

i-LAND: An interactive Landscape for Creativity and Innovation

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ABSTRACT

We describe the i-LAND environment which constitutes an example of our vision of the workspaces of the future, in this case supporting cooperative work of dynamic teams with changing needs. i-LAND requires and provides new forms of human-computer interaction and new forms of computer-supported cooperative work. Its design is based on an integration of information and architectural spaces, implications of new work practices and an empirical requirements study informing our design. i-LAND consists of several 'roomware' components, i.e. computer-augmented objects integrating room elements with information technology. We present the current realization of i-LAND in terms of an interactive electronic wall, an interactive table, two computer-enhanced chairs, and two "bridges" for the Passage-mechanism. This is complemented by the description of the creativity support application and the technological infrastructure. The paper is accompanied by a video figure in the CHI'99 video program.

Keywords

Integrated design, interactive landscape, architectural space, virtual information space, augmented reality, ubiquitous computing, roomware, cooperative rooms, creativity support, dynamic team work, CSCW, workspaces of the future

INTRODUCTION

In this paper, we present an approach for the design and implementation of innovative workspaces that are based on an integrated design of virtual information spaces and – with equal weight – real architectural spaces. While the general approach for the *workspaces of the future* is applicable to a wide range of application scenarios, we will focus in this paper on a specific example, the support for creative teams. The first results of our approach will be presented in terms of the i-LAND environment: an interactive landscape for creativity and innovation.

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We approach the issues involved from the following four perspectives. First, we discuss the relationship between the affordances provided by real, physical objects in the architectural space and digital information objects in the virtual information space. Second, we discuss the implications of new work practices resulting from organizational innovations and their requirements for the design of collaborative workspaces. These two perspectives represent the general conceptual framework. In order to make our ideas more concrete, we illustrate them by two example scenarios which had a guiding function for our design. A third perspective is provided by the technological framework, considering developments in augmented reality and ubiquitous computing. The fourth perspective is provided by the results of an empirical requirements study informing our design by current work practices of existing teams and their expectations about future work environments. These four perspectives set the stage for the central part of this paper: the introduction of our 'roomware' concept and the description of the first prototype implementation in terms of the i-LAND environment. The paper ends with a discussion of our approach with respect to related work and directions for future work.

CONCEPTUAL FRAMEWORK

It is our vision of the workspaces of the future – for individuals as well as groups – that the environment around us becomes more of an interface to information which can and should be (re)presented in many more different forms than it is currently the case.

Integrated Design of Information and Architectural Spaces

The advent of information technology resulted in a shift to a situation where information is being created, stored and communicated by means of computers resulting in virtual worlds as the places of information. As a consequence, interfaces to information are being realized as – and in our perspective reduced to – displays of desktop computers or via virtual reality gadgets. On the other hand, our day-to-day living and working environments are highly determined by the architectural space around us. Buildings with their rooms, walls, floors, ceilings, doors, windows, furniture, etc. constitute rich information spaces due to their inherent

affordances – either as concrete and direct information sources or by providing ambient peripheral information [7].

Examples are the distribution and availability of physical objects as, e.g., books, magazines, drawings, notepads, photo copies placed on desks, tables, or window shelves; diagrams, pictures, and calendars hanging on the walls. Another example is the physical layout of the workplace in an office or a meeting room and how it is embedded in the overall architectural environment. The positioning of desks, chairs, tables, shelves in offices results from existing work practices. At the same time, these characteristics constrain current group activities in terms of possible changes of their structure. For example, the ease of forming subgroups of a team working in a meeting room is very much dependent on the flexibility of the furniture and the access to multiple information devices. Architectural spaces are and serve as information and cooperation spaces.

With the spread of desktop computers in offices, the situation changed dramatically. The monitor of the desktop computer became the primary, almost “holy” entrance to up-to-date information. There is a tendency that information is more or less available only via the computer. At the same time, the desktop computer turned out to be a bottleneck. There are limitations for parallel access to different sources and types of information and limited screen space results often in complex handling of windows.

