides intuitively understandable information about its current operating state, a temporary deactivation via a switch might not be as clear. Therefore, the switch was designed to integrate harmoniously into the shape of the artefact when inactive, and to generate a disharmonious perturbation while activated.

In order to clearly identify users and prevent misuse of personal information, it is necessary that *ID Sticks* can only be used by the person they belong to. To guarantee this, a concept of key and lock is applied: only if two matching parts are connected, the *Personal.Aura* is complete and operational. Therefore, a special security profile is engraved into the surfaces of the *Reader Module* and *ID Sticks*, which is unique for each *Personal.Aura* artefact. This security profile works like a key and makes it impossible to connect an *ID Stick* to a wrong *Reader Module*.

10.2 Hello.Wall

In order to represent public awareness information, a large-scale ambient display called *Hello.Wall* was developed. The *Hello.Wall* uses special light patterns to communicate information in an ambient and unobtrusive way (see Figure 7). As the design of the light patterns is independent from the technical realization of the *Hello.Wall*

Fig. 7. Hello.Wall artefact showing different light patterns depending on the social situation

artefact, a broad variety of different patterns can be designed to communicate information. This enables to develop individual "pattern languages", tailored to the specific needs of a distributed team.

To demonstrate the potential of this approach, an exemplary pattern language was developed to visualize information in an ambient and unobtrusive way. The goal was to improve workplace awareness and support opportunities for chance encounters between remote colleagues. Based on the types of information defined in the conceptual approach, patterns for the following information were designed (see Figure 8):

- general mood of the remote team,
- general activity in the remote work space,
- presence and availability of certain team members, and
- interest in communication with a remote team member.

According to the conceptual approach, two groups of patterns are distinguished: ambient patterns that represent general information, like mood and activity, and notification patterns, communicating individual or personalized messages.

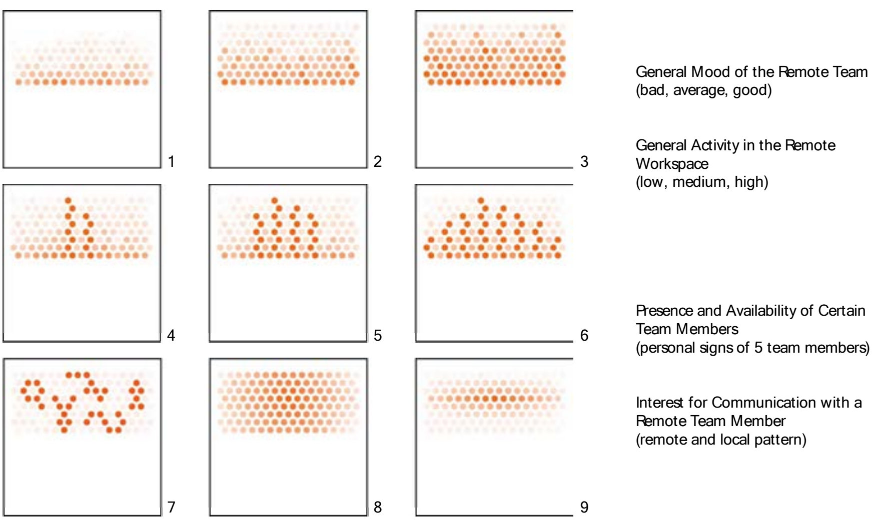


Fig. 8. Visual concept for the design of the different patterns

The *Hello.Wall* continuously displays dynamic ambient patterns overlayed with each other, representing the overall mood and general activity of the remote team members. Churchill et al. (2004) explored different forms of information representation and found that too dynamic visualizations are likely to be distracting, while visualizations with too little variation appear static and unresponsive. Based on these findings, Vogel and Balakrishnan (2004) argue, that the aesthetics of the displayed information, as well as the transitions between different states, are crucial factors for successful system design. In an iterative design process, different types of patterns were created and tested. The final set of patterns is characterized by a rather abstract nature to achieve an aesthetically pleasing and calm appearance. To reduce the complexity and support peripheral perception, each parameter is divided into three levels (low, medium, high) with corresponding patterns.

With the integrated sensing infrastructure of the *Hello.Wall*, it is possible to support context-dependent information representation. This enables several distributed teams to share *Hello.Wall* artefacts available in their local work environment. To support the formation and maintenances of a collective identity, Konradt and Hertel (2002) recommend establishing individual symbols and signs for each team. As the meaning of these codes is known only by the members of each team, it is also possible to "communicate" private and group-relevant information in public spaces.

