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Services and Applications for Smart Office Environments - A Survey of State-of-the-Art Usage Scenarios

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***Abstract*—**This paper reports on a survey of state-of-the-art application scenarios for smart office environments. Based on an analysis of ongoing research activities and industry projects, functionalities and services of future office systems are extracted. In a second step, these results are used to identify the key characteristics of emerging products.

***Keywords*—**Ambient Intelligence, Ubiquitous Computing, Smart Office Environments, Application Scenarios.

I. Introduction

RECENT advances in the area of material science enable designers to build computers in a variety of new forms and sizes. Extrapolating these developments, we soon have to expect office spaces, where computers are ubiquitously available throughout the entire work environment. The increasing miniaturization of computer technology is expected to result in processors and sensors being integrated into more and more everyday objects, leading to the disappearance of traditional desktop computers [9]. This coming 'post-PC' era will be characterized by the emergence of 'smart environments', which recognize and respond to the needs of their inhabitants in an almost invisible fashion [77]. Based on the initial idea of Ubiquitous Computing [99], the concept of smart environments envisions a future, where a multitude of computers are seamlessly embedded into everyday objects of the physical world. In this sense, Cook and Das [13] define a smart environment as "a small world, where all kinds of smart devices are continuously working to make inhabitants' lives more comfortable". These smart artefacts are equipped with sensors, memory and communication capabilities (see, e.g., [26] or [35]) and are able to capture information about their surrounding, communicate with each other and react according to previously defined rules [86].

In general, smart environments open up new possibilities for enhancing communication and collaboration in office spaces and thereby enable new and more efficient ways for organizing team and project activities ([4],[27],[31],0). The theoretical advantages range from increased work productivity through time-saving operations to higher work satisfaction through attentive and reactive environments.

Nevertheless, it is still rather unclear where the current developments are heading. Especially in the work domain, there exists only very limited knowledge about the impact of these technologies on business processes, and how these applications can create an added value for companies [27]. This 'vagueness of the vision' [2] is caused by a considerable divergence between the technical feasibility and the ability to use it in a beneficial way [8].

Therefore, this papers tries to shed light on current trends by providing an overview over ongoing developments in the area of smart office applications. This will be done by analyzing state-of-the-art usage scenarios, which were recently developed in research as well as industry projects, and identifying the key functionalities of the envisioned systems.

II. The Role of Scenarios in the Product Development Process

Today, scenario-based design techniques are widely used in early phases of most product development cycles. In the field of user-centered design research, the term 'scenario' refers to a narrative, which describes an individual interacting with a device or an application in order to achieve a specific goal (see, e.g., [6]). With this definition, the term is used in a sharp contrast to its usage in other domains, like, e.g. 'scenario planning', which usually refers to the macroscopic view of large-scale market trends [57].

The usage of scenarios in the design process of new technologies and applications brings a variety of advantages over traditional design techniques (see, e.g., [100]). With technology cycles in the information and communication industry becoming shorter every year, scenario-based planning provides one of the few structured ways to get an impression of the future [22]. At the same time scenarios help to uncover the specific steps and challenges, that have to be taken into account when envisioning future applications [31]. In contrast to other methods, like for example the Delphi method, scenarios provide the ability to anticipate several orthogonal futures, instead restricting future developments to a single forecast [7].

When predicting up-coming technologies and applications, it is helpful to divide the future into four intervals, instead of

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using chronological measuring units [14]. Each time interval (see Fig. 1) describes a future world, which is either 'technological feasible', 'argumentative feasible', 'vision' or pure 'utopia' (see also [47]). Scenarios usually describe applications and systems, which, from a technical point of view, are not yet practicable, but are argumentatively already feasible.

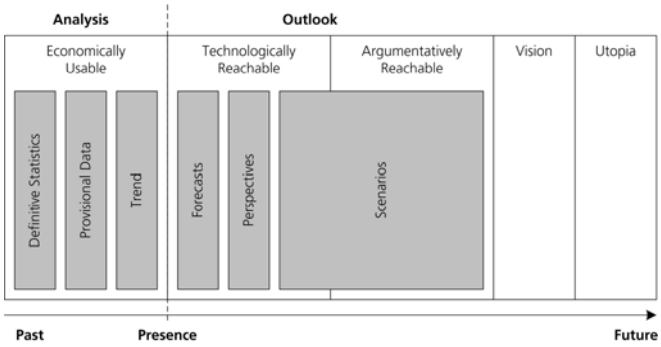

Fig. 1. Temporal scope of scenarios according to Coroama et al. [14].

Especially in cross-organizational projects, scenarios are often used to establish a common ground and communicate individual goals as well as functional expectation among the different project partners. Once this is done, the different ideas from the initial scenarios are mostly combined in a final project scenario, which incorporates the desired functionalities, and thereby helps to guide the development process and communicates the project goals to the outside world. Hence, the scenario elements described in the next sections, provide a good overview over the development processes currently going, and are therefore a quite reliable indicator for products and systems, which will become available in the near future.

III. Analysis of Usage Scenarios

In order to identify emerging services and applications, an analysis of existing research and project literature was conducted. The focus of this analysis was on work-related scenarios developed in the US, Europe, and Asia. During the review process it became evident, that a variety of projects (e.g., Amigo [80] or AwareHome [46]) specifically concentrate on the home domain. In order to get a broader and more representative collection of scenario samples, elements of home scenarios were taken into account, if the functionalities described in these scenarios are also usable in the office domain. In the end, N=516 scenario elements were extracted from 68 different sources. The analysis shows that there are three basic types of scenario elements: beneficial, enabling and negative scenario elements.

(1) Beneficial Scenario Elements describe situations, where users gain concrete benefits from the usage of the described technologies. In most cases these scenario elements describe a high-level service, without describing the underlying technical processes, which are necessary to provide this service.

(2) Enabling Scenario Elements describe functionalities, which do not provide a direct benefit for the user, but are necessary in order to provide other 'high-level' services. Most of these elements describe localization or identification processes within smart environments.

(3) Negative Scenario Elements describe problems as well as consequences that arise, when smart office applications go wrong or do not work as expected. Loss of control and device malfunctions are typical problems illustrated in these scenario elements.

Subsequent to the analysis, the scenario elements were grouped according to their functionalities. As this paper aims to identify the key services and application of future office systems, only beneficial scenario elements were included in the process. Additional information on the identified enabling and negative scenario elements can be found in [76]. The following section provides an overview over the different types of functionalities, which were identified in the survey.

IV. Emerging Services and Applications

The services and applications described in the various beneficial scenario elements comprise a wide range of functionalities, ranging from the automation of standard office tasks, like automatic meeting protocols to complete new services, like adaptive office environments. The elements are clustered into six main groups. In order to detect functionalities, which are representative for smart office applications, a group had to comprise at least three scenario elements describing the same functionality. If this was not the case, the described functionality was not considered to be representative for current developments. The corresponding elements were then either integrated into a group of similar scenario elements or (if the elements could not be related to any other group) left out of the analysis.

The first group of scenario elements subsumes different types of communication services. The described functionalities either focus on the communication process itself or describe different types of mechanisms to support or coordinate communication processes among users. The scenario elements in the second group describe novel interaction techniques as well as input and output devices, which are based on Ambient Intelligence technologies. The next group combines scenario elements, which address different types of information processing functionalities, including aspects of data collection and transfer as well as information access mechanisms. In the fourth group, scenario elements are listed, which illustrate different forms of user- and context-adapted services. Based on automatically captured location and identity information, the majority of scenario elements describe the personalization of devices and applications, or the situation-based adaptation of the physical surrounding. The fifth group contains different types of smart

office services, which support users in their everyday office activities. In most cases, the service is based on intelligent, and sometimes autonomously acting, personal digital assistants. The scenario elements in the last group describe different types of smart office management functionalities.

In the remainder of this section, the different groups of scenario elements are described in more detail. To enhance readability, three representative elements are listed as examples for each functionality. The complete lists of all scenario elements can be found in [76].

A. Communication

The role of teamwork has gained significant importance in knowledge-based work environments. Besides an immense increase in the use of work groups within companies (see, e.g., [37], [91] or [96]), also virtual teams, where team members collaborate from remote locations, become more and more popular [69]. As a result, the importance and amount of remote communication is constantly increasing. The scenario elements either focus on the communication process itself or describe functionalities that are employed in order to support or initiate communication processes between multiple users.

1) Synchronous Communication

With more and more employees working in teams, the role of communication in the workplace becomes increasingly important. The precondition for the successful completion of a task is the existence of a shared mental model, which serves as the basis for a common understanding of responsibilities and information demands of the single team members ([10],[62],[84]). As a consequence, missing or insufficient communication leads to the inability to build up the required shared mental models [63]. Several studies (e.g., [19]) proved that the communication among team members has a strong influence on their performance.

In order to support remote communication among members of distributed teams, a variety of scenario elements describe novel functionalities and devices for explicit and direct remote communication.

TABLE I EXAMPLES OF SCENARIO ELEMENTS DESCRIBING EXPLICIT COMMUNICATION

Element	Element Description	Source
A1.1.1	So, they initiated a synchronous AV-connection to the lounge, respectively people with the same mood at the downstairs conference.	[70]
A1.1.2	When Daniel and Marc want to speak to each other, they each go to the mirror and face each other to talk.	[55]
A1.1.3	She briefly connects [...] to say hello to Charlotte, and her video picture automatically appears on the flat screen that is currently used by Charlotte.	[40],[66]

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 [90]. Mutual awareness usually leads to informal interactions, spontaneous connections and the development of shared cultures, all important aspects of maintaining working relationships [21]. A detailed description of team awareness and its consequences for remote collaboration can be found in [75]. The importance for adequate systems to support awareness in distributed work teams is addressed in a variety of scenarios. Similar scenario elements can be found in Table .