We are convinced that - also in the age of information technology - physical objects and their placement in the architectural space provide valuable “affordances” for organizing content information and meta information for the work process of individuals as well as for groups. These affordances should be complemented by augmenting the physical environment by the rich information available in digital information spaces. In some cases, this requires to present this “invisible” information via (dynamic) physical objects in correspondence with the (changing) underlying digital information. There are many ways to approach this overall design goal. For related approaches see [1] and [7].

New Work Practices

In the future, work and cooperation in organizations will be characterized by a degree of dynamics, flexibility, and mobility that will go far beyond many of today's developments and examples. On demand and ad hoc formation of teams, virtual organizations, physically distributed and mobile workers, desk sharing are only initial examples of the work practices and organizational innovation to be expected. Contents and participants as well as contexts, tasks, processes and structures of collaboration will be changing frequently, in various ways and with an increasing rate of the innovation cycle. The role of physical office space will change. It is time to reflect these developments in the design of equally dynamic, flexible, and mobile work environments.

On demand and ad hoc formation of teams requires powerful methods and tools for the support of different work phases in teams. In one of our empirical studies [8],

where we evaluated our previously developed meeting support system [18], we found that the provision of hypermedia functionality facilitates the division of labor in team work. This resulted in better results in the group problem solving activities [8]. In another empirical study [22], we investigated different combinations of personal and public information devices (four networked computers mounted in a table, one interactive electronic whiteboard) and their role for collaboration in meetings. These results show that the groups which developed a balanced proportion of individual work, subgroup activities, and working in the full group achieved better results than those groups which stayed most of the time in the full-group work configuration. The degree of flexibility to work in different modes was largely determined by the range and combination of information devices provided to the team.

While these results were obtained in “standard” electronic meeting rooms, these constellations do not provide the necessary flexibility of assigning different workspace areas within a meeting room to subgroups and individuals. Standard electronic meeting rooms usually employ one large static table and computers on top of it or mounted in the table [e.g., 10, 11, 17] as we also did in the past [18, 22]. So far, it was not possible to (re)configure the combination of furniture and computer devices in a very flexible way. It is a high priority design goal for i-LAND to provide an environment with high spatial flexibility and mobility of the employed information devices.

Two Sample Scenarios

In order to have concrete examples of how we can transform our general approach into working prototypes, we developed sample scenarios guiding our ideas of how to work and cooperate in the future. We present two of them.

First scenario

Meeting a colleague by chance in the hallway and starting a discussion might result in the intention to explain something by drawing a sketch on the wall and annotate it by some scribbles. Besides the fact that this is usually not accepted in office buildings, traditional walls do not support to store and later modify these elements of the discussion. It is also not possible to search for related information in a background information base and to link this information to the sketch and the scribbles on the wall. In the future, we like to be able to turn to the wall and do just this. Think of the wall as an “interactive wall” or as one being “covered” by a high resolution electronic wallpaper providing the functionality needed. A wall like this is also of great use for informal communication in other places, e.g., the cafeteria.

Second scenario

It often happens in group work, that a team divides the work by assigning subtasks and breaks up so that individuals and subgroups can go off to do their work. After some time, e.g., on the next day, the full team meets again and discusses the results which form the basis for the next phase of cooperation. In a time-critical situation, it would be very useful if one can reduce this cycle time of full team

meeting/ subgroup meetings. An alternative is to provide ways for subgroups to split off *during the meeting in the same work space*, do their work, rejoin and then immediately merge the results. Providing adequate IT support for this scenario requires a team or project room which is equipped with components and resources which are so flexible that they can be reconfigured dynamically and on-demand in order to meet the different requirements of changing team work situations. From our analysis of this scenario, we came up with a plenary situation and different subgroup constellations. The plenary is characterized by the full team sitting in chairs and facing a (large) public display. One example of subgroup work is that some people move their chairs and group them in one corner of the room, discuss their task and exchange ideas. Another subgroup might walk over to an ad hoc meeting table, stands around it, views and edits tables and diagrams. A third subgroup walks up to a large whiteboard, draws sketches and annotates them with scribbles.