To visualize individual presence and availability information, a set of abstract personal signs is created. Each team member is represented by one sign (see Figure 9). The different social roles of each user are symbolized through slight variations of the basic form of this sign. These personal signs are displayed as an overlay to the ambient patterns. To ensure better recognizability, the individual signs are displayed at fixed positions on the *Hello.Wall*. Besides the static personal signs, dynamic and attention-catching patterns are used to signal communication requests towards remote team members.

Fig. 9. Identification via the Personal.Aura artefact: Connecting an ID Stick to the Reader Module triggers the identification process, resulting in a personal sign being displayed at the remote Hello.Wall

10.3 View.Port

To provide personalized awareness information and simultaneous multi-user interaction, a mobile device called *View.Port* was developed. The *View.Port* is a portable compound artefact with a touch-sensitive display and sensing technology. Due to its graphical display, it can be used for showing detailed and personalized information stored in the *Information Cells* of the *Hello.Wall*.

The functionality of the *View.Port* is enhanced through the integration of a passive RFID reader that makes it possible to identify tagged people and objects. The information about the spatial surrounding can be used to support direct interaction mechanisms as well as personalized information presentation.

As the integrated sensing technology enables to identify tagged users, the information shown on the *View.Port* can be temporarily personalized for the current user. Depending on the active digital role of the user, the *View.Port* can be used to view personalized information, relevant in the current situation. For example, users can directly access in-depth information about a remote user, by bringing their personalized *View.Port* close to the specific personal sign at the *Hello.Wall*. Depending on their access rights, additional information about the remote user is displayed on the screen of the *View.Port*. In combination with the touch sensitive display, users can "directly" interact with this information.

As smart environments require continuous information exchange, the design of privacy-enhancing interaction metaphors is a major challenge. Especially the mechanisms to disclose private information must be easy and intuitively understandable, to prevent unintended data disclosure. In the current version of the *View.Port*, private and public parts of the display are differentiated by form (see Figure 10). By dragging information objects from the private to the public area, private information can be easily disseminated.

Fig. 10. User interface concept of the View.Port: Public and private display areas for easy information dissemination, and physical buttons for direct access to important functions

To support the interaction between the *Hello.Wall* and the *View.Por*t, two independent RFID systems and a wireless LAN network are used. People, entering the *Notification Zone* (see next section) are detected via their *Personal.Aura* artefact, according to the social role currently activated. Once a person is detected, the identification information is sent to a control computer working in the background for further processing. Depending on the kind of application, data can be transmitted to the *View.Port* via a wireless network connection, or personalized information can be displayed on the *Hello.Wall* artefact. Within the *Interaction Zone*, users can access the information "stored" in each *Information Cell* by reading the cell's ID with the integrated short-range reader of the *View.Port*. With the received identification data, the *View.Port* can access the corresponding information stored on the processing computer in the background via wireless LAN. The following figure 11 shows a schematic sketch of the *View.Port* and the *Hello.Wall* coupled via RFID technology and a wireless network.

