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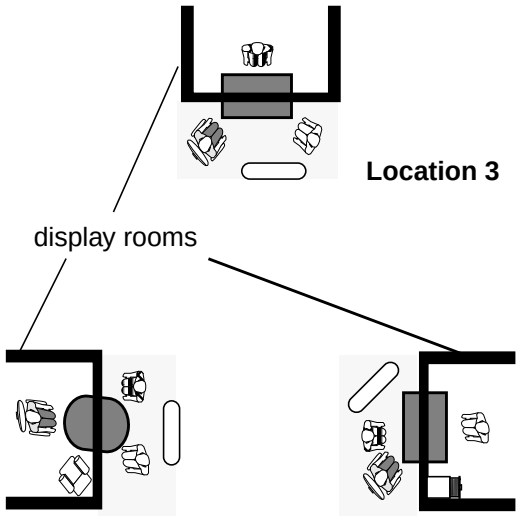

Figure 9 co-presence and co-working from three remote locations

presence session. During the session these artifacts are textured mapped onto a virtual projection wall and combined with video imagery of the remote participants.

The usefulness of the appraoch has been presented by the use of two scenarios. However, there is evidence that the results of our work could be of interest for a broader application domain in today's distributed offices. In future work we will investigate specific needs of different applications domains to enhance the usefulness of our approach.

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Figure 6 Remote participants with virtual projection wall in TELEPORT's virtual extensions

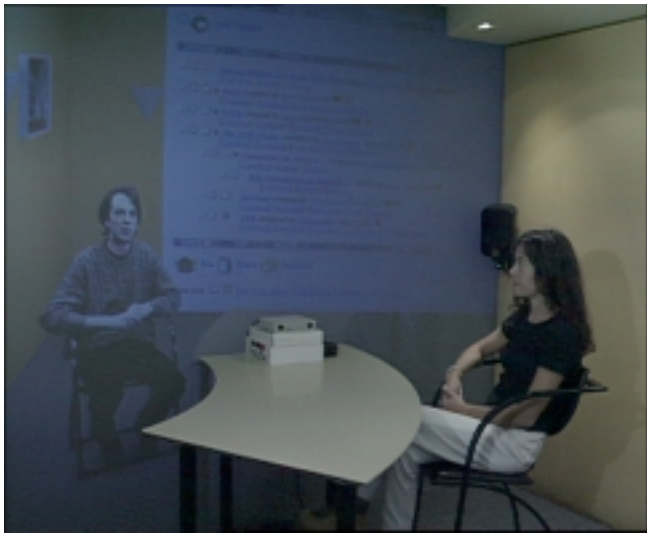

Figure 7 Session between two remote sites as seen from within a TELEPORT's display room

In addition, another video signal from a remote participant's notebook (or other computer) is texture-mapped onto a surface representing a virtual projection wall. As shown in Figure 8, the virtual projection walls are combined within the virtual extensions, together with the remote participants.

For example, the video signal coming from one participant's notebook (location 1 display room) is mapped as a texture onto a virtual projection surface, and is projected into the virtual extension of location 2, and vice-versa. The virtual projection walls can be positioned and sized within the 3D virtual space, according to the preferences of the participants in real-

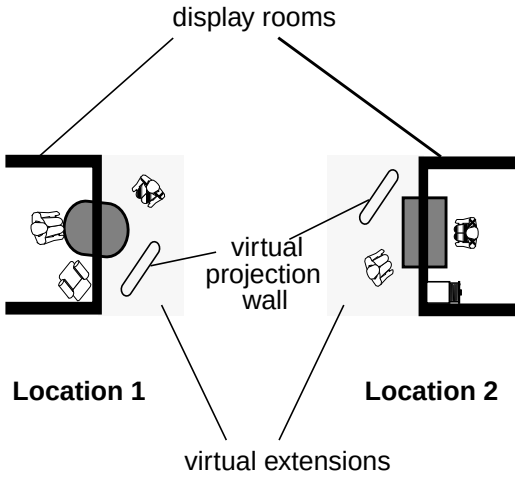

Figure 8 co-presence and co-working session

time. This is particularly useful when more than two locations and display rooms are used or there are more than one participants at each site.