TABLE II EXAMPLES OF SCENARIO ELEMENTS DESCRIBING IMPLICIT COMMUNICATION

Element	Element Description	Source
A1.2.1	The patterns exposed on the Hello.Wall reflected both the presence or activity level and the mood of collaborators at the remote space.	[60]
A1.2.2	Bettina relaxes in the lounge space of her company. The Hello.Wall shows the presence and mood of her colleagues in the lounge area of a remote office.	[55]
A1.2.3	They have had an ‘ambience sharing’ system installed [...].	[3]

2) Asynchronous Communication

Asynchronous communication tools, like e-mail or instant messaging, are currently the most widely used forms of computer-mediated communication in office environments and, as a storage-based and asynchronous communication medium, have several advantages for task-related communication. Although text-based communication tools are widely used today, they require a comparatively high effort of expressing sensitive information in an appropriate way, so that no misunderstandings occur. In addition, the usage of text-based communication applications often leads to recurring distractions of the work process. Especially e-mail communication is often cited as one of the major sources for interruptions in office environments. In a study about e-mail usage, Jackson et al. [41] found, that 70% of the observed e-mail users reacted to notifications of incoming e-mail within six seconds. After having read the e-mail, users, on average, took 64 seconds to “recover the mental thread” of what they were doing before in order to be able to resume their previous tasks. Smart office environments can help to improve asynchronous communication in several ways. For example, new user interfaces and interaction techniques can help to reduce the communication effort, while context-aware application can be employed to adapt the notification and information visualization to the current context of the user.

TABLE III EXAMPLES OF SCENARIO ELEMENTS DESCRIBING ASYNCHRONOUS COMMUNICATION

Element	Element Description	Source
A2.1	While Sara and I were on our way to the 10th floor, we were informed by the elevator that Mark left us a message.	[70]
A2.2	I give a short answer to the Office, in case he comes back before his appointment and remind him to leave his PDA on my desk for the system demonstration on Friday.	[70]
A2.3	François enters the building and the entrance door [...] delivers him a message Saadi left for him last night: "I will be late tomorrow, you can use my office if you need it!"	[70]

3) Communication Support

Information about the presence and availability of colleagues are key issues of improving teamwork ([38],[34], [56]). One of the main drawbacks of current communication technologies is that they fail to provide availability awareness. For example, around 60 % of business phone calls fail to reach the intended party, either because people are not present, or they are already talking to someone else ([61],[74],[92],[93], [101]). In addition, sharing an indication about the current state of a person also helps to avoid interruptions through poorly timed communication attempts [28]. The following scenario elements describe situations, where users employ specific applications or devices in order to obtain information about the availability and presence of others.

TABLE IV EXAMPLES OF SCENARIO ELEMENTS DESCRIBING AVAILABILITY CHECKS

Element	Element Description	Source
A3.1.1	The Mobile Presence Server manages messages, pictures and real time reachability information.	[55]
A3.1.2	Based on the different context, which could be derived from the different locations, the status respectively the working situations of the captured device and persons are determined.	[14]
A3.1.3	On the display of his smart phone, all colleagues are shown, who have currently activated their professional role.	[54]

The second sub-group of scenario elements describes functionalities and devices, which support the communication between distributed users. The communication functionality is either provided by the same systems, or users have to employ other (mostly traditional) communication tools. The communication itself mostly takes place in form of video-conference, or by means of a virtual reality application.

TABLE V EXAMPLES OF SCENARIO ELEMENTS DESCRIBING THE SUPPORT OF REMOTE COMMUNICATION

Element	Element Description	Source
A3.2.1	Mami is talking to [...] Jean via the wall-mounted display that is wirelessly connected to the mobile terminals. The three-dimensional images of Jean are displayed to provide a 3D telepresence.	[18]
A3.2.2	She briefly connects [...] to say hello to Charlotte, and her video picture automatically appears on the flat screen that is currently used by Charlotte.	[40],[66]
A3.2.3	The 'Request Pattern' shown at the Hello.Wall indicates that one of the Ambient-Agoras team members asks for a video conference with his remote colleague.	[60]

The last set of scenario elements addresses the support of personal encounters, either between people that already know each other, or between new people based on similar interests or profiles.

TABLE VI EXAMPLES OF SCENARIO ELEMENTS DESCRIBING THE SUPPORT OF PERSONAL ENCOUNTERS

Element	Element Description	Source
A3.3.1	The Personal Aura tracks other Personal Auras and negotiates opportunities of contacts.	[52]
A3.3.2	[He] activates his availability to meet a person, putting his profile at disposal.	[16]
A3.3.3	Knowing who is in the building the system can connect people spontaneously - especially when they are already in a recreation lounge or intend to have a break soon.	[67]

B. Interaction

Studies by Kraut et al. ([48],[49]) showed, that the behavioral costs of accessing a communication system are an important determinant of the system's usefulness. Hence, the interaction between the user and the application should be simple and lightweight, without requiring much effort from the user in order to minimize the costs associated with each instance of use [103]. As the requirements for providing and perceiving information are fundamentally different [75], a combination of different interaction modalities can help to reduce the interaction costs. By using different devices and modalities for input and output interactions, it is possible to adapt the interfaces to the specific requirements of each form of interaction. The scenario elements in the following sections describe novel interaction techniques and interfaces, which are based on novel sensing technologies.

1) Input Interaction

While mice and keyboards are currently the main input interfaces for most electronic devices, smart office environments will provide a variety of new interfaces concepts, which will enable easy and intuitive user input. The most promising interface concepts include tangible user interfaces, speech interfaces and implicit interaction mechanisms. The term Tangible User Interface (TUI) was coined by Ishii and Ullmer [39] and describes user interfaces, which enable users to interact with digital information through physical objects or their immediate environment. With sensors and processors being embedded in objects of our physical world, most everyday objects have the potential to become an interface to the digital world. As Table shows, this vision can be realized in a multitude of different ways.

TABLE VII EXAMPLES OF SCENARIO ELEMENTS DESCRIBING TANGIBLE USER INTERFACES

Element	Element Description	Source
B1.1.1	By simply putting his key chain on the table in front of him, his presentation is started on the wall next to him.	[14]
B1.1.2	All participants can interact directly at the mobile electronic walls.	[70]
B1.1.3	Content can, e.g., be directed to an appropriate display by changing Sepia's orientation, or by pointing their finger to it.	[55]

Speech input is not a totally new interaction technique and is already supported by some devices today. But while current devices only support single commands, future devices will enable natural communication based on a rich set of vocabulary.

TABLE VIII EXAMPLES OF SCENARIO ELEMENTS DESCRIBING SPEECH INPUT

Element	Element Description	Source
B1.2.1	"Show me today's agenda", she instructs the computer.	[72]
B1.2.2	[...] Alice asks her address book to place the call.	[68]
B1.2.3	The user is able to ask for how many new e-mails he/she has, using the most common sentences for that such as "Maior-Domo, tell me how many e-mails I have" or "Maior-Domo, do I have any new e-mails?" among many others.	[32]

Tangible user interfaces as well as speech interface require explicit input from the user in order to perform the intended action. In contrast, several scenario elements describe interaction techniques, which exploit 'implicit contextual cues', such as body orientation and user proximity to the device [97] as input parameters for the system.

TABLE IX EXAMPLES OF SCENARIO ELEMENTS DESCRIBING IMPLICIT INTERACTION MECHANISMS

Element	Element Description	Source
B1.3.1	Approaching the wall leads to a higher level of detail.	[67]
B1.3.2	[...] her motion is detected and the coffee machine starts to brew coffee.	[83]
B1.3.3	When Maria walks towards one of the screens, the image of John [...] zooms in and the two talk about what they did during the day and their plans [...].	[3]

2) Information Output

In contrast to most input interactions, perceiving information does not require users to directly interact with the presentation devices. Hence, to support more natural forms of information perception, it seems favorable to present the information within the physical spaces the users occupy [20]. To do this, the extracted scenario elements envision a variety of different output devices, ranging from traditional graphical displays to completely new visualization artifacts.

In quite a number of scenario elements, large-sized graphical displays are employed to visualize information in the users' environment. While most scenario elements still describe traditional display technologies, graphical displays are only one way of presenting information in intelligent environments. Nevertheless, large public displays are likely to become an integral part of most future office spaces [79].

TABLE X EXAMPLES OF SCENARIO ELEMENTS DESCRIBING LARGE-SCREEN DISPLAYS

Element	Element Description	Source
B2.1.1	The phone is equipped with a micro-projector, which projects a small display to the wall.	[59]
B2.1.2	In Jack's working room, a large white board covers half of the wall serving as computer and interaction screen.	[44]
B2.1.3	As Bob is walking close to an active wall, he is presented a message relevant to his trip.	[100]

The second sub-group of scenario elements, that addresses output interactions, uses Ambient Displays to visualize information. Ambient Displays usually present information within the user's environment through subtle changes in light, sound and movement, which can be processed in the background of awareness [102]. The term 'display' in this context means any construction, which makes information visible. So an ambient display must not necessarily be a traditional display like a computer monitor, but it may also be a dynamic light installation, a water fountain or any other artifact, which is able to display information. Most Ambient displays do not visualize the data directly, but use different

degrees of abstraction to display information, making it easier to be interpreted and requiring less attention [50].