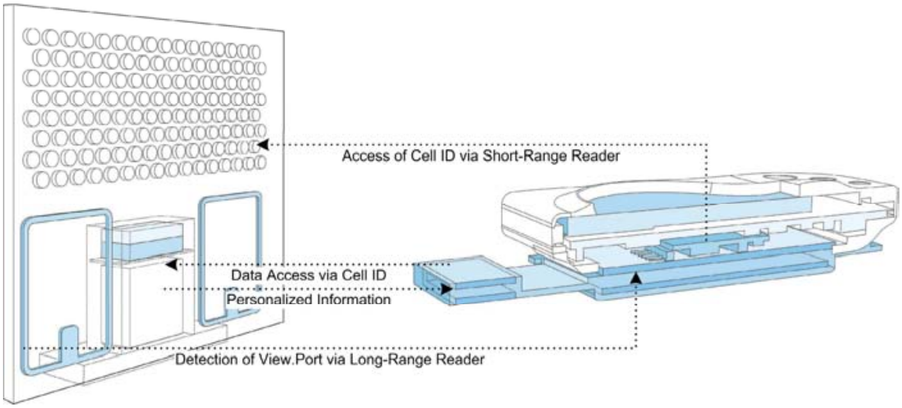


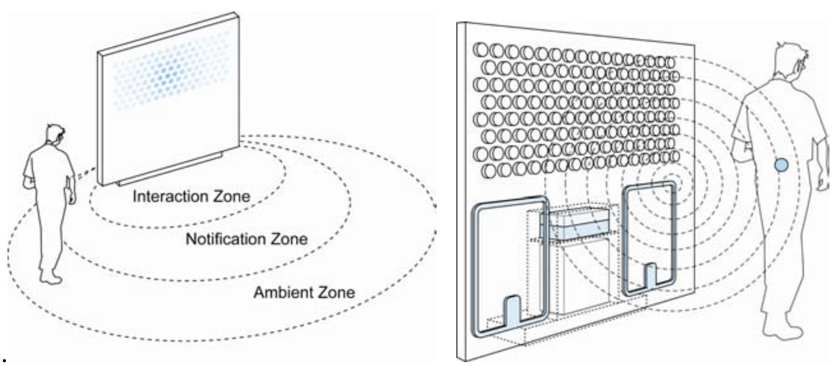
Fig. 11. Communication between the Hello.Wall and View.Port

10.4 Different Zones of Interaction

In order to provide differentiated services, especially for achieving the goal of providing context-aware services, one has to differentiate also the approach for sensing people and collecting relevant parameters. Our objective was that the service provided by the artefact should be location- and situation-based depending on the proximity of people passing by. Therefore, we distinguish between three different "zones of interaction" (see Figure 12) and their respective modes dependent on the distance from the Hello.Wall:

- Ambient Zone
- Notification Zone
- Interaction Zone

The different zones of interaction allows us to introduce a "distance-dependent semantic", implying that the distance of an individual from the smart artefact defines the kind of information shown and the interaction offered. This is realized by integrated sensors covering different ranges. They can be adapted according to the surrounding spatial conditions.



.

Fig. 12. Three zones of interaction (left and detection of a user (right)

11 Pilot Installation and Evaluation

To evaluate the artefacts under real-world conditions, a test environment was set up at two remote work spaces of a distributed project team. Two remote office environments with dedicated lounge areas for communication were used to evaluate the developed prototypes.

11.1 Test Environment

A symmetrical configuration of two *Hello.Wall* artefacts with additional video-conferencing facilities was installed in the lounge spaces at two sites. The first set of artefacts was installed at Fraunhofer IPSI in Darmstadt (Germany), the second at the Laboratory of Design for Cognition, EDF R&D in Paris (France). See Figure 13 for the spatial setting and Figure 14 for the technical concept.

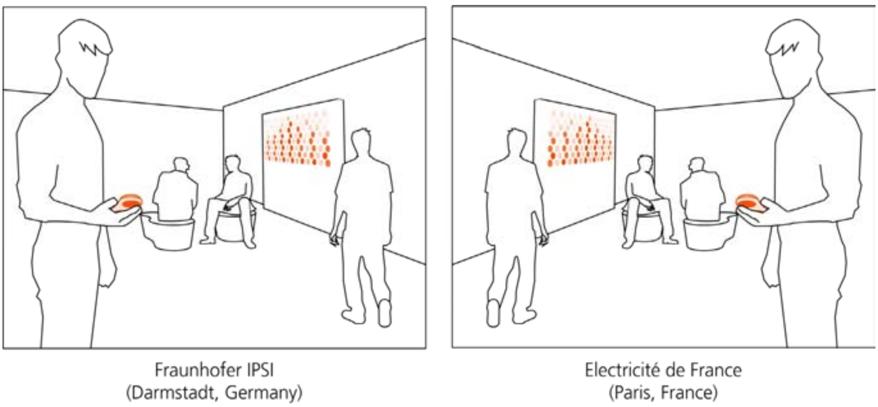


Fig. 13. Vision scribble for the installation of artefacts in the lounge areas at both sites

This setup draws upon the observation, that people in the lounge spaces are tentatively available for conversations while having their coffee break (Prante et al. 2004).