Furthermore, it is possible to use more than one virtual projection walls in one site Figure 9. This might be useful when for example an electronic document is needed in parallel with the video image from a participant's notebook.

Finally, more than two sites can be connected. In this case, the video image from all the other locations is combined and projected into the virtual extension of each participant. A co-presence and co-working session with three locations is shown in Figure 9. Occasions were more than one virtual projection walls are used in one location, are possible. However, consideration must be given as to the size of the surfaces and the number of group member's participating in the meeting, due to the size of a TELEPORT display room.

5. CONCLUSIONS

In this paper we have presented an approach for co-presence and co-working in a distributed office. The approach integrates two systems developed at GMD, namely TELEPORT and the BSCW Shared Workspace System. TELEPORT is a teleconfereincing system that merges virtual and real envirnoments by the use of wall display surfaces and viewer tracking provides the sensation of face-to-face meetings. The BSCW Shared Workspace System provides basic facilities for collaborative information sharing, activity awareness and integration of external applications based on the World Wide Web architecture. The approach presented in this paper provides support for co-working by integrating the functionality of the both systems. In particular, group members at different sites use the BSCW system to prepare artifacts needed in the co-

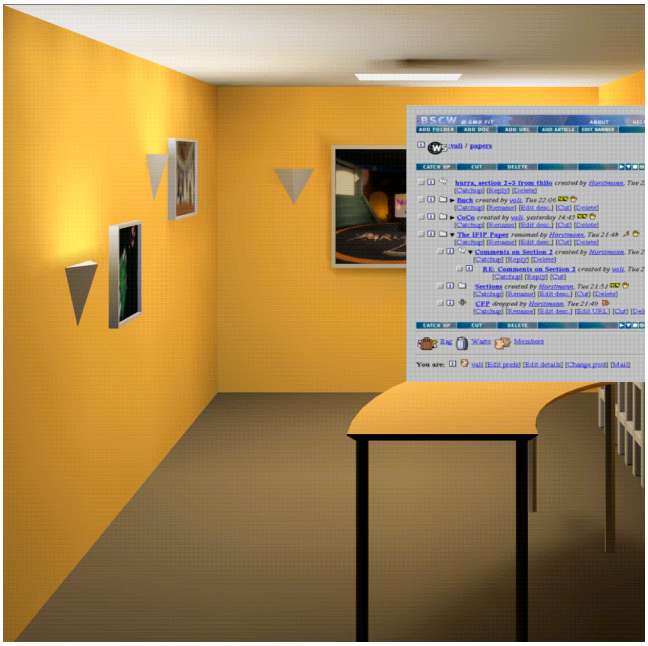

Figure 4 virtual projection wall within the virtual extension of a TELEPORT display room

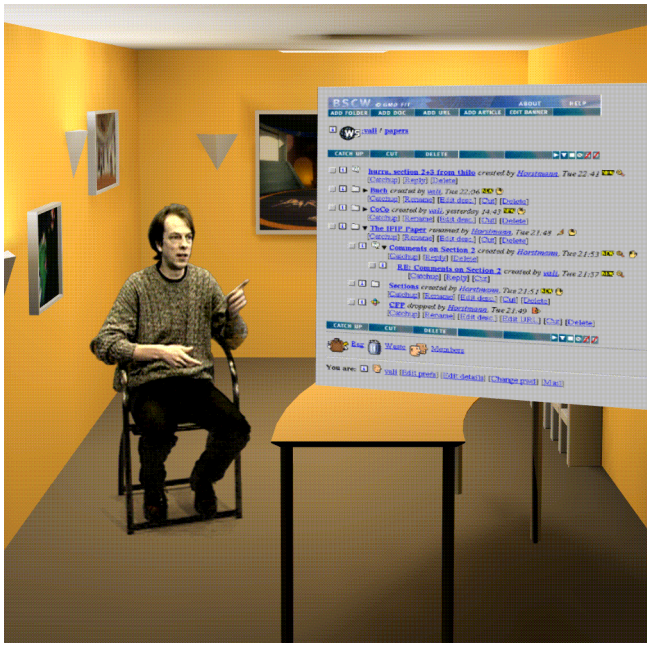

Figure 5 Remote Participant with virtual projection wall in TELEPORT's virtual extension