It is our vision that the chairs, the table, and the whiteboard are all interactive electronic devices providing adequate IT support for these interaction and cooperation situations. We also suggest places for individual work, e.g., searching for background information, called 'Columns of Knowledge'. Furthermore, we think that there will be always paper in one way or another. Thus, we suggest a device, the mobile 'ScanTable', for scanning paper documents so that the content is immediately available in the network. Fig. 1 presents a first visualization of our ideas when we started the i-LAND project (in spring 1997) showing parallel work of three subgroups and two individuals.

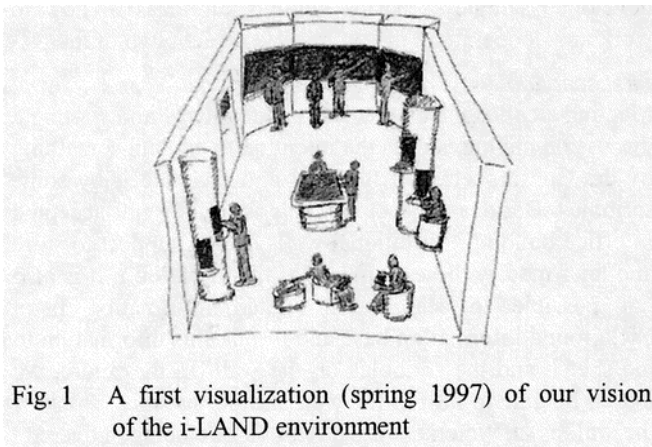


Fig. 1 A first visualization (spring 1997) of our vision of the i-LAND environment

TECHNOLOGICAL FRAMEWORK

We are convinced that *we have to go beyond desktops* in order to realize our vision of the 'workspaces of the future' presented above. It is obvious that this goal requires a different technological setup as usually available in offices. In particular, two areas of recent developments are relevant: *augmented reality* and *ubiquitous computing*.

Augmented Reality

This area reflects our view that the real world around us should be more of an interface to information than it is currently. Rather than sitting in front of the monitor of your

desktop computer and "diving" into cyberspace or wearing helmets, head-mounted displays, goggles, etc. in order to immerse in a virtual world, augmented reality is concerned with the use of computational devices in order to augment our perception and interaction in the physical world. For an overview of initial work see [27]. Early examples are the **DigitalDesk** [26], **Chameleon** [3], and the **NaviCam** [15]. A related but different approach is the notion of 'graspable' user interfaces [4] and 'tangible bits' [7].

Ubiquitous Computing

Pursuing the approach of augmented reality at a larger scale requires to have many, loosely spread and networked information devices around, with displays of different sizes, providing functionality everywhere. This is the concept of **ubiquitous computing** [24, 25] and – related – of **ubiquitous media** [1]. The size of these devices can range **from** very small to very large. Some of the devices will stand out and be recognized as computers, others will be "invisible" as they are embedded in the environment. Once the physical space is filled with multiple devices, two set of issues come up. First, how can one transfer information between them in an intuitive and direct way and, more general, how to interact with them. Second, it is desirable to know the position of the devices and their state wherever they are in a room or a building. The first issue is addressed, e.g., by the 'pick-and-drop' technique [13, 14] and by our concepts of 'take-and-put' and 'Passage' described later on. The second issue requires to set up an infrastructure of sensing and localization technology. We are aware that collecting information on where the devices and especially where the users are raises problems with respect to privacy issues. A combination of ideas from augmented reality and ubiquitous computing is employed in the approach of so called **Reactive Environments** [2].

REQUIREMENTS ANALYSIS

While innovative concepts, visions about possible scenarios and advances in basic technologies are important to make progress, we know from the principles of user- and **task-oriented** design that this is not sufficient for the development of new systems. We have to inform our design also by the requirements of anticipated user groups. Therefore, we conducted an empirical study in order to investigate the current work situation of teams and their requirements for future environments.