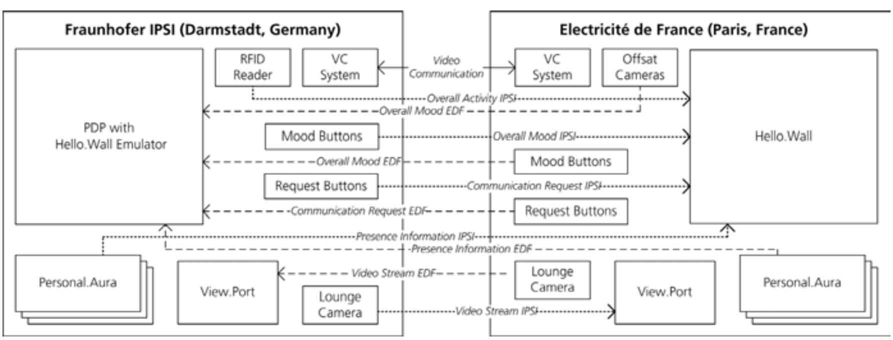


Fig. 14. Technical concept for the test environment.

The “zones of interaction” model, introduced before, was mapped to the floor plans of both office spaces (see Figure 15). While people in the *Ambient Zone* only contribute to the ambient activity patterns, people entering the *Notification Zone* are identified via their *Personal.Aura,* and their personal sign is displayed at the *Hello.Wall* in the remote lounge space. Thus, the *Hello.Wall* continuously presents an intuitively perceivable picture about the atmosphere at the remote site in an ambient and unobtrusive way.

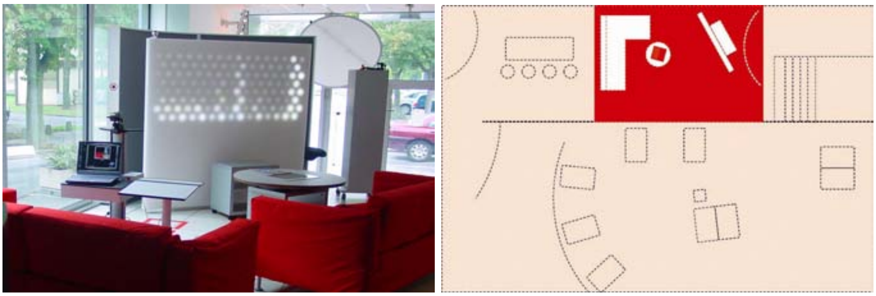


Fig. 15. Lounge area at EDF with the Hello.Wall artefact and the video-conference station (left) and floor plan (right), showing the Ambient Zone (light grey) and the Notification Zone (dark)

To prepare the ground for informal face-to-face communication, the test installation aimed at supporting the team members on both sides in approaching each other by successive signals of agreement, before actually engaging in a conversation. Therefore, special “request buttons” were installed, which could be used to express the interest for a video communication with remote users. Pressing the request button results in an attention-catching pattern to be shown on the *Hello.Wall* at the remote site. The overall mood of each team was captured with an easy, but very effective three-button interface (see Figure 16). After one of the “mood buttons” (bad, average or good) is pressed, its respective value is added to overall mood of the local team, and the updated mood pattern (see Figure 8) appears on the *Hello.Wall* in the remote lounge.

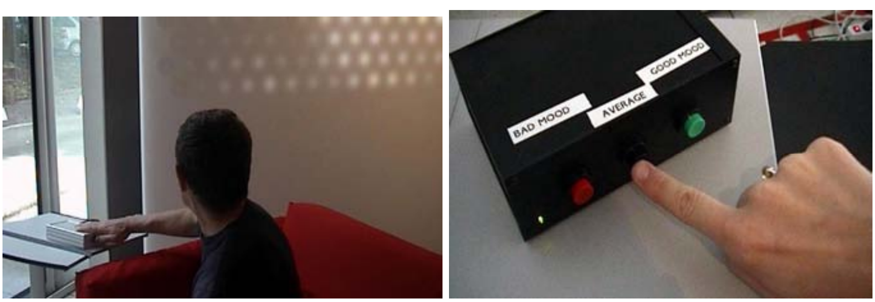


Fig. 16. Request button (left) and mood button (right)

In addition, webcams were installed in both lounge areas, to provide short glances into the remote lounge area. The webcams could be accessed from the remote lounge space using a *View.Port*, which provides users with more detailed information about the current situation in the remote lounge area. To avoid misuse, a special pattern is displayed at the *Hello.Wall*, if a remote colleague is using a *View.Port* to glance into the lounge area.