TABLE XI EXAMPLES OF SCENARIO ELEMENTS DESCRIBING AMBIENT DISPLAYS

Element	Element Description	Source
B2.2.1	While he is sitting at the table with Petra, an overview of incoming e-mails is shown by means of an abstract visualization on a large wall display.	[54]
B2.2.2	When I approach the building close to eight, there are vague sounds indicating the level of activity in areas I am interested in.	[70]
B2.2.3	In a standby mode, John may be presented with various instances of an audio-video ambience of his liking.	[3]

Speech output is another output modality, which is frequently used in situations, where peripheral information perception is possible. In most scenario elements, speech is used as an alternative output channel for written text, especially e-mail, or as direct feedback on a previous (vocal) user command.

TABLE XII EXAMPLES OF SCENARIO ELEMENTS DESCRIBING SPEECH OUTPUT

Element	Element Description	Source
B2.3.1	Because Bob is not listening to the radio, the PDA decides to communicate this information by vocal command using the car speakers.	[100]
B2.3.2	The Maior-Domo answers, telling how many messages there are and the sender of everyone. The user can choose, which one he would like to listen to and the Maior-Domo will read it.	[32]
B2.3.3	Mr. Rossi, with a vocal command, may order the E2R device to read the entire message or not.	[17]

While the scenario elements listed so far, employ display technologies, which are already available today (at least in a simplified form), the last sub-group describes visualization devices, which are quite different from the displays we know today. In this context, two different approaches can be distinguished. In the first approach, everyday objects or part of the physical surrounding, like tables or walls, are used to visualize digital information in the user's surrounding. In the second approach, new devices are employed, which do not yet exist. On most devices, the information is visualized in an explicit form, compared to the ambient displays described in the last paragraph.

TABLE XIII EXAMPLES OF SCENARIO ELEMENTS DESCRIBING NEW OUTPUT DEVICES

Element	Element Description	Source
B2.4.1	They no longer miss calls or visitors, because they cannot get to the telephone or door in time; microphones and speakers in the walls enable them to answer either at any time.	[64]
B2.4.2	When she enters the [...] memo frame lights up to indicate that there are new messages.	[40]
B2.4.3	The message is displayed on the Table.	[1]

So far, the information was only presented on a singular output device. But especially in dynamic situations, where people, for example, move through a physical environment, it is helpful, to dynamically switch between different displays or combine multiple devices in order to provide better visualization quality. In a number of scenario elements, mobile devices with relatively small screen sizes dynamically transfer information to a larger screen, which is available in the user's environment. The act of switching from one interface to another is either triggered by the user or automatically done by the output device(s).

TABLE XIV EXAMPLES OF SCENARIO ELEMENTS DESCRIBING A COMBINATION OF MULTIPLE OUTPUT DEVICES

Element	Element Description	Source
B2.5.1	While you are working at the computer workstation, you tell the EasyLiving system to move your display to the wall screen in the room. It moves there.	[87]
B2.5.2	A computer projector automatically displays your sales presentation, after your mobile phone beams a web address into the projector.	[11]
B2.5.3	Unfortunately, with a frustratingly small screen on your PDA, you can't see much information. Mobile Valet allows you to context-shift the service into a nearby kiosk, where you can view the information in far greater detail.	[25]

3) Automatic Device Configuration

While the last two sections described situations, in which users interact with devices or their immediate environments, a third group of scenario elements describes the interaction among multiple smart devices. The goal of the automated integration and configuration functionalities, described in the scenario, is to take off the burden of the technical configuration process from users.

TABLE XV EXAMPLES OF SCENARIO ELEMENTS DESCRIBING AUTOMATIC DEVICE CONFIGURATION

Element	Element Description	Source
B3.1	François would like to display the video, but the video-projector is not correctly set. François asks it to set as it was last Wednesday, when he used it for the last time.	[70]
B3.2	If a colleague arrives, she is able to use the complete infrastructure (e.g. printers, whiteboard) if she brings along her own notebook or PDA.	[29]
B3.3	The dishwasher is not working properly and it itself detects the failures. The domotic controller contacts manufacturer's maintenance server and the dishwasher is remotely diagnosed. After the diagnosis, downloading a new component can repair the dishwasher. (remark: the functionality is transferable to devices in the office domain, e.g., copy machine)	[55]

C. Information

In their daily routine, office workers work on different tasks and projects. In each situation, they rely on a multitude of information in order to successfully complete their tasks. Hence, providing users with fast and intuitive mechanisms to access and transfer data are important aspects when designing smart office applications.

1) Activity Histories

Finding and re-using information is a substantial and time-consuming part of knowledge work [71]. The scenario elements in this section describe usage situations, where users are supported in accessing previously captured information streams. The information is usually accessed via context cues, which are related to the respective information. These cues include the physical location, people present at this time as well as things, which are going on at the same time and immediately before and after the specific event [95].

In its simplest form, activity histories refer only to the personal past of users and contain information about personal events, places users have been to or people they met. As activity histories usually comprise all events that happened in the past, it is necessary to continuously capture all activities a user is engaged in.

TABLE XVI EXAMPLES OF SCENARIO ELEMENTS DESCRIBING PERSONAL ACTIVITY HISTORIES

Element	Element Description	Source
C1.1.1	He brings up the timeline view of his automatic context diary.	[55]
C1.1.2	The buildings remember my traces, so that they can react as a coherent whole towards my needs and questions. In this way, every building I use has a somehow different relationship to me.	[70]
C1.1.3	Greg is using his Personal aura to access his routes and interactions to find out, what and with whom he has spent time with this week.	[70]

While personal activity histories only provide information about situations a user has already been to in the past, public activity histories also include information about past activities of other users. Although information about the past incidents within a building or the activities of a certain colleague might be helpful in a variety of situations, this information can lead to serious privacy violations for the person being captured.

TABLE XVII EXAMPLES OF SCENARIO ELEMENTS DESCRIBING PUBLIC ACTIVITY HISTORIES

Element	Element Description	Source
C1.2.1	As I start wondering what it could have been, a sketch is suddenly displayed inside the elevator. It was retrieved from the History Poll of the Information River and seems to be the one Chris was looking for.	[70]
C1.2.2	Coming back from a business trip, Eric and I enter my office, which recognizes us and begins to give us a short overview over what happened since we left [...].	[70]
C1.2.3	Lars is using his privilege access to one of his colleagues he is interested in to see how she is using the place. This way he can try to plan as many accidental meetings as possible that day.	[70]

The last group of scenario elements describes automatic capturing mechanisms for meetings, where - in contrast to the previous scenario elements - only the specific event of the meeting is recorded. A further difference to the previous two sub-groups is, that meetings are usually perceived as a public situation, where it is not uncommon that comments and activities are captured. In most cases, users are aware of the fact that information is being captured, and sometimes have a chance to deny this or delete specific parts of the recorded sequence. The information is usually not further processed and only available to the people, who participated in the respective meeting.

TABLE XVIII EXAMPLES OF SCENARIO ELEMENTS DESCRIBING AUTOMATIC MEETING PROTOCOLS

Element	Element Description	Source
C1.3.1	An audio track of the meeting is recorded and converted to a document, as it is normal practice in Maruja's company (thanks to AmI, nobody needs to write and distribute 'meeting minutes' anymore!).	[72]
C1.3.2	To be prepared for our weekly meeting, I ask the Office to play back the relevant video sequence of the presentation, where Mark introduced the new user interface of the software to be shipped soon.	[70]
C1.3.3	I could not attend the first part of the meeting. Before asking a question I review, if the subject has already been discussed.	[70]

2) Easy Data Transfer

As people are becoming more and more mobile, fast and easy data transfer between devices and locations becomes a key aspect of efficient work. The scenario elements in the following table describe novel data transfer concepts. In general, two different approaches can be distinguished. In the first approach, data is directly exchanged between two different devices, in most cases between stationary and mobile devices. The second approach involves an additional device, which is used to transfer data between two locations or devices.

TABLE XIX EXAMPLES OF SCENARIO ELEMENTS DESCRIBING EASY DATA TRANSFER MECHANISMS

Element	Element Description	Source
C2.1	Peter picks a project that seems interesting to him, looks at the details, marks it thus indicating his interest, and takes it with him on his ViewPort.	[89]
C2.2	As he walks in, Aura transfers his final changes to the projection computer.	[33],[85]
C2.3	Frank uses his ID stick as a data transporter and links his presentation to it.	[81]

3) Access

The last group of information-related scenarios addresses different aspects of information access. While the scenario elements in Table described situations, where people physically transported data from one place or device to the other, the elements in Table describe remote access situations. Those anytime, anyplace scenarios require a ubiquitously available network infrastructure, which is permanently available to users.

TABLE XX EXAMPLES OF SCENARIO ELEMENTS DESCRIBING UBIQUITOUS INFORMATION ACCESS

Element	Element Description	Source
C3.1.1	Mobile Services are used for business activities outside the office. Users are able to access corporate networks from outside, for example, to instantly retrieve design drawings from a construction site, or to receive necessary business data to make a presentation at the client's office.	[43]
C3.1.2	[...] in the Ambient Intelligence environment, information resources are available anywhere in the urban system.	[24]
C3.1.3	Finally, if the data is stored within the ubiquitous infrastructure, John would be able to access the information from any device that is able to connect to the network.	[88]

The second sub-group of scenario elements describes situations, where users are provided with context information that is usually not available in the real world. By using personal devices, like, e.g., PDAs users can access additional digital information related to a physical object or person.