Method of the empirical study

We selected five companies **from** the automobile and oil industry and the advertising and consulting business. These companies were selected because they had special work groups which were called "creative teams" or could be labeled as such. They are working in the areas of strategic planning, identifying future trends, designing and marketing new products, etc. We expected these teams to be good candidates for working already with innovative tools and being creative when asked about their ideas and requirements of future work environments for team work.

We interviewed at least one, sometimes more representatives of the teams, visited the project team rooms where they usually hold their meetings, and distributed a questionnaire to all team members. The total number of people in these five teams was 80. The age range was from 28 to 55 years. They usually had an academic education and came from various educational and professional backgrounds: engineering, computer science, business administration, psychology, and design. Unfortunately, only 20 % of the distributed questionnaires were returned but together with the interviews and site visits they provided valuable information.

Results of the empirical study

Due to limited space, we report only selected results relevant for the design of i-LAND. For details see [23]. In most cases, the facilities were traditional meeting rooms furnished with standard equipment as, e.g., large solid tables and chairs, flip charts, whiteboards, and overhead projectors. In only one case, there were a couple of computers, a scanner and a printer permanently installed in the meeting room. In another case, people would bring a laptop and a beamer in order to project computer displays on the wall. This configuration was only used for prepared presentations. No active creation of content during the meeting was done with the aid of computers. Different creativity techniques (e.g. brainstorming, Metaplan,..) were used but only in a paper-based fashion. These results on the current state of the rooms were contrary to our expectations. We had expected more (active) usage of computer-based technology in the meetings.

The situation changed when we asked about the requirements for the future. Usually, a large room was required with a flexible setup and mobile components that would allow different configurations. The room should have the character of a market place or a landscape providing opportunities for spontaneous encounters and informal communication. Quote (translated from German): "Team meetings are not anymore conducted by meeting in a room but by providing an environment and a situation where encounters happen". The furniture should be multifunctional and flexible. Although the current situation was rather low-tech, there was a great openness for computer-based support in the following areas: support for information gathering while preparing meetings by accessing internal and external data bases; in a special case, "pools of ideas" were mentioned - in an advanced version so called "idea spaces"; computer-based support for a wide range of creativity techniques allowing for flexible configuration or tailoring of the underlying rules; support for presentation styles deviating from the traditional situation and involving the attendees in an active fashion labeled as "participatory presentation"; support for visualizations inspiring and enhancing the creative process; support for communicating and experiencing content also via other channels than only visual, e.g., acoustic, tactile. There was less emphasis on videoconferencing. The teams stressed the importance of personal presence being essential

for creating a stimulating and productive atmosphere. It was also mentioned that "creative teams" are not only busy being creative all the time but they also have to plan and organize their work. This motivated the request for computer- and video-based support for (on-line) documentation of meetings and preparation of the minutes. While computer-based support was strongly requested, the computer should be in the background. Quote (translated from German): "We have the creative potential, not the computers." Another issue was the creation of a certain atmosphere described with labels as freedom, room for individuality, flexibility, etc. In summary, the teams wanted to have much freedom in (re)configuring their physical environment and their information environment.

THE ROOMWARE-COMPONENTS

Our approach to meet the requirements of flexible configuration and dynamic allocation of resources in integrated physical and information environments is based on the concept we call *roomware*. By *roomware*, we mean computer-augmented objects resulting from the integration of room elements, e.g., walls, doors, furniture (tables, chairs, etc.) with computer-based information devices. The general goal of developing roomware is to make progress towards the design of integrated real architectural spaces and virtual information spaces from the perspective of augmenting reality. In the context of supporting team work, roomware components can be tailored and composed to form flexible and dynamic "cooperation landscapes" serving multiple purposes: project team rooms, presentation suites, information foyers, etc. These goals have in common that they require also to develop new forms of multi-user, multiple-displays human-computer interaction. We will present examples as we go along. The current focus is on designing workspaces for collocated teams but the i-LAND environment can easily be extended to provide support for global cooperation of distributed teams.