11.2 Evaluation

To verify the validity of the conceptual approach, and to confirm the added value of the technical prototypes compared to related research results, the developed artefacts were evaluated in a three-step process. To capture subjective as well as performance related aspects, a combination of qualitative and quantitative evaluation techniques was employed.

In a first step, the perception and recognition of the ambient light patterns were tested in a controlled experiment. The evaluation showed, that the ambient light patterns developed for the *Hello.Wall* were easily and intuitively perceptible by all participants. Although the participants were untrained, the recognition rate for both parameters was around 90%. As there might be a learning effect, it is likely, that the recognition will further improve, when users get accustomed to the new representation form.

In a second experimental evaluation, the pattern representation used to visualize information at the *Hello.Wall* was compared to a video representation, which is currently the most-widely used representation form in multi-user awareness systems. Both representation methods were compared regarding their suitability to provide awareness information, their disruptive effects on work as well as privacy concerns that arise during usage. The evaluation showed that the pattern representation used for the *Hello.Wall* significantly reduces distractions. In addition, the privacy concerns, when using the pattern representation, were significantly lower. Hence, the evaluation supported the approach of using ambient patterns to visualize awareness information because it could be shown that using a pattern representation significantly reduces distractions and privacy concerns, without negatively effecting the perception of awareness information.

As standard experimental evaluations are not suitable to test utility aspects of ambient awareness systems, a living-lab evaluation was conducted. All artefacts were tested under real-world conditions for several weeks, in order to investigate their potential for supporting awareness and informal communication in a distributed team. The goal of the evaluation was, to create personal connections between remote team colleagues by establishing awareness moments, and supporting community interactions between both sides. The results of the observation proved the effectiveness of the developed artefacts and confirmed its positive effects on workplace awareness and group communication. The data extracted from the questionnaires showed, that more interactions between both labs took place, and that the video communication system was used more often than before. The test installation was appreciated for providing a feeling for the atmosphere at the remote site and the number of people present, without disturbing the participants' privacy and workflow. Users found it very helpful to see “who is there”, and seemed to gain experience of how the remote colleagues work, and the way the lab is organized. The *Hello.Wall* was described as “a good measure to establish an everyday relationship with people, who are not physically present”, and to improve the atmosphere in the lab “by taking it from isolation”. Besides these more functional aspects, also the design of the artefacts and interaction techniques were considered to be very good and aesthetically pleasing.

It could also be shown, that the *Hello.Wall* can serve as an unobtrusive awareness device in real-world working environments. While the members of the distributed team gained practical benefits using the *Hello.Wall*, the artefact did not attract any attention of people who were not participating in the joint activity, but were just spending some time in the lounge area around the *Hello.Wall*. Details of the evaluation can be found in (Nosulenko et al. 2003).

12 Conclusions

The work reported demonstrates our approach on the role of information and communication technology in future smart buildings for which the notions of the “disappearing computer” and calm technology are of central importance. While in our previous work, e.g., on developing the Roomware components (Streitz et al. 1998, 1999, 2001) the focus was on supporting productivity-related processes of team work and group meetings, the Ambient Agoras environment reported here focused on informal communication and social awareness. In this case, we combined two corresponding design goals: First, to develop a smart environment that supports selected social processes as, e.g., awareness, informal communication, and coordination of team work in local and distributed collaboration settings. Second, the implementation corresponds to and is compatible with the nature and characteristics of the processes addressed by following the objectives of developing a calm technology providing appropriate affordances. Computers move into the background and are not considered or perceived anymore to be computers or computer-related devices.

As part of our subsequent and current work, we exploit the results gained in office environments and transfer our experiences to building intelligent user services for smart home environments with a focus on home information and entertainment. Issues of capturing information about people’s activities and transforming them into experiences of awareness exchanged between remote sites reappear here again in the context of scenarios for remote but networked homes. This work is done in the EU-funded project “Amigo – Ambient Intelligence in the Networked Home Environments”. Some results on the corresponding work on awareness can be found, e.g., in Röcker and Etter (2007) and Etter and Röcker (2007).

Acknowledgements

The work reported in this chapter was supported by the European Commission as part of the “Disappearing Computer” initiative (“Ambient Agoras” project, contract IST–2000-25134). Furthermore, we like to thank all those project members, not being authors, from the German office manufacturer Wilkhahn and the French electrical power utility provider EDF (Electricité de France) as well as members and students of the Fraunhofer research division AMBIENTE who contributed substantially to realizing the different components and environments.