TABLE XXI EXAMPLES OF SCENARIO ELEMENTS DESCRIBING ADDITIONAL CONTEXT INFORMATION

Element	Element Description	Source
C3.2.1	Everyone carrying a device, equipped with a reader, can access additional information and services relating to the tagged item.	[24]
C3.2.2	As she visits each exhibit, her mobile device automatically displays the web page that is tied to each exhibit.	[11]
C3.2.3	After 20 minutes talking time, the traffic light of Martina's presentation monitor changes to yellow, which indicates that the concentration of the audience dropped significantly. This type of feedback is due to the intelligent chairs, the audience is sitting on. Martina immediately increases her speed and incorporates an anecdote and, indeed, the traffic light is switching back to green.	[30]

D. Adaptation

Based on automatic localization and capturing technologies as well as improved data mining mechanisms, a variety of new, user- and context-adapted services are becoming possible. These services include the personalization of devices, situation-based adaptation of the physical surrounding as well as different types of context-adapted user service.

1) Personalization of Devices

In future office environments a variety of public devices

will be available for users, which can be temporally personalized and thereby adapted to the individual needs of the user. The scenario elements of this category describe situations, where different types of public devices, which are available at the immediate surrounding of the user, like, e.g., desktop computers or smart objects, are personalized for temporal usage.

TABLE XXII EXAMPLES OF SCENARIO ELEMENTS DESCRIBING THE PERSONALIZATION OF DEVICES

Element	Element Description	Source
D1.1	The system logs her in, responds with a welcome message [...].	[82]
D1.2	The multi-band reconfigurable equipment of Eve is monitoring/interpreting context information continuously and is able to select a system to connect in a personalized way: the system selection may be carried out according to the various profiles [...].	[17]
D1.3	You are using a computer in the room. You get up and walk over to a different computer and sit down. You are automatically logged off from the first computer and logged onto the new one, and your desktop pops up automatically as well.	[87]

2) Adaptation Surrounding

While the previously described scenario elements address only the personalization of single devices, the adaptation of the whole physical environment to the needs of its inhabitants is another aspect, recurringly described in several application scenarios.

The automatic activation or deactivation of devices has to be regarded as the most basic form of adaptation. In some cases users are not even individually identified, which means, that the functionality could also be provided by existing non-computational technologies based on motion detection, like, e.g., infrared sensors. Nevertheless, the described functionalities take over necessary and sometimes time-consuming activities, and thereby contribute to the optimization of work processes in future office environments.

TABLE XXIII EXAMPLES OF SCENARIO ELEMENTS DESCRIBING THE AUTOMATED ACTIVATION OF DEVICES

Element	Element Description	Source
D2.1.1	Via RFID the intelligent office of the future 'realizes', that the office worker is present and autonomously switches to operating mode.	[36]
D2.1.2	Upon arrival, without activating any device, the [...] light gets 'on'.	[42]
D2.1.3	As soon as an employee arrives at his workplace, this is detected by intelligent office via the RFID tag: It automatically switches to operating mode, changes the status display and the lightning, switches on the displays, [...].	[98]

The scenario elements contained in the following two tables describe more sophisticated adaptation mechanisms, where specific parts of the working environment are automatically adapted to the personal preference(s) of its inhabitant(s). In the first sub-group of scenario elements (see Table), the overall goal is usually to enhance the performance of employees by automatically providing the applications or information that are necessary in a certain situation (mostly meetings).

TABLE XXIV EXAMPLES OF SCENARIO ELEMENTS DESCRIBING THE ADAPTATION OF THE ENVIRONMENT IN ORDER TO ENHANCE PERFORMANCE

Element	Element Description	Source
D2.2.1	If the supervisor appears unexpectedly, this is again detected via RFID from a distance - pictures at the wall are giving way to, for example, e-mails or spreadsheets.	[98]
D2.2.2	This kind of work needs the chance for spontaneous meetings. To realize these meetings, people find in the building between the PCs special meeting areas with different characteristic atmospheres.	[70]
D2.2.3	When René is calling for a meeting, the walls will show a certain individual configured environment.	[70]

The goal of the second sub-group of scenario elements is to increase the personal well-being of office workers. In contrast to the previously described scenario elements, there are no direct economical benefits envisioned (at least they are not explicitly stated in the scenario description). Nevertheless, in some of the scenario elements, a positive correlation between personal well-being and work productivity is expected (see, e.g., [98]).

TABLE XXV EXAMPLES OF SCENARIO ELEMENTS DESCRIBING THE ADAPTATION OF THE ENVIRONMENT IN ORDER TO ENHANCE PERSONAL WELL-BEING

Element	Element Description	Source
D2.3.1	Moreover, temperature and lightning intensity are adapted to the pre-defined settings of the employee.	[98]
D2.3.2	Her desk lamp turns on automatically, it dims into a pink shade and her favorite track 'For Elise' from Best of Beethoven is being played as she starts responding a client's e-mail.	[45]
D2.3.3	Martina waits for a few seconds at the door until her PDA responds with a soft beep. A second later, the Venetian blinds are lowered, the lightning is slightly getting brighter and the climate control adjusts - one of her personal room profiles that the personal environment controller extracted from her previous meetings sessions.	[30]

3) Context-Adapted Information Presentation

This section subsumes scenario elements, in which the information presentation is adapted to the current context of one or more users. Some of the scenario elements are similar to those described above in the section 'Information Output'. But while the focus of the scenario elements, described in the section above, was on visualization devices and interaction techniques, this chapter focuses on the adaptation process and its corresponding functionalities.

The adaptation of the presented information can happen in different ways. The easiest way is to adapt the information to a specific user or a certain location. In most cases the user's identity together with data about his relative location is used in order to provide information on a display in his direct surrounding.

TABLE XXVI EXAMPLES OF SCENARIO ELEMENTS DESCRIBING THE ADAPTATION OF PRESENTED INFORMATION TO A SINGLE USER

Element	Element Description	Source
D3.1.1	She briefly connects [...] to say hello to Charlotte, and her video picture automatically appears on the flat screen that is currently used by Charlotte.	[40],[66]
D3.1.2	As Bob is walking close to an active wall, he is presented a message relevant to his trip.	[100]
D3.1.3	While she is waiting for her client, the table she is sitting at shows that tonight there are still tickets left for her favorite musical 'Les Miserables' and that her favorite perfume is on sale at Saks and Fifth.	[45]

The scenario elements listed in Table extend the previous situation by adapting the visualized information to multiple users. In addition to the adaptation process itself, the application has to deal with problems, which arise through contradicting user preferences and also address privacy problems, which are likely to evolve in multi-user situations.

TABLE XXVII EXAMPLES OF SCENARIO ELEMENTS DESCRIBING THE ADAPTATION OF THE PRESENTED INFORMATION TO MULTIPLE USERS

Element	Element Description	Source
D3.2.1	The system displays a summary of the main news with the preferences of Maria (sport, local and technology) and Jerry (world, finances and weather).	[3]
D3.2.2	They both identify by stepping on Dan's doormat. They are served with a representation of their joint appointments and activities for the next two weeks, wherefrom a discussion evolves: There is a project meeting next week, where a preliminary agenda has been proposed.	[70]
D3.2.3	Paul receives multiple messages on his PWC the moment he leaves his boss's office. He had all incoming communications on hold from the moment he entered his office.	[72]

In the previous two sub-groups described situations, where a combination of user and/or location information was used to adapt the presented information. In some scenario elements the visualized information was also adapted to pre-defined user preferences. But in office environments, the information needs also depend on the activity or task a user is currently involved. Therefore, some scenario elements use additional context information (like, e.g., the current activity) in order to dynamically adapt the content of the visualized information to the current need of the user.

TABLE XXVIII EXAMPLES OF SCENARIO ELEMENTS DESCRIBING THE ADAPTATION OF THE INFORMATION CONTENT

Element	Element Description	Source
D3.3.1	In addition, the form and content of the dialogue have been adapted for Mrs. Brown according to her preferences and to the way she uses the [...] assistant.	[15]
D3.3.2	While entering her office she automatically changes to her professional role. Immediately up-to-date client information are shown on her screen.	[54]
D3.3.3	Due to intelligent information provision, the employee gets the new sales data of his client during the sales meeting, while the new version of the strategy document is waiting at his desktop.	[30]

In addition to the location of the information visualization and its content, several scenario elements also address the adaptation of the output parameters and output modality to the current situation. The goal of this adaptation process is usually the avoidance of interruptions through interfering output devices and/or inadequate presentation techniques.

TABLE XXIX EXAMPLES OF SCENARIO ELEMENTS DESCRIBING THE ADAPTATION OF INFORMATION TO OUTPUT PARAMETERS AND OUTPUT MODALITIES

Element	Element Description	Source
D3.4.1	While he is sitting at the table with Petra, an overview of incoming e-mails is shown by means of an abstract visualization on a large wall display.	[54]
D3.4.2	In order not to interfere with the soundtrack, the animated character now uses speech bubbles instead of speech.	[23]
D3.4.3	If the eMoodCube is set to a 'Do not disturb' status, John is notified only for the emergent events.	[12]

4) Different Forms of Context-Adapted Service

The adaptation of services and functionalities is not restricted to the application domains, explicitly mentioned in this chapter. A variety of other context-adapted services are possible and also addressed in several scenario elements. Table gives an overview over different types of context-

adapted services, which are not related to any of the groups mentioned above.