There are a number of advantages in this approach. Firstly, the participants can focus on the speakers and be able to glance at the operations performed by him/her on the virtual projection wall, thus the concentration of the participants does not shift from the expert to a computer screen or computer window as happens with most of the teleconferencing systems. Furthermore, the expert can concentrate in presenting the functionality of the demonstrated tool rather than explaining how to choose menu-items and so on.

Position and size of the virtual projection wall can be easily adjusted and either included or excluded from the virtual extension of a display room. This is particularly important for an interactive seminar, where participants are asked to complete specific tasks or tests, or answer electronic questions. If this is a requirement, then different virtual projection walls can be inserted next to the participants whenever this is necessary.

Since BSCW is used during the session, the process of generating reports, lists of questions and answers or whatever might be necessary after the session becomes easier. Participants might even be able to "walk out" of a session having all the necessary information downloaded into their notebook or the site's computer system for future reference.

4.2 Meeting Example

The same approach can be used to support meetings of geographically dispersed groups. In particular, preparation of the meeting is very similar to that of a seminar. The type of electronic information might vary from electronic agendas to sales reports or other information for decision support. The functionality described above for the seminar case, can facilitate the preparation of the meeting and therefore make the meeting an even more effective one.

A major difference between a meeting and a seminar situation, is that during the co-presence session, the level of participation of group members is more equal. Group members from all sites would need to exchange ideas and display electronic documents that might support their ideas and arguments on an equal base. The way this is achieved is the same as in the seminar case. However, consideration must be given as to the number and size of virtual projection walls because of the limited space of the display rooms and their virtual extensions. It might, for example, be better to use only one virtual projection wall for each group's site rather than one for each group member.

Figure 6 and Figure 7 show an example of co-presence and co-working between two remote sites. One participant and the virtual projection wall are combined with the virtual background (Figure 6) and the mixed image becomes the virtual extension of the other participant's display room (Figure 7).

4.3 Technical Approach

Our approach uses two or more TELEPORT display rooms as described in this section. The video signal of each participant is texture-mapped onto a surface within the virtual room, using the capabilities of the TELEPORT system.

of a URL link object to be added to the current folder, while the latter perform operations on the individual objects, such as ‘rename’, ‘edit description’ and so on. As a short-cut, the check-boxes to the left of each object in combination with the buttons above or below the list of objects allow operations on multiple object selections.

Clicking on an object name will perform different operations depending on the type of the object; clicking on a document will download it, possibly for display by the browser (for HTML files or GIF images for example), display by an external application (as with a Microsoft Word document) or saving to disk, while clicking on a folder ‘opens’ the folder and replaces the current view with a display of the folder contents. This last method of navigating ‘down’ through a folder hierarchy is supplemented by a navigation bar at the top of the page presenting the current location and path; clicking on the first element of the path (":vali" in Figure 3) returns to the current user’s ‘home folder’, which lists all the workspaces of which the user is a member, and therefore has access to.

The event service provided by the BSCW system provides users with information on the activities of others with respect to objects in a workspace. Events are triggered when a user performs an action such as uploading a document, renaming a document and so on. The system presents the recent events to each user as event icons in the workspace listing (Figure 3). ‘Recent’ in this context means events which have occurred for an object since the user last ‘caught up’; an operation by which users can indicate they are aware of events that have occurred so far and no longer wish to see them in the workspace (like catching up articles in a Usenet newsgroup). Events can be caught up at different levels, from individual objects to complete workspace folder hierarchies.

The system distinguishes several types of events in the workspace listing such as ‘new’, ‘read’, ‘written’ and so on. The ‘touch’ event (shown by a hand icon) signals that something has happened to an object inside a folder or other container. Clicking on an event icon returns a list of all events of the type which have occurred since the last catch-up. This service therefore provides a very simple form of event information regarding changes within the workspace.