We have designed and implemented an initial set of *roomware* components. So far, it consists of an interactive electronic wall (*DynaWall*), an interactive electronic table (*InteracTable*), and mobile and networked chairs with integrated interactive devices (*CommChairs*). They are assembled in the AMBIENTE-Lab at GMD-IPSI in order to form the first version of the i-LAND environment.

The DynaWall

The objective of the *DynaWall* is to provide a computer-based device that serves the needs of teams, e.g., in projects rooms where large areas of assembled sheets of paper covering the walls are used to create and organize information. The *DynaWall* can be considered an "interactive electronic wall" represented by a touch-sensitive information device. Our current realization provides a total display size of 4.5 m width and 1.1 m height. It covers one side of the room completely (Fig. 2). The software we developed (BEACH) enables teams to display and interact with large information structures collaboratively on the *DynaWall*.

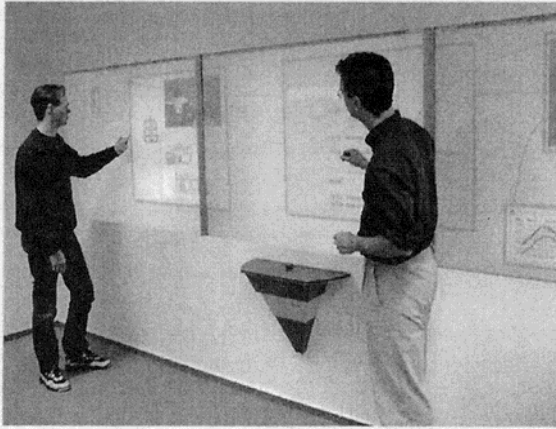


Fig. 2 Two people cooperating at the DynaWall

Two or more persons are able to either work individually in parallel or to share the whole display space. The size of the DynaWall provides new challenges for human-computer interaction. For example, it will be very cumbersome to drag an object or a window holding down a mouse over a distance of more than 4 m. Therefore, we have developed two mechanisms addressing these problems. Our “take and put” feature allows to take information objects at one position, walk over (without being in contact with the DynaWall) and put them somewhere else on the display. “Shuffle” allows to throw objects (with different accelerations) from one side to the opposite side where it can be caught by another team member. The initial design idea was presented in [19] and as a late-breaking result in [6]. Now it is implemented and working.

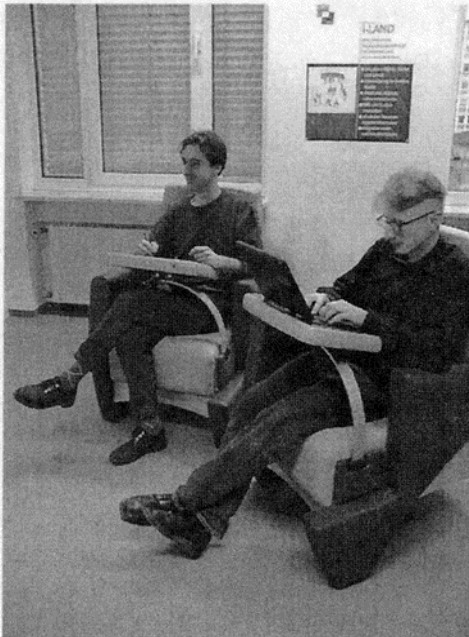


Fig. 3 Usage of two CommChairs
The CommChairs

The *CommChairs* (Fig. 3) are mobile chairs with built-in slate computers. They represent a new type of furniture combining the mobility and comfort of armchairs with high-end information technology.