References

Ambient Agoras website: http://www.ambient-agoras.org

Alexander, C.: A Pattern Language. Oxford University Press, New York (1977)

Bellotti, V., Bly, S.: Walking Away from the Desktop Computer: Distributed Collaboration and Mobility in a Product Design Team. In: Proceedings of the ACM Conference on Computer Supported Cooperative Work (CSCW'96), pp. 209–218. ACM Press, New York (1996)

Bellotti, V., Ducheneaut, N., Howard, M., Smith, I.: Taking Email to Task: The Design and Evaluation of a Task Management Centred Email Tool. In: Proceedings of the Conference on Human Factors in Computing Systems (CHI'03), pp. 345–352 (2003)

Bly, S., Harrison, S.R., Irwin, S.: Media Spaces: Bringing People Together in a Video, Audio, and Computing Environment. Communications of the ACM 36(1), 28–46 (1993)

Churchill, E.F., Nelson, L., Denoue, L., Helfman, J., Murphy, P.: Sharing Multimedia Content with Interactive Public Displays: A Case Study. In: Proceedings of the Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques (DIS'04), pp. 7–16 (2004)

Dourish, P., Bly, S.: Portholes: Supporting Awareness in a Distributed Work Group. In: Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'92), pp. 541–547. ACM Press, New York (1992)

Eldridge, M., Barnard, P., Bekerian, D.: Autobiographical Memory and Daily Schemes at Work. Memory 2(1), 51–74 (1994)

Etter, R., Röcker, C.: A Tangible User Interface for Multi-User Awareness Systems. In: Proceedings of the International Conference on Tangible and Embedded Interaction '07, Baton Rouge, USA, February 15–17 (2007)

Fish, R.S., Kraut, R.E., Root, R.W., Rice, R.E.: Evaluating Video as a Technology for Informal Communication. In: Bauersfeld, P., Bennett, J., Lynch, G. (eds.) Proceedings of the ACM CHI 1992 Conference, pp. 37–48. ACM Press, New York (1992)

Gaver, W.: Technology Affordances. Proceedings of the ACM CHI 1991 Conference, pp. 79–84. ACM Press, New York (1991)

Gaver, W.W., Moran, T., MacLean, A., Lovstrand, L., Dourish, P., Carter, K.A., Buxton, W.: Realizing a Video Environment: EuroPARC's RAVE System. In: Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'92), pp. 27–35. ACM Press, New York (1992)

Gellersen, H.-W., Schmidt, A., Beigl, M.: Ambient Media for Peripheral Information Display. Personal Technologies 3(4), 199–208 (1999)

Gibson, J.: The Ecological Approach to Visual Perception. Houghton Mifflin, Boston (1979)

Guzzo, R., Salas, E.: Team Effectiveness and Decision Making in Organizations. Jossey-Bass, San Francisco (1995)

Gwizdka, J.: TaskView: Design and Evaluation of a Task-Based Email Interface. In: Proceedings of the Conference of the Centre for Advanced Studies on Collaborative Research, pp. 136–145 (2002)

Huang, E.M., Russell, D.M., Sue, A.E.: IM here: Public Instant Messaging on Large, Shared Displays for Workgroup Interactions. In: Proceedings of the Conference on Human Factors in Computing Systems (CHI'04), pp. 279–286 (2004)

Ishii, H., Wisneski, C., Brave, S., Dahley, A., Gobert, M., Ullmer, B., Paul, Y.: AmbientROOM: Integrating Ambient Media with Architectural Space. In: Proceedings of Human Factors in Computing Systems (CHI 1998), pp. 173–174. ACM Press, New York (1998)

ISTAG: Scenarios for Ambient Intelligence in 2010. Final Report by the IST Advisory Group (2001), ftp://ftp.cordis.lu/pub/ist/docs/istagscenarios2010.pdf

Konradt, U., Hertel, G.: Management virtueller Teams - Von der Telearbeit zum virtuellen Unternehmen. Beltz Verlag, Weinheim (2002)

Kraut, R.E., Fish, R.S., Root, R.W., Chalfonte, B.L.: Informal Communication in Organizations: Form, Function, and Technology. In: Oskamp, S., Spacapan, S. (eds.) Human Reactions to Technology: The Claremont Symposium on Applied Social Psychology, pp. 145–199. Sage, Beverly Hills (1990), reprinted in: Baecker, R.M. (ed.) Readings in Groupware and Computer-Supported Cooperative Work. Morgan Kaufmann, San Francisco, pp. 287–314