4. The Co-presence and Co-working Approach

To overcome the limitations of desktop video conferencing and provide support for co-working, we integrate the functionality of the two systems. Our approach provides support for co-working before, during and after co-presence.

In particular, preparation of a group meeting with participants from remote sites is supported by the use of the BSCW common workspaces. Group members can prepare agendas, schedules, shared documents and electronic material that might be necessary for the session. This is also the phase, where decisions such as who is participating in the meeting or which material should be prepared from each site are made.

Once the preparation phase is completed, group members from different sites are now ready to meet in the purpose build display rooms in each site. In our approach, information in the form of electronic documents, presentation material and so on, are displayed on a virtual projection wall and combined with the 3D virtual room and the remote participant’s video image.

4.1 Seminar Example

To exemplify the approach, we first consider the remote seminar case. In today’s distributed companies seminars and skill improvement courses could be very costly both in terms of time and money, because of the travelling involved, either for the expert giving the seminar or for the people participating. Also seminars very often are about or make use of specific software tools which require the use of a well prepared seminar room with the necessary hardware and software installed for this particular situation.

To save time and reduce costs of traveling, in our approach the expert and students meet in a TELEPORT session and are able to view teaching material, ask questions and have a seminar that provides the illusion of been in a seminar room together with other participants and face to face with the expert.

This is achieved by introducing a virtual projection wall that is mixed in the 3D model of the virtual rooms whenever that is necessary. This virtual projection wall is directly connected, for example, to the expert’s notebook. Thus the expert can choose what to show to the other participants, i.e. slides, pie charts or the way a software tool it’s been used. To demonstrate for example the use of BSCW the expert could open a workspace as shown in Figure 3.

The image from the expert’s notebook is textured-mapped onto a virtual projection wall. The projection wall is then combined with the virtual 3D room, rendered in real time and transferred to the other participants’ display rooms. The virtual extension room would then look like that of Figure 4. In addition, video imagery of the participants is also texture-mapped into a surface within the virtual rooms (Figure 5).

Figure 2 Remote Participant in Virtual Meeting Area

The current system uses a 3m x 2.25m rear-projected *video wall* attached to a 3m square room. The video-wall is driven by a pair of high luminosity video projectors. Both projectors can display mid-resolution video signals and high-resolution RGB signals. A *camera* is placed on a stand or a table and set at approximately eye height. The field of view is wide enough to take in a full upper body shot of the local participant. A *viewer tracking system* determines the position of the local participant within the display room, from which their viewpoint is derived. Two techniques are used for *segmentation* (for determining the regions of the video signal where a participant appears) chroma-keying and delta-keying.

The virtual extension is *rendered* from the viewpoint of a tracked participant located in the display room. Because this person is free to move within the display room, the virtual extension must be continuously re-rendered. Currently an SGI RealityEngine2 is used to achieve rendering rates, with texturing and full anti-alising of up to 25 frames per second. The video imagery of remote participants is combined with the rendered virtual extension (*compositing*). For audio, each participant wears a small microphone. The audio signals from remote participants are mixed together and sent to speakers mounted on either side of the video wall.

3.2 BSCW

The BSCW system is based on the notion of a 'shared workspace' which the members of a group establish for organizing and coordinating their work [2][3][4][14]. A shared workspace as realized by BSCW is a repository for shared information, accessible to group members using a simple user name and password scheme. A BSCW server (a Web server extended with the BSCW system through the CGI programming interface) manages a number of such workspaces for different groups and users may be members of several workspaces (e.g. one workspace corresponding to each project a user is involved with).

A workspace can contain information such as documents, images, links to other Web pages or FTP sites, threaded discussions, member contact information and more. The contents of a workspace are represented as information *objects* arranged in a folder hierarchy. Members can transfer (upload) information from their machines to a workspace and set access rights to control the visibility of this information and the operations which can be performed by others. Members can download, modify and request more details on the information objects by clicking on HTML links to request workspace operations from the BSCW server. After each operation the server returns a new HTML page showing the new state of the workspace (Figure 3)

Figure 3 A BSCW Shared Workspace.