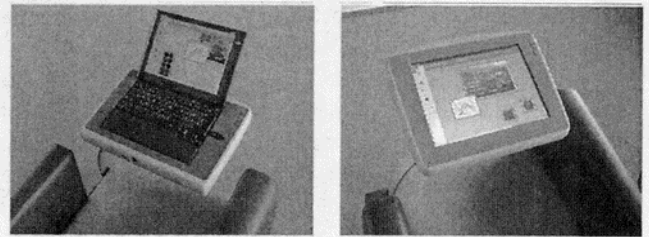


Fig. 4 Two versions of the CommChairs

Currently, there are two versions: one with a docking facility so that people can bring their laptop computer and drop them into the swing-up desk which is part of the armrest. The other version has an integrated pen-based computer built into the swing-up desk (see Fig. 4).

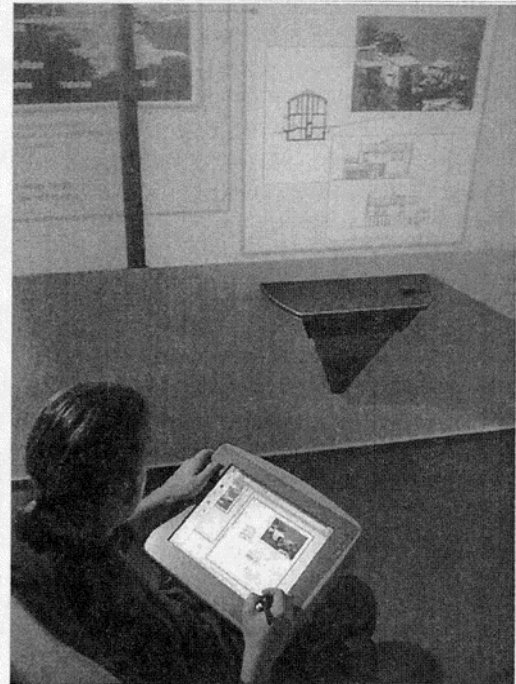


Fig. 5 Remote annotations from CommChair to DynaWall

The CommChairs allow people to communicate and to share information with people in other chairs, standing in front of the DynaWall or around the InteracTable. They can make personal notes in a private space but also interact remotely on shared (public) workspaces, e.g., making remote annotations at the DynaWall (see Fig. 5). The cooperative functionality is provided by our BEACH software. For maximum flexibility and mobility each chair is provided with a wireless network and independent power supply. The initial design idea was presented in [19] and as a late-breaking result in [8]. Now it is implemented.

The InteracTable

The *InteracTable* is a mobile interactive table that is designed for creation, display, discussion and annotation of information objects by a group of two to six people standing around it. The current stand-up version (1.15 m high) of the InteracTable is built as a vertical bottom-up projection unit (Fig. 6). An LCD beamer projects a high-resolution image to the top of the table providing a horizontal touch-sensitive display of 65 cm x 85 cm.



Fig. 6 Discussion of a subgroup at the InteracTable

People can write and draw on it with a pen and interact via finger or pen gestures with information objects. There is also a wireless keyboard for more extensive text input. The InteracTable, with its horizontal set-up display and people standing around it at each side, is an example of an interaction area with no predefined orientation as top and bottom, left and right at the desktop computer. Therefore, horizontal and round or oval-type displays require new forms of human-computer interaction. As a first step, we developed gestures for rotating and shuffling individual and groups of information objects across the surface. This accommodates easy viewing from all perspectives (Fig. 7).

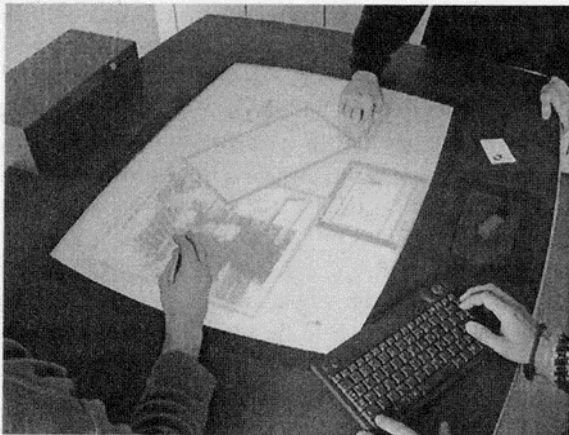


Fig. 7 Rotating windows on the InteracTable
The Passage Concept

Passage describes an elegant mechanism of connecting information structures in the digital, virtual world of computers with a real-world object. Such a detectable object, a so-called *Passenger*, can be seen as a physical bookmark into the virtual world. One can assign information to it, take it, carry it physically to a new location, and simply by putting it on a device called *Bridge*, the information is displayed immediately at the new location. It is no longer necessary to open windows, browse hierarchies of folders, worry about mounted drives, etc.