TABLE XXX EXAMPLES OF SCENARIO ELEMENTS DESCRIBING DIFFERENT TYPES OF CONTEXT-ADAPTED SERVICES

Element	Element Description	Source
D4.1	He logs on and the […] system prompts Mr. Conti with a list of possible services to help him in his job, presented on his […] wall display.	[55]
D4.2	While enjoying this revitalizing treatment, the reception room recognizes me as a guest with consulting status, who has been here before and has now an appointment with an employee of The-Future-Is-Here. It checks me in and offers me a choice of information about recent projects of the company that are related to my interests, to read my favorite newspaper or to connect to some new messages waiting for me.	[70]
D4.3	Under normal circumstances, Martina's computer would have recommended a software update and also the number of unread e-mails in the inbox is constantly getting larger. All these things have been postponed, which is due to her current stress level, or more specifically, due to the glove she is wearing at her right hand and which transmitted unusual values for both pulse and skin resistance to her computer, which in turn decided not to bother her in the current situation.	[30]

E. Personal Assistance

Providing users with personalized and context-adapted assistance is one of the main goals when designing intelligent office environments. The following sections show different types of applications and services, that were specifically designed to support users in everyday office activities. The functionality is usually incorporated in form of a personal digital assistant and realized by means of an intelligent software agent, which is autonomously acting in order to accomplish a task [31]. Agents are programs that continuously run in the background, capture environmental information and, if appropriate, proactively act on behalf of the user. See, e.g., [53] for more information about software agents.

1) Dynamic Task Scheduling

By using sensors embedded in the environment, systems and applications are aware of current activities with a physical space. In combination with digital information about planned events in the future, smart office applications are able to dynamically schedule upcoming activities, tasks or events, based on real-time incidents. This functionality can be used to optimize individual work processes as well as group process, and thereby helps to avoid unnecessary idle times.

TABLE XXXI EXAMPLES OF SCENARIO ELEMENTS DESCRIBING DIFFERENT TYPES OF DYNAMIC TASK SCHEDULING

Element	Element Description	Source
E1.1	For example, his scheduling agent negotiates his maintenance tasks for the day with the different machine companies, taking the time requirements and best route for his travel into account.	[44]
E1.2	She checks the calendar of her handheld device and notices that it has already been updated to reflect the new time.	[94]
E1.3	As she arrives to offices, she has an interchange with a mobile remote agent that brings her the agenda of the day.	[58]

2) Calendar Synchronization

Synchronizing the schedules of multiple persons is a tedious task with current technologies. In future office environments, software agents could take over this task without their users being directly involved in this process. Table shows some examples of how such functionality could be implemented.

TABLE XXXII EXAMPLES OF SCENARIO ELEMENTS DESCRIBING DIFFERENT TYPES OF CALENDAR SYNCHRONIZATION

Element	Element Description	Source
E2.1	He [...] instructs his scheduling agent to set up a lunch date, so that he can thank her for the suggestion.	[68]
E2.2	All three decide to meet next week in Paris. Conversing with their E21s, they ask their automated calendars to compare their schedules and check the availability of flights from New York and London to Paris.	[64]
E2.3	I have an appointment with a collaborator: Our two Personal Auras show instantaneously all adherences between our agenda, task lists, targets etc., so that we quickly can get a good shared picture of what we have to discuss.	[52]

3) Navigation and Orientation

As people are becoming more and more mobile, both within an office building and outside, situations, where users have to orient themselves in unfamiliar space will increase.

Table shows several examples of how smart environments can be used to guide people through an unfamiliar terrain. The scenario elements address navigation aspects in public spaces (e.g., train stations or airports) as well as semi-public spaces (mostly large company buildings).

TABLE XXXIII EXAMPLES OF SCENARIO ELEMENTS DESCRIBING DIFFERENT TYPES OF NAVIGATION AND ORIENTATION MECHANISMS

Element	Element Description	Source
E3.1	If the user wants to go to an office and doesn't know the way, she can ask her user-agent for navigating her. The user-	[5]

	agent then displays arrows in the direction the user has to go.	
E3.2	I have already been once in that building, but I am not sure to be in the right direction: I ask to the corridor "have I ever been there before?".	[52]
E3.3	Ralph asks his H21 where they can find Hélène. It tells them she's across the street, and it provides an indoor/outdoor navigation system to guide them to her.	[64]

4) Personal Reminder

The personalized reminder services, sub-summed in Table , support users in remembering personal appointments, upcoming events or approaching deadlines. In contrast to the reminder functionality, included in most calendar and task applications today, the reminder services also incorporate real-time events, which take place in the physical world of the user (e.g., the user is informed that a visitor just arrived). In addition, the notification processes are usually context-adapted and mostly done via devices, which are embedded in the user's physical environment.

TABLE XXXIV EXAMPLES OF SCENARIO ELEMENTS DESCRIBING PERSONAL REMINDER AND NOTIFICATION MECHANISMS

Element	Element Description	Source
E4.1	Finally, the internal clock of the wearable gets close to the time of a calendar entry, reminding the wearer of a meeting, and the Remembrance Agent brings up pointers to that entry, to remind her that she should be on her way.	[73]
E4.2	At the start of the day, she reviews her diary with her personal agent. The personal agent reminds her about the preparation for the party for her friends that she will have this evening.	[58]
E4.3	Her computer reminds her to take a coffee break and tells her not to forget her lunch appointment at 13:00 with one of her biggest clients.	[45]

5) Recommendation

Besides simply reminding users about upcoming events, intelligent office applications could also give recommendation to perform certain tasks, based on information captured in the past or scheduled appointments in the future.

TABLE XXXV EXAMPLES OF SCENARIO ELEMENTS DESCRIBING RECOMMENDATION MECHANISMS

Element	Element Description	Source
E5.1	François accesses his mailbox. Messages are sorted according to the context: The system points out two mails probably important to look at because they came from people he will have a meeting with later this morning.	[70]
E5.2	My agents have proposed a blurred summary of my working day.	[70]
E5.3	After the identification/authentication the system logs him in and the aware system displays on its screen a list of items that could be useful during the teleconferencing session.	[55]

6) Virtual Secretary

Besides supporting various office activities, secretaries usually take over a broad variety of other responsibilities, which are not always related to official tasks or project. Providing employees with an individual secretary can help to reduce overall employee costs, as workers have more time focusing on their primary working tasks. Table shows same examples of how virtual secretaries can support users in future office scenarios.

TABLE XXXVI EXAMPLES OF SCENARIO ELEMENTS DESCRIBING VIRTUAL SECRETARY FUNCTIONALITIES

Element	Element Description	Source
E6.1	'Sophie, the printouts are for the meeting room', Martina calls to her computer, waits for the confirming 'Will be done immediately' and leaves the office. Sophie, her digital avatar, informs the secretary's office to which meeting room the printouts should be brought.	[30]
E6.2	Carmen wants to leave for work in half an hour and asks AmI, by means of a voice command, to find a vehicle to share with someone on her route to work.	[24]
E6.3	Rebecca has configured her inbox to automatically sort the messages by the importance and urgency level and the category. She will be notified, if an urgent incident happens she has to deal with herself immediately, but most are either delegated to the responsible people in her team, or grouped to attend to in a concentrated working session.	[44]

7) Privacy Protection

In order to provide context-adapted services, smart environments rely on a variety of personal and sometimes confidential information about users. Hence, sophisticated mechanisms to protect user privacy in intelligent environments should be central requirements for all applications. The scenario elements focus on different aspects of smart services and include a variety of mechanisms for privacy protection, including the adaptation of the physical environment, context-adapted information presentation, identity management or the use of pseudonyms in electronic transactions.

TABLE XXXVII EXAMPLES OF SCENARIO ELEMENTS DESCRIBING DIFFERENT TYPES OF PRIVACY PROTECTION MECHANISMS

Element	Element Description	Source
E7.1	As the presentation proceeds, Fred is about to display a slide with highly sensitive budget information. Aura senses that this might be a mistake: The room's face detection and recognition capability indicates that there are some unfamiliar faces present.	[33],[85]
E7.2	It interrupts the chat if other persons enter the room.	[80]
E7.3	During the conversation the ambient is manipulating the sound field in the room in such a way, that others do not hear this conversation.	[22]

F. Office Management

The functionalities described in this section address different aspects of facility and building management. In most cases, the benefits for the company are significantly higher than for the individual employee. But as the expected savings are larger than those of most other scenario elements, the described functionalities are likely to be implemented quite soon. Therefore, it seems of particular importance to include them in the user evaluation.

1) Facility Management

Increased mobility leads to reduced and irregular presence times of employees within the local office space. In future office environments, sensor technologies can be employed to minimize leasing costs by dynamically assigning meeting rooms and personal office. Table contains several examples of dynamic desk sharing mechanisms.

TABLE XXXVIII EXAMPLES OF SCENARIO ELEMENTS DESCRIBING DIFFERENT TYPES OF DYNAMIC DESK-SHARING MECHANISMS

Element	Element Description	Source
F1.1	In cooperation of personal agenda and temperature sensors, the heating and air condition are controlled - avoiding heating costs, if the personal agenda indicates dates outside the own office.	[29]
F1.2	The guide senses what building the organizer is in, and automatically displays a listing of available meeting rooms at the specified meeting time.	[11]
F1.3	Because the team members are spread over the whole building, the electronic navigation system will show every time the best-situated and available meeting area.	[70]

2) Security and Access Control

Besides real-time facility management, improved processes in the areas of security and access control can lead to considerable reductions of fixed costs. Table shows several examples, ranging from aspects of general building security to sophisticated mechanisms for automated access control, based on biometric information.