Lahlou, S., Jegou, F.: European Disappearing Computer Privacy Design Guidelines V1.0. Ambient Agoras Report D15.4, Disappearing Computer Initiative (2003)

Lahlou, L., Langheinrich, M., Röcker, C.: Privacy and trust issues with invisible computers. Communications of the ACM 48(3), 59–60 (2005)

Lamming, M., Eldridge, M., Flynn, M., Jones, C., Pendlebury, D.: Satchel: Providing Access to any Document, any Time, anywhere. ACM Transactions on Computer-Human Interaction 7(3), 322–352 (2000)

Langheinrich, M.: Privacy by Design – Principles of Privacy-Aware Ubiquitous Systems. In: Abowd, G.D., Brumitt, B., Shafer, S. (eds.) Ubicomp 2001: Ubiquitous Computing. LNCS, vol. 2201, pp. 273–291. Springer, Heidelberg (2001)

Mankoff, J., Dey, A., Hsieh, G., Kientz, J., Lederer, S., Ames, M.: Heuristic Evaluation of Ambient Displays. In: Proceedings of ACM Conference CHI 2003, pp. 169–176 (2003)

McGrenere, J., Ho, W.: Affordances: Clarifying an Evolving Concept. In: Proceedings of Graphics Interface 2000 (Montreal, Canada), pp. 179–186 (2000)

Nardi, B.A., Whittaker, S., Bradner, E.: Interaction and Outeraction: Instant Messaging in Action. In: Proceedings of the ACM Conference on Computer Supported Cooperative Work (CSCW'00), pp. 79–88. ACM Press, New York (2000)

Norman, D.: The Psychology of Everyday Things. Basic Books, New York (1988)

Norman, D.: Affordance, Conventions, and Design. ACM Interactions (May and June 1999), pp. 38–42. ACM Press, New York (1999)

Nosulenko, V., Samoylenko, E., Welinski, P.: D12.10 – Hello.Wall and Videomaton User Experience. Deliverable of the 'Ambient Agoras' Project for the Third Disappearing Computer Jamboree, Ivrea, Italy (2003)

OECD - Organization for Economic Co-operation and Development: Guidelines on the Protection of Privacy and Transborder Flows of Personal Data (1980), http://www.junkbusters.com/fip.html

Panko, R.R.: Managerial Communication Patterns. Journal of Organizational Computing 2(1), 95–122 (1992)

Pelizäus-Hoffmeister, H.: Mobilität - Chance oder Risiko? Soziale Netzwerke unter den Bedingungen räumlicher Mobilität - Das Beispiel freie JournalistInnen. Leske und Budrich, Opalden (2001)

Potter, R., Balthazard, P.: Virtual Team Interaction Styles: Assessment and Effects. International Journal for Human-Computer Studies 56(4), 423–443 (2002)

Prante, T., Stenzel, R., Röcker, C., van Alphen, D., Streitz, N., Magerkurth, C., Plewe, D.: Connecting Remote Teams: Cross-Media Integration to Support Remote Informal Encounters. In: Video Track and Adjunct Proceedings of the Sixth International Conference on Ubiquitous Computing (UBICOMP'04), Nottingham, England, September 7-10, 2004 (2004)

Robbin, A.: The Loss of Personal Privacy and its Consequences for Social Research. Journal of Government Information 28(5), 493–527 (2001)

Röcker, C.: Awareness and Informal Communication in Smart Office Environments. Verlag Dr. Driesen, Taunusstein (2006)

Röcker, C., Etter, R.: Social Radio: A Music-Based Approach to Emotional Awareness Mediation. In: Proceedings of the 10th International Conference on Intelligent User Interfaces (Honolulu, USA), pp. 286–289 (2007)

Rohall, S.L., Gruen, D., Moody, P., Wattenberg, M., Stern, M., Kerr, B., Stachel, B., Dave, K., Armes, R., Wilcox, E.: ReMail: A Reinvented Email Prototype. In: Extended Abstracts of the Conference on Human Factors in Computing Systems (CHI'04), pp. 791–792 (2004)

Sonnentag, S.: Work, Recovery Activities, and Individual Well-Being: A Diary Study. Journal of Occupational Health Psychology 6(3), 196–210 (2001)