Passage is a concept for ephemeral binding of content to an object. It provides an intuitive way for the “transportation” of information between computers/ roomware components, e.g., between offices or to and from meeting rooms.

A Passenger does not have to be a special physical object. Any uniquely detectable physical object may become a Passenger. Since the information structures are not stored on the Passenger itself but only linked to it, people can turn any object into a Passenger: a watch, a ring, a pen, glasses, or other arbitrary objects. The only restriction Passengers have is that they can be identified by the Bridge and that they are unique. Fig. 6 and Fig. 7 show a small wooden block as an example of a Passenger placed on the margin of the InteracTable where the Bridge device is embedded. The current Passage implementation uses the weight of physical objects for identification and computer-controlled scales built in the Bridge for detection.

THE APPLICATION: SUPPORT FOR CREATIVE WORK

The current application for i-LAND is to support team work with a focus on creativity and innovation. The software we develop supports different types of creativity techniques and related generic functionality as, e.g., visualization of knowledge structures. The BEACH software provides the new forms of human-computer interaction, e.g., *take-and-put*, *throw*, *shuffle*, *rotate*, etc.

We focus on support for different brainstorming techniques and for project organization. It has been shown that computer-supported brainstorming results in more number of ideas than verbal brainstorming [5]. There are limitations with existing brainstorming systems (e.g., [10]) we like to overcome. Our software enables teams to work with networked hypermedia structures providing adequate representations for their ideas. This is based on our earlier hypermedia work [18] combined with new concepts. The possibility to display large information structures at once, e.g., on the DynaWal, provides new opportunities for innovative idea creation and concept presentation modes. Our development includes new visualization metaphors for presenting content and structures of our ‘thoughtscapes’.

THE TECHNOLOGY INFRASTRUCTURE

While each of the roomware components presented above has a value of its own, the full benefit is only available via a comprehensive integration and combined use. This integration requires a network infrastructure providing the connectivity between the components and a software infrastructure providing a wide range of cooperative sharing capabilities. For extending the mobility of team members and roomware components within the Lab and later on in the whole building it is necessary to identify them in different locations. This requires a sensing and localization infrastructure planned for the near future.

Network infrastructure

In the current implementation, we use a combination of the local area network already installed in the building and an RF-based wireless network. For maximum flexibility all

mobile roomware components are connected to the wireless network. The CommChairs are equipped with an antenna which comes along with a PC-Card. Laptops with a wireless adapter are carried along (e.g., when returning from a business trip), plugged into the docking station of the CommChair and the team member can join the meeting without reconfiguration. The computers of fixed roomware components as, e.g., the DynaWall are connected via cables to the LAN. The network connection for the wireless access to the LAN is realized by a 2-channel access-point which acts as a bridge between the cable-based and the RF-based Ethernet. The transfer rate of one RF channel is currently 2 Mbps, soon to be upgraded to 10 Mbps.

Software infrastructure

In order to meet the functional and integration requirements for i-LAND, we have developed BEACH. It provides the software infrastructure for cooperative sharing of information between the devices in combination with new forms of human-computer interaction required and enabled by the roomware components. BEACH is designed as a layered architecture. The lowest level is the COAST framework [16] previously developed also at GMD-IPSI. It provides the functions necessary for distributing, replicating and synchronizing information objects. This framework was used to create shared information spaces between different roomware components and, in addition, to couple several physically separate roomware components to a logically homogenous workspace. This is also important for large interaction areas as the DynaWall which is currently build from three separate segments because of the limitations of displays currently available.