TABLE XXXIX EXAMPLES OF SCENARIO ELEMENTS DESCRIBING DIFFERENT EXAMPLES OF SECURITY AND ACCESS CONTROL MECHANISMS

Element	Element Description	Source
F2.1	Doors open automatically due to biosensors, and she is out on the street.	[58]
F2.2	The front door recognizes her and lets her in without the need for her to grope for keys.	[3]
F2.3	At the front door, she is recognized by an intelligent surveillance camera, the door alarm is switched off and the door unlocks and opens.	[66]

V. SUMMARY

In the course of the scenario analysis, N=430 beneficial scenario elements were extracted from 63 scenario descriptions. Nearly half of all scenario elements (48,38%) described either new interaction mechanisms (28,60%) or various forms of user adaptation (19,78%). The remaining scenario elements are distributed over the other four groups: Communication (18,14%), Personal Assistance (17,91%), Information (11,40%) and Office Management (5,12%). The four largest functional sub-groups are Adaptation to Enhance Personal Well-Being (D2.3), Adaptation to Single User (D3.1), Adaptation of Content (D3.3) and Privacy Protection (E7), with each sub-group containing more than 5% of all scenario elements.

Table gives an overview over the different types of functionalities.

TABLE XL OVERVIEW OVER APPLICATION SCENARIOS (N=430)

Scenario Element		Freq.	Perc.
A	**Communication**	**78**	**18,14%**
	A1 Synchronous Communication	15	3,49%
	A1.1 Explicit Communication	*11*	*2,56%*
	A1.2 Implicit Communication	*4*	*0,93%*
	A2 Asynchronous Communication	17	3,95%
	A3 Communication Support	46	10,70%
	A3.1 Availability Check	*14*	*3,26%*
	A3.2 Support of Remote Communication	*9*	*2,09%*
	A3.3 Support of Personal Encounters	*23*	*5,35%*
B	**Interaction**	**123**	**28,60%**
	B1 Input Interaction	42	9,77%
	B1.1 Tangible User Interfaces	*14*	*3,26%*
	B1.2 Speech Input	*20*	*4,65%*
	B1.3 Implicit Interaction Mechanisms	*7*	*1,63%*
	B2 Information Output	74	17,21%
	B2.1 Large-Screen Displays	*14*	*3,26%*
	B2.2 Ambient Displays	*19*	*4,42%*
	B2.3 Speech Output	*9*	*2,09%*

	B2.4 New Output Devices	*19*	*4,42%*
	B2.5 Comb. of Multiple Output Devices	*13*	*3,02%*
	B3 Automatic Device Configuration	7	1,63%
C	**Information**	**49**	**11,40%**
	C1 Activity Histories	30	6,98%
	C1.1 Personal Activity Histories	*3*	*0,70%*
	C1.2 Public Activity Histories	*17*	*3,95%*
	C1.3 Automatic Meeting Protocol	*10*	*2,33%*
	C2 Easy Data Transfer	12	2,79%
	C3 Access	7	1,63%
	C3.1 Ubiquitous Information Access	*3*	*0,70%*
	C3.2 Additional Context Information	*4*	*0,93%*
D	**Adaptation**	**85**	**19,78%**
	D1 Personalization of Devices	11	2,56%
	D2 Adaptation Surrounding	40	9,30%
	D2.1 Automatic Power-On	*8*	*1,86%*
	D2.2 Adaptation to Enhance Performance	*7*	*1,63%*
	D2.3 Adaptation to Enhance Personal Well-Being	*25*	*5,81%*
	D3 Context-Adapted Inform. Presentation	68	16,05%
	D3.1 Adaptation to Single User	*27*	*6,28%*
	D3.2 Adaptation to Multiple User	*10*	*2,33%*
	D3.3 Adaptation of Content	*22*	*5,12%*
	D3.4 Adaptation to Output Parameters…	*9*	*2,09%*
	D4 Diff. Forms of Context-Adap. Services	6	1,40%
E	**Personal Assistance**	**77**	**17,91%**
	E1 Dynamic Task Scheduling	10	2,33%
	E2 Calendar Synchronization	5	1,16%
	E3 Navigation and Orientation	15	3,49%
	E4 Personal Reminder	17	3,95%
	E5 Recommendation	5	1,16%
	E6 Virtual Secretary	3	0,70%
	E7 Privacy Protection	31	7,21%
F	**Office Management**	**22**	**5,12%**
	F1 Facility Management	10	2,33%
	F2 Security and Access Control	12	2,79%

VI. Conclusion

This paper reported on a survey of state-of-the-art application scenarios for smart office environments. Based on an analysis of ongoing research activities, representative functionalities and services of future office systems were extracted. The results of the analysis show, that the vision of smart office environments is not as vague and unclear as often argued, as current technological developments revolve around a few, clearly identifiable topics.

References

[1] 2WEAR (2001). *Report on Key Reference Scenarios*. Deliverable D1 of the IST-Project '2WEAR - A Runtime for Adaptive and Extensible Wireless Wearables', IST-2000-25286.

[2] Adamowsky, N. (2000). *Kulturelle Relevanz.* Ladenburger Diskurs 'Ubiquitous Computing', February 2000.

[3] Amigo (2004). *Annex I - Description of Work*. Report of the IST-Project 'Amigo - Ambient Intelligence for the Networked Home Environment', IST-004182.

[4] Araya, A. (1995). Questioning Ubiquitous Computing. In: *Proceedings of the 23rd Annual Conference on Computer Science*, ACM Press, pp. 230 – 237

[5] Bagci, F., Schick, H., Petzold, J., Trumler, W., Ungerer, T. (2005). Communication and Security Extensions for a Ubiquitous Mobile Agent System (UbiMAS) In: *Proceedings of the Conference on Computing Frontiers* (CO'05), pp. 246 – 251.

[6] Beyer, H., Holtzblatt, K. (1998). *Contextual Design*. Morgan Kauffman, San Francisco.

[7] Björk, S. (2002). *Designing Mobile Ad Hoc Collaborative Applications: Scenario experiences with Smart-Its.* Position Paper at the Mobile Ad Hoc Collaboration Workshop at the ACM Conference on Human Factors in Computing Systems (CHI'02).

[8] Bohn, J., Coroama, V., Langheinrich, M., Mattern, F., Rohs, M. (2003). *Disappearing Computers Everywhere – Living in a World of Smart Everyday Objects.* Paper presented at the Conference on New Media, Technology and Everyday Life in Europe, London, UK, April 2003.

[9] Bohn, J., Coroama, V., Langheinrich, M., Mattern, F., Rohs, M. (2005). Social, Economic, and Ethical Implications of Ambient Intelligence and Ubiquitous Computing. In: W. Weber, J. Rabaey, E. Aarts (Eds.): *Ambient Intelligence.* Springer-Verlag, Heidelberg, pp. 5 – 29.

[10] Cannon-Bowers, J. A., Salas, E., Converse, S. A. (1993). Shared Mental Models in Expert Team Decision Making. In: N. J. Castellan, Jr. (Ed.) *Current Issues in Individual and Group Decision Making.* Erlbaum, Hillsdale, pp. 221 – 246Chen, 2001

[11] Chen, W. (2001). *Using CoolBase to Build Ubiquitous Computing Applications*. Report HPL-2001-215. Mobile Systems and Services Laboratory. HP Laboratories Palo Alto. Available at: http://www.hpl.hp.com/techreports/2001/HPL-2001-215.pdf, last accessed April 26, 2007.

[12] Christopoulou, E., Goumopoulos, C., Kameas, A. (2005). An Ontology-Based Context Management and Reasoning Process for UbiComp Applications. In*: Proceedings of the International Conference on Smart Objects & Ambient Intelligence* (sOc-EUSAI'05), October 12 - 14, Grenoble, France, pp. 265 – 270.

[13] Cook, D., Das, S. (2004). *Smart Environments: Technology, Protocols and Applications*. Wiley-Interscience.

[14] Coroama, V., Hähner, J., Handy, M., Rudolph-Kuhn, P., Magerkurth, C., Müller, J., Strasser, M., Zimmer, T. (2003). *Leben in einer smarten Umgebung: Ubiquitous-Computing-Szenarien und -Auswirkungen*. Technical Report No. 431, ETH Zurich, December 2003.

[15] De Haan, G., Blanson Henkemans, O., Aluwalia, A. (2005). Personal Assistants for Healthcare Treatment at Home. In: *Proceedings of the 2005 Annual Conference on European Association of Cognitive Ergonomics*, pp. 225 – 231.

[16] Delaitre, S. (2006). Identity in the Ambient Intelligence Environment. In: T. Nabeth (Ed.): *Set of Use Cases and Scenarios.* Deliverable D2.2 of the Project 'FIDIS - Future of Identity in the Information Society'. FIDIS consortium - EC Contract No. 507512.

[17] Dimitrakopoulos, G., Malamateniou, F., El Khazen, K., Bourse, D., Hope, S. (2004). *Scenarios, System Requirements and Roadmaps for Reconfigurability.* White Paper of the Wireless World Research Forum Working Group.

[18] DoCoMo (2002*) Vision 2010.* NTT DoCoMo USA. Available at http://www.docomo-usa.com/vision2010/, last accessed May 5, 2007.

[19] Donchin, Y., Gopher, D., Olin, M., Badihi Y., Biesky M., Sprung C. L., Pizov, R., Cotev, S. (1995). A Look into the Nature and Causes of

Human Errors in the Intensive Care Unit. In: *Critical Care Medicine*, Vol. 23, No. 2, pp. 294 – 300.

[20] Dourish, P. (1997). Extending Awareness Beyond Synchronous Collaboration. Paper presented at the CHI'97 Workshop on Awareness in Collaborative Systems, Atlanta, USA.

[21] Dourish, P., Bly, S. (1992). 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.

[22] Ducatel, K., Bogdanowicz, M., Scapolo, F., Leijten, J., Burgelman, J. C. (2001). *Scenarios for Ambient Intelligence in 2010*. Final Report of the IST Advisory Group (ISTAG).

[23] Elting, C. (2005). Orchestrating Output Devices - Planning Multimedia Presentations for Home Entertainment with Ambient Intelligence. In: *Proceedings of the International Conference on Smart Objects & Ambient Intelligence* (sOc-EUSAI'05), October 12 - 14, Grenoble, France, pp. 153 – 146.