Streitz, N.: Mental models and metaphors: Implications for the design of adaptive user-system interfaces. In: Mandl, H., Lesgold, A. (eds.) Learning Issues for Intelligent Tutoring Systems. Cognitive Science Series, pp. 164–186. Springer, New York (1988)

Streitz, N.: Augmented Reality and the Disappearing Computer. In: Smith, M., Salvendy, G., Harris, D., Koubek, R. (eds.) Cognitive Engineering, Intelligent Agents and Virtual Reality, pp. 738–742. Lawrence Erlbaum Associates, Mahwah (2001)

Streitz, N., Geißler, J., Holmer, T.: Roomware for Cooperative Buildings: Integrated Design of Architectural Spaces and Information Spaces. In: Streitz, N.A., Konomi, S., Burkhardt, H.-J. (eds.) CoBuild 1998. LNCS, vol. 1370, pp. 4–21. Springer, Heidelberg (1998)

Streitz, N., Geißler, J., Holmer, T., Konomi, S., Müller-Tomfelde, C., Reischl, W., Rexroth, P., Seitz, P., Steinmetz, R.: i-LAND: an Interactive Landscape for Creativity and Innovation. In: Proceedings of ACM Conference CHI'99 (Pittsburgh, USA), pp. 120–127. ACM, New York (1999)

Streitz, N., Magerkurth, C., Prante, T., Röcker, C.: From Information Design to Experience Design: Smart Artefacts and the Disappearing Computer. ACM Interactions, Special Issue on Ambient intelligence (July and August 2005), 12(4), 21–25 (2005a)

Streitz, N., Nixon, P.: The Disappearing Computer. Communications of the ACM 48(3), 33–35 (2005)

Streitz, N., Tandler, P., Müller-Tomfelde, C., Konomi, S.: Roomware: Towards the Next Generation of Human-Computer Interaction based on an Integrated Design of Real and Virtual Worlds. In: Carroll, J. (ed.) Human-Computer Interaction in the New Millennium, pp. 553–578. Addison-Wesley, Reading (2001)

Streitz, N., Prante, T., Röcker, C., van Alphen, D., Magerkurth, C., Stenzel, R., Plewe, D.A.: Plewe~DA Ambient Displays and Mobile Devices for the Creation of Social Architectural Spaces: Supporting informal communication and social awareness in organizations. In: O'Hara, K., Perry, M., Churchill, E., Russell, D. (eds.) Public and Situated Displays: Social and Interactional Aspects of Shared Display Technologies, pp. 387--409. Kluwer Publishers, Dordrecht (2003)

Streitz, N., Röcker, C., Prante, T., van Alphen, D., Stenzel, R., Magerkurth, C.: Designing Smart Artifacts for Smart Environments. IEEE Computer, March 2005, pp. 41-49 (2005b)

Sundstrom, E.: Supporting Work Team Effectiveness. Jossey-Bass, San Francisco (1999)

Utz, S.: Identifikation mit virtuellen Arbeitsgruppen und Organisationen. In: Boos, M., Jonas, K.J., Sassenberg, K. (eds.) Computervermittelte Kommunikation in Organisationen, pp. 41–55. Hogrefe, Göttingen (2000)

Vogel, D., Balakrishnan, R.: Interactive Public Ambient Displays: Transitioning From Implicit to Explicit, Public to Personal, Interaction with Multiple Users. In: Proceedings of the ACM Symposium on User Interface Software and Technology (UIST'04), pp. 137–146. ACM Press, New York (2004)

Weiser M.: The Computer for the 21st Century. Scientific American, September 1991, 66-75 (1991)

Weiser, M., Brown, J.S.: Designing Calm Technology, Xerox PARC report (December 21, 1995)

Whittaker, S., Frohlich, D., Daly-Jones, O.: Informal Workplace Communication What is it Like and How Might we Support it? In: Proceedings of ACM Conference on Human Factors in Computing Science (CHI '95), pp. 131–137. ACM, New York (1994)

Wisneski, C., Ishii, H., Dahley, A., Gorbet, M., Brave, S., Ullmer, B., Yarin, P.: Ambient Displays: Turning Architectural Space into an Interface between people and Digital Information. In: Streitz, N.A., Konomi, S., Burkhardt, H.-J. (eds.) CoBuild 1998. LNCS, vol. 1370, pp. 22–32. Springer, Heidelberg (1998)