Access to workspace functions is provided by the buttons at the very top of the page as well as the text HTML anchors below each object. The former operate on the current folder being shown, so that 'add URL' will return a HTML form for specifying the name and URL

technology for developing cross-organizational groupware applications. The W3 addresses problems of integration, allowing developers to focus on application details rather than complexities of different system configurations [2][5]. The W3 is the first real example of such a common infrastructure, offering huge potential to CSCW system developers, through:

- platform, network and operating system transparency,
- integration with end-user environments and application programs,
- a simple and consistent user interface across platforms,
- an application programmer interface for 'bolt-on' functionality, and
- ease of deployment facilitating rapid system prototyping.

In this direction, Groupware systems have been developed to support for example decision making, or document/information sharing and structuring.

AltaVista Forum is a structured storage and management area for office documents, accessible through the Internet with any standard browser [8]. Forum stores documents for universal access by team members or other authorized users, and permits annotations and discussions around the documents. It allows team members in different locations to create document-sharing processes and discussion forums.

WebEvent is a World Wide Web group calendar program which allows users to access event (calendar) information in a simple format. Users can access the information from any computer which is connected to the World Wide Web.

The WebShare suite of products allows companies to create customized groupware applications for internal teams using the infrastructure of the World Wide Web [26]. WebShare supports structured information sharing and management within an organization.

HyperNews is a package of software that supports conferencing on the World-Wide Web [17]. HyperNews lets readers add responses to existing WWW pages. Furthermore, responses to each of those responses are displayed to an arbitrary depth.

3. BACKGROUND

The primary goal of combining TELEPORT and BSCW is to provide an environment for co-working were geographically dispersed groups could not only meet as if face-to-face but also have support for preparing, carrying out and report after the meeting. A variety of tasks are performed by different members of the group during this process. Members of geographically dispersed groups might need to schedule meetings, prepare the agenda, prepare slides or documents that will be needed, generate reports and electronic documents during and after the meeting.

This section briefly presents the two systems that form the basis of our approach, which is then described in detail in section 4.

3.1 Teleport

Co-presence in TELEPORT overcomes some of the major limitations of the current desktop video conferencing systems, described in the previous section. TELEPORT mimics a shared physical context, using 3D modeling and rendering, and provides life-sized display of remote group members placed within a virtual space [6][12].

Figure 1 TELEPORT Display Room

The system is based around special rooms, called display rooms, where one wall is a "view port" into a virtual extension as shown in Figure 1. The geometry, surface characteristics, and lighting match the real room to which it is attached. When a teleconferencing connection is established, video imagery of the remote participant (or participants) is composited with the rendered view of the virtual extension (see Figure 2).

The viewing position of the local participant is tracked, allowing imagery appearing on the wall display to be rendered from the participant's perspective. The combination of viewer tracking, a wall-sized display, and real-time rendering and compositing, give the illusion of the virtual extension being attached to the real room. The result is a natural and immersive teleconferencing environment where real and virtual environments are merged without the need for head-mounted displays or other encumbering devices.

applications to collaborate in dispersed locations at a different time, etc.

	Same Time	Different Times
Same Place	Electronic Meeting Rooms Group Decision Support Systems	Shift work
Different Places	Video Conference Systems Chat Applications Audio (Telephony) Applications	Workflow Shared Calendars E-mail Shared Workspace Appl.

Table 1: CSCW Taxonomy

Current research in CSCW, however, suggests to overcome the boundaries between the different application areas [11][13]. It has been argued that often a working group currently working in an electronic meeting room, like [18], need to access data maintained for example, by shared group calendar tool. On the other hand, users of workflow system should have access to an audio application to get more information on an artifact from a collegue in a different room or department.