[24] Emiliani, P. L., Stephanidis, C. (2005). Universal Access to Ambient Intelligence Environments: Opportunities and Challenges for People with Disabilities. In: *IBM Systems Journal*, Vol. 44, No. 3, pp. 605 – 619.

[25] Fano, A, Gershman, A. (2002). The Future of Business Services in the Age of Ubiquitous Computing. In: *Communications of the ACM*, Vol. 45, No. 12, pp. 83 – 87.

[26] Ferguson, G. T. (2003). Have Your Objects Call My Objects. In: *Harvard Business Review*, Vol. 80, No. 6, pp. 138 – 143.

[27] Fleisch, E., Tellkamp, C. (2003). *The Challenge of Identifying Value-Creating Ubiquitous Computing Applications.* Paper presented at the workshop on Ubiquitous Commerce, International Conference on Ubiquitous Computing (UbiComp'03), Seattle, USA. Available at: http://www.m-lab.ch/pubs/The%20Challenge%20of%20Identifying%20Value-Creating%20Ubiquitous%20Computing.pdf, last accessed January 7, 2007.

[28] Fogarty J., Lai J., Christensen J. (2004). Presence versus Availability: The Design and Evaluation of a Context-Aware Communication Client. In: *International Journal of Human-Computer Studies*, Vol. 61, No. 3, pp. 299 – 317.

[29] Fraunhofer (2004). Scenarios for Ambient Intelligence. Fraunhofer IGD. Avaliable at: http://www.igd.fhg.de/igd-a1/amiatini/, last accessed April 26, 2007.

[30] Fraunhofer (2006). *Inno Visions - Das Zukunftsmagazin der Fraunhofer Iuk-Gruppe. Ambient Intelligence - Welch ein Glück!* Ausgabe 1/2006.

[31] Friedewald, M., Vildjiounaite, E., Wright, D. (2006). *The Brave New World of Ambient Intelligence: A State-of-the-Art Review*. Deliverable D1 of the SWAMI consortium to the European Commission under contract 006507

[32] Gárate, A., Herrasti, N., López, A. (2005). GENIO: An Ambient Intelligence Application in Home Automation and Entertainment Environment. In: *Proceedings of the International Conference on Smart Objects & Ambient Intelligence* (sOc-EUSAI'05), October 12 - 14, Grenoble, France, pp. 241 – 245.

[33] Garlan, D., Siewiorek, P. D., Smailagic, A., Steenkiste, P. (2002). Project Aura: Toward Distraction-Free Pervasive Computing. In: *Pervasive Computing*, Vol. 21, No. 2, pp. 22 – 31.

[34] Gaver, W. W. (2002). Provocative Awareness. In: *Computer Supported Cooperative Work*, Vol. 11, No. 3–4, pp. 475 – 493.

[35] Gellersen, H.-W., Schmidt, A., Beigl, H.-W. (2000). Adding Some Smartness to Devices and Everyday Things. Paper presented at the IEEE Workshop on Mobile Computing Systems and Applications, December 7 – 8, Monterrey, USA.

[36] Görisch, F., Hennig, F. (2006). *Ambient Business - Ubiquitous Computing im wirtschaftlichen Kontext.* Seminar on Novel Forms of Human Computer Interaction: Smart Artifacts and Ambient Intelligence. Department of Computer Science, Technical University of Darmstadt.

[37] Guzzo, R., Salas, E. (1995). *Team Effectiveness and Decision Making in Organizations*. Jossey-Bass, San Francisco, CA, USA.

[38] Handel, M., Herbsleb, J. D. (2002). IM Everywhere: What is Chat Doing in the Workplace? In: *Proceedings of the ACM Conference on Computer Supported Cooperative Work* (CSCW'02), pp. 1 – 10.

[39] Ishii, H., Ullmer, B. (1997). Tangible Bits: Towards Seamless Interfaces between People, Bits, and Atoms. In: *Proceedings of the ACM Conference on Human Factors in Computing Systems* (CHI'97), pp. 234 – 241.

[40] Iversen, O. S., Kanstrup, A. M., Graves Petersen, M. (2004). A Visit to the 'New Utopia': Revitalizing Democracy, Emancipation and Quality in Cooperative Design. In: *Proceedings of NordiCHI '04*, pp. 171 – 179.

[41] Jackson, T. W., Dwason, R., Wilson, D. (2003). Understanding Email Interaction Increases Organizational Productivity. In: *Communications of the ACM*, Vol. 46, No. 8, pp. 80 – 84.

[42] Kaasinen, E., Rentto, K., Ikonen, V., Välkkynen. P. (2004). *MIMOSA Initial Usage Scenarios*. Deliverable D1.1 of the Project 'Microsystems Platform for Mobile Services and Applications (MIMOSA)', IST-2002-507045.

[43] Kato, E. (2004). *Flying Carpet 2. Towards the 4th Generation Mobile Communication Systems.* Report of the Mobile IT Forum (mITF).

[44] Katzy, B., Löh, H., Zhang, C., Aschmoneit, P., Schaffers, H. (2003). *Visionary Scenarios.* Deliverable D2.2 of the Project 'Context-Aware Collaborative Environments for Next-Generation Business Networks (COCONET)', IST-2001-37460.

[45] Kawsar, F., Fujinami, K., Nakajima, T. (2005). Augmenting Everyday Life with Sentient Artefacts. In: *Proceedings of the International Conference on Smart Objects & Ambient Intelligence* (sOc-EUSAI'05), October 12 - 14, Grenoble, France, pp. 141 – 146.

[46] Kientz, J. A., Patel, S. N., Jones, B., Price, E., Mynatt, E. D., Abowd, G. D. (2008) The Georgia Tech aware home. In: extended abstracts of the conference on Human factors in computing systems (CHI '08), pp. 3675-3680.

[47] Kirsch, W. (1990). *Unternehmenspolitik und strategische Unternehmensführung*. Verlag Barbara Kirsch, München, Germany.

[48] Kraut, R. E., Egido, C., Galegher, J. (1988). Patterns of Contact and Communication in Scientific Collaboration. In: *Proceedings of the Conference on Computer-Supported Cooperative Work* (CSCW'88), pp. 1 – 12.

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

[50] Laakso, M. (2004). Ambient Displays and Changing Information. Paper presented at the *Seminar on User Interfaces and Usability*, Helsinki University of Technology, Finland.

[51] Lahlou, S. (2001). *D3.3 – Design Approach Report.* Deliverable of the 'Ambient Agoras' Project for the First Disappearing Computer Jamboree, Zürich, Switzerland.

[52] Lahlou, S., Jégou, F. (2001). *D2.2 – Report on Functional Requirements*. Deliverable of the 'Ambient Agoras' Project for the First Disappearing Computer Jamboree, Zürich, Switzerland.

[53] Maes, P. (1994). Agents that Reduce Work and Information Overload. In: *Communications of the ACM*, Vol. 37, No. 7, pp. 30 – 40.

[54] Magerkurth, C. (2006). *Konzeptentwicklung zu ‚Identifizierung und Rollenmanagement zur Ermöglichung personalisierter Services'*. Technical Report, Fraunhofer Institut für Integrierte Informations- und Publikationssysteme (IPSI), Darmstadt, Germany.

[55] Magerkurth, C., Streitz, N., Janse, M., Portolan, N., Barone, M., di Marco, S., Larrannaga, A., Lucas, I., Arribas, J., Carro-Martinez, S. (2005). *Report on User Requirements: State of the Art*, Volume II. Deliverable D1.2 of the IST Project 'AMIGO - Ambient Intelligence for the Networked Home Environment', IST-004182.

[56] Markopoulos, P., IJsselsteijn, W.A., Huijnen, C., Romijn, O., Philopoulos, A. (2003). Supporting Social Presence through Asynchronous Awareness Systems. In: G. Riva, F. Davide, W. A. IJsselsteijn (Eds.) *Being There - Concepts, Effects and Measurements of User Presence in Synthetic Environments*. IOS Press, Amsterdam, pp. 261 – 278.

[57] Marturano, L., Turner, T., Pulli, P., Excell, P., Visciola, M. (2003). *The Use of Scenarios for the Wireless World*. White Paper of the Wireless World Research Forum.

[58] Masera, M., Bloomfield, R. (2003). *A Dependability Roadmap for the Information Society in Europe, Part 1 – An Insight into the Future.* Deliverable D1.1 of the Project 'Accompanying Measure System Dependability (AMSD)', IST-2001-37553.

[59] Niemelä, M., Ikonen, V., Kaasinen, E., Välkkynen, P. (2005). *MIMOSA Updated Usage Scenarios.* Deliverable D1.5 of the Project

'Microsystems Platform for Mobile Services and Applications' (MIMOSA), IST-2002-507045.

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

[61] O'Conaill, B., Frohlich, D. (1995). Timespace in the Workplace: Dealing with Interruptions. In: *Extended Abstracts of ACM Conference on Human Factors in Computing Systems* (CHI'95), pp. 262 – 263.

[62] Orasanu, J. (1990) *Shared Mental Models and Crew Decision Making*. Technical Report 46, Princeton University, Cognitive Science Laboratory, Princeton, NJ.

[63] Orasanu, J., Salas, E. (1993) Team Decision Making in Complex Environments. In: G. Klein, J. Orasanu, R. Calderwood, C. Zsambok (Eds.) *Decision Making in Action: Models and Methods.* Ablex Publishing, Norwood, NJ, pp. 327 – 345.