The next level of BEACH covers the interaction of one user with a roomware device. Here, the software must take care of the different input and output characteristics of the roomware components: Display sizes vary from rather small (as in a CommChair) to the huge display of the DynaWall. The user's orientation might be fixed with respect to the display (as with a "traditional" desktop PCs) or it might be arbitrary and can change over time at the InteracTable. The available input devices are keyboard, mouse, and pen, resp. touch in general. Gesture recognition is crucial for realizing the interaction forms.

On top of this, BEACH provides mechanisms to structure collaboration. The basic metaphor is the "virtual location", which defines who is working together on which topic and which data are used. The virtual location is the virtual counterpart of a physical meeting room: a meeting room is attached to a virtual location during a meeting – it might be associated with another virtual location at another time for another task or project. There is a strong correspondence between the physical places and virtual locations. If, for example, a team decides within a meeting to split up into subgroups, each subgroup might go to a different area of the meeting room or the building to continue their collaboration there. The software must be able to recognize such situations, to decouple the previous homogenous

workspace, and to automatically create shared workspaces for each subgroup. This is achieved by creating a new sublocation for each subgroup within the team's virtual location, corresponding to the different areas, the physical sublocations. BEACH is developed in Smalltalk using Parc Place Systems' Visual Work environment.

DISCUSSION AND FUTURE WORK

We have presented the design and implementation of innovative collaborative workspaces based on an integrated design of real architectural and virtual information spaces. Our approach is related to and was inspired by different developments in human-computer interaction, augmented reality, ubiquitous computing and computer-supported cooperative work, in particular meeting support systems. We developed new ideas for human-computer interaction and applied them to the design of collaborative work environments. On the other hand, we extended interaction techniques by cooperative functionality to create ubiquitous and collaborative workspaces. Since there is not enough space to discuss the relationship to other work in detail, we do this only for a few examples.

Compared to work in augmented reality, e.g., the DigitalDesk [26], the *InteracTable* provides a touch-sensitive interactive display with a bottom-up projection. This avoids the problems of shadows caused by the overlay of video projections on the real surface of the DigitalDesk. Our *Passage* mechanism was inspired by the idea of the "marble answering machine" [12] but extends it by using physical objects not only as representatives for voice or, more general, digital information. It is also used as means for physical transport between different roomware components. Re ubiquitous computing, our roomware approach concentrates on devices that are embedded in furniture, like chairs and tables, as well as in architectural elements of buildings, such as doors or walls. The 'take-and-put' technique for the DynaWall is related to the 'pick-and-drop' mechanism in [13, 14] but it does not require a special pen. It is based on gestures. Compared to work in CSCW, especially meeting support systems [10, 11, 17], including our own previous work [18, 22], our new approach is different due to the flexibility and mobility of the *roomware* components. It allows flexible and dynamic creation and allocation of workspaces in different parts of a room or a building in correspondence with different modes of the group activity instead of having a fixed setup, e.g., a set of chairs around a static table with computers. This enables new methods of establishing cooperation and sharing of information. For example, a subgroup is formed by simply moving chairs in close spatial proximity (see also below). The reactive environments described in [2] are different due to their focus on the special issues of video conferencing rooms.

The i-LAND environment introduces new forms of human-computer interaction. Thus, we have to evaluate their usefulness and their usability. This will be done in the spirit of our previous evaluation studies in a systematic fashion

with controlled empirical experiments. Furthermore, we plan to sense and track the position of roomware components and people. Thus, "the room will know" the position and orientation of each component and who is interacting with which device. The i-LAND software mentioned above will process this information and, for example, automatically initiate a coupled session with shared displays between two or three CommChairs when they are moved together to form a subgroup and their distance is below a defined threshold.

The i-LAND environment is a first implementation of the roomware approach which is part of a more general framework called "cooperative buildings" which was introduced in [19, 21] and further discussed on a panel at CSCW'98 [20]. It represents a more global vision about the design of the "workspaces of the future".

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