[64] Oxygen (2000). *Project Overview. MIT Project Oxygen - Pervasive Human-Centered Computing,* MIT Laboratory for Computer Science. Available at: http://oxygen.lcs.mit.edu/publications/oxygen.pdf, last accessed April 20, 2007.

[65] Philips (2005). Ambient Intelligence Scenarios. In: *Password Magazine*, No. 23, Philips Research, pp. 10 – 11.

[66] Philips (2007). *Ambient Intelligence - A new user experience.* Available at: http://www.research.philips.com/technologies/syst_softw/ami/vision.html, last accessed April 26, 2007.

[67] Plewe, D., Prante, T. (2002). *Redesign Leading to Third Version of Artefacts: GossipWall and ViewPort*. Deliverable of the 'Ambient Agoras' Project for the Second Disappearing Computer Jamboree, Göteborg, Sweden.

[68] Portolano (2002). *Portolano: An Expedition into Invisible Computing*. Department of Computer Science and Engineering, University of Washington. Available at: http://portolano.cs.washington.edu/scenario/, last accessed May 5, 2007.

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

[70] Prante, P., Welen, P., Wilson, A., Jégou, F., Lahlou, S., Remmers, B. (2001). *D1.2 – Scenarios and Narrative Structures.* Deliverable of the 'Ambient Agoras' Project for the First Disappearing Computer Jamboree, Zürich, Switzerland.

[71] Prante, T., Stenzel, R., Petrovic, K., Bayon, V. (2004). Exploiting Context Histories: A Cross-Tool and Cross-Device Approach to Reduce Compartmentalization when Going Back. In: *Proceedings of Informatik 2004*, pp. 314 – 318.

[72] Punie, Y., Delaitre, S., Maghiros, I., Wright, D. (2005). *Dark Scenarios in Ambient Intelligence: Highlighting Risks and Vulnerabilities.* Deliverable D2 of the SWAMI consortium to the European Commission under contract 006507.

[73] Rhodes, B. (1997). The Wearable Remembrance Agent: A System for Augmented Memory. In: *Personal Technologies Journal, Special Issue on Wearable Computing*, Vol. 1, No. 1, pp. 218 – 224.

[74] Rice R. E., Shook, D. (1990). Voice Messaging, Co-Ordination and Communication. In: J. Galegher, R. Kraut, C. Egido (Eds.). *Intellectual Teamwork*. Lawrence Erlbaum Press, Hillsdate, N.J., USA, pp. 327 – 350.

[75] Röcker, C. (2006). *Awareness and Informal Communication in Smart Office Environments*. Verlag Dr. Driesen, Taunusstein, Germany.

[76] Röcker, C. (2009). *Design Requirements for Future and Emerging Business Technologies: An Empirical Cross-Cultural Study Analyzing the Requirements for Ambient Intelligence Applications in Work Environments.* Verlag Dr. Driesen, Taunusstein, Germany. ISBN 978-3-86866-112-5.

[77] Röcker, C. (2009b). Toward Smart Office Environments - Benefits and Drawbacks of Using Ambient Intelligence Technologies in Knowledge-Based Enterprises. In: *Proceedings of the International Conference on Economics, Business, Management and Marketing* (EBMM'09), Singapore, October 9 -11, 2009, pp. 17 - 21.

[78] Röcker, C., Hinske, S., Magerkurth, C. (2006). SPIROS - A System for Privacy-Enhanced Information Representation in Smart Home Environments. In: *Proceedings of the Second International Conference on Intelligent Environments* (IE'06), July 5 – 6, Athens, Greece, pp. 267 – 274.

[79] Röcker, C., Hinske, S., Magerkurth, C. (2007). Intelligent Privacy Support for Large Public Displays. In: C. Stephanidis (Ed.): *Universal Access in HCI, Part II, HCII 2007, LNCS 4555*. Proceedings of the 12th International Conference on Human-Computer Interaction (HCI International 2007), July 22 – 27, Beijing International Conference Center, Beijing, P.R. China. Springer-Verlag, Heidelberg, pp. 198 – 207.

[80] Röcker, C., Janse, M., Portolan, N., Streitz, N. A. (2005) User Requirements for Intelligent Home Environments: A Scenario-Driven Approach and Empirical Cross-Cultural Study. In: Proceedings of the International Conference on Smart Objects & Ambient Intelligence (sOc-EUSAI'05), October 12 - 14, Grenoble, France, pp. 111 – 116.

[81] Röcker, C., Lex, S. (2003). *D9.4 - Sensing Infrastructure and Personal Aura Artefact*. Deliverable of the 'Ambient Agoras' Project for the Third Disappearing Computer Jamboree, Ivrea, Italy.

[82] Roussos, G., Koukara, L., Kourouthanasis, P., Touminen, J., Seppala, O., Frissaer, J. (2002). A Case Study in Pervasive Retail. In: *Proceedings of the 2nd International Workshop on Mobile Commerce* (WMC'02), September 28, 2002, Atlanta, Georgia, pp. 90 - 94.

[83] Saffiotti, A., Broxvall, M. (2005). Peis Ecologies: Ambient Intelligence meets Autonomous Robotics. In: *Proceedings of the International Conference on Smart Objects & Ambient Intelligence* (sOc-EUSAI'05), October 12 - 14, Grenoble, France, pp. 277 – 281.

[84] Salas, E., Stout, R. J., Cannon-Bowers, J. A. (1994) The Role of Shared Mental Models in Developing Shared Situational Awareness. In: R. D. Gilson, D. J. Garland, J. M. Koonce (Eds.) *Situational Awareness in Complex Systems*. Embry-Riddle Aeronautical University Press, Daytona Beach, FL, pp. 297 – 304.

[85] Satyanarayanan, M. (2001). Pervasive Computing Vision and Challenges. In: *IEEE Personal Communications*, Vol. 6, No. 8, pp. 10 – 17.

[86] Schoch, T., Strassner, M. (2002). Today's Impact of Ubiquitous Computing on Business Processes. In: *Short Paper Proceedings of the First International Conference on Pervasive Computing* (Pervasive'02), Zürich, Switzerland, pp. 62 – 74.

[87] Shafer, S. (2001). *Ubiquitous Computing and the EasyLiving Project.* Report of the Ubiquitous Computing Group, Microsoft Research. Available at: http://www.research.microsoft.com/easyliving/Documents/2001%2011%20Shafer.doc, last accessed April 26, 2007.

[88] Slay, H., Thomas, B., Vernik, R. (2005). A Clipboard Model for Ubiquitous Computing Environments. In: *Proceedings of the 4th International Symposium on Information and Communication Technologies*, Cape Town, South Africa, pp. 173 – 178.
Smith, M. A. (2000). Some Social Implications of Ubiquitous Wireless Networks. In: *ACM SIGMOBILE Mobile Computing and Communications Review*, Vol. 4, No. 2, pp. 25 – 36.

[89] Streitz, N. (2001). *Overview over the Deliverables in Terms of Documents, Presentations, Video Clips, and Demonstration of Prototypes.* Deliverable of the 'Ambient Agoras' Project for the First Disappearing Computer Jamboree, Zürich, Switzerland.

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

[91] Sundstrom, E. (1999). *Supporting Work Team Effectiveness*. Jossey-Bass, San Francisco, USA.

[92] Tang, J. C., Isaacs, E. A., Rua, M. (1994). Supporting Distributed Groups with a Montage of Lightweight Interactions. In: *Proceedings of the ACM Conference on Computer Supported Cooperative Work* (CSCW'94), pp. 23 – 34.

[93] Tang, J. C., Yankelovich, N., Begole, J., Van Kleek, M., Li, F., Bhalodia, J. (2001). ConNexus to Awarenex: Extending Awareness to Mobile Users. In: *Proceedings of the Conference on Human Factors in Computing Systems* (CHI'01), pp. 221 – 228.

[94] Tarasewich, P., Warkentin, M. (2002). Information Everywhere. In: *Information Systems Management*, Vol. 19, No. 1, pp. 8 – 13.

[95] Tulving, E. (1993). What is Episodic Memory? In: *Current Perspectives in Psychological Science*, No.2, pp. 67 – 70.

[96] Utz, S. (2000). Identifikation mit virtuellen Arbeitsgruppen und Organisationen. In: M. Boos, K. J. Jonas, K. Sassenberg (Eds.)

Computervermittelte Kommunikation in Organisationen. Hogrefe, Göttingen, Germany, pp. 41 – 55.

[97] Vogel, D., Balakrishnan, R. (2004). 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.

[98] von Ah, M. (2004). Das Büro passt sich an. In: *InfoWeek.ch* (online). Available at: http://www.infoweek.ch/archive/ar_single.cfm?ar_id=13928&ar_subid=2&sid=0, last accessed June 23, 2008.

[99] Weiser, M. (1991). The Computer for the Twenty-First Century. In: *Scientific American*, Vol. 265, No. 3, pp. 94 – 104.

[100] Welen, P., Wilson, A., Nixon, P. (2003). *Scenario Analysis.* Deliverable D.9 of the project 'GLOSS - Global Smart Spaces', IST-2000-26070.

[101] Whittaker, S., Frohlich, D., Daly-Jones, O. (1994). 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.

[102] Wisneski, G., Ishii, H., Dahley, A., Gorbet, M., Brave, S., Ullmer, B., Yarin, P. (1998). Ambient Display: Turning Architectural Spache into an Interface between People and Digital Information. In: *Proceedings of the First International Workshop on Cooperative Buildings* (CoBuild'98), pp. 22 – 32.

[103] Zhao, Q. A. (2001). *Opportunistic Interfaces for Promoting Community Awareness*. PhD Thesis, Georgia Institute of Technology, Atlanta, GA.

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