In this paper we focus on the integration of Same Time/ Different Places applications (namely Video Conference systems) with Different Times/Different Places Applications (namely Shared Workspace applications). In the literature these categories are also referred to as synchronous and asynchronous collaborative applications, respectively. In this section we collect existing synchronous collaborative applications mainly in the area of video conferencing and asynchronous applications that have been designed for the use in the Internet.

2.1 Synchronous Collaborative Applications

A variety of synchronous systems and research prototypes exist using metaphors such as the blackboard, or the desk for creating a shared working environment that resembles a physical desk or a blackboard.

LiveBoard is produced by a subsidiary of the Xerox Corporation and has a 67-inch, full-color, rear-projected display and is controlled by a standard MS-Windows based PC[24]. Users can draw on the screen, run Windows applications, or see other people at remote sites. The controlling software is called MeetingBoard and allows users to create and manipulate images with a wireless pen and the ability to link 31 sites together. If no video is required, then the Liveboards work across normal modem links - otherwise ISDN is required.

The HighRoad Demonstrator developed within the *EuroCODE* project [25] is based on Xerox' LiveBoard. focuses on the particular problem of reflecting the current state of a construction. Input by the user to the system is mainly through manipulation of a red light pen, which is monitored by an infra-red camera. Output of computer generated interaction dialogues and other images (including stored visual media) is through a projection of the computer screen onto the desk from a LCD projector mounted above the desk. Audio-visual links with other engineers can be established by pointing to the engineer's name with the pen.

ClearBoard[15] uses the metaphor of a transparent glass window. It provides eye-contact and a shared drawing space for remote collaboration between two users.

VideoWindow[23] uses a very high aspect ratio (8:3) video display, allowing for the impression of talking to and seeing people in an adjacent room through a window using a large display device.

DigitalDesk[22] provides a computer-augmented environment in which electronic images are projected onto a desk and onto paper documents. Interaction is done via pens or bare fingers and paper documents can be read into the system simply by placing them on the desk.

Currently there are also a number of commercial systems avialable. They are mainly built on top of low-bandwidth technology like ISDN or the Internet. The most prominent representatives are *ProShare* (Intel), *NetMeeting* (Microsoft) or *CUSeeMe* (WhitePine Software). They allow the transmission of low-resolution video frames along with a synchronised audio stream. As for the Internet based systems (NetMeeting, CUSeeMe) the quality depends on the bandwidth available. The ISDN-based systems (ProShare) allow for a better quality up to 20 frames/ sec. ProShare and NetMeeting both support synchronous sharing of applications like MS-Word or other Windows applications with a limited support for floor control. However, scheduling and preparing a collaborative working session requires additional means like e-mail or telephone.

2.2 Asynchronous collaborative applications for the Internet

With the wide spread adoption of the World Wide Web (W3) a number of applications have emerged that use the W3 as the basis for information sharing across widely dispersed working groups. Numerous studies pointed out the potential of the Web as an enabling

systems on there own do not reflect the complexity of cooperation processes. Asynchronous tools do not require participants to be present at the same time. Therefore, group members could prepare artifacts according to their individual schedules. However, discussion on these artifacts or group decision making require the support of synchronous tools.

In local working groups, the lack of synchronous collaboration support in asynchronous CSCW systems, can be easily overcome by social interaction. However, this is not the case for widely dispersed working groups. Social interaction becomes more difficult and must be supported by appropriate collaboration facilities. Although desktop video-conferencing or electronic meeting systems address such situations, it is still recognized that there are many situations were face-to-face meetings are essential [19][20]. In situations, such as distributed negotiation, conflict resolution meetings or remote seminars and teaching, body-language and eye contact become important. Ideally, in such situations, we would like to provide geographically separated group members with a sensation of being in the same room at the same time and meeting face-to-face. This is what is called “co-presence”.

Current CSCW use of desktop video-conferencing provides limited degree of co-presence mainly due to three deficiencies: loss of shared physical context, differences of display size and body size, and difficulties in establishing eye contact and gaze awareness. Furthermore, the lack of adequate bandwidth limits the use of current sychronous collaboration applications via the Internet. Current intercontinental links shared by a large number of users are not sufficient to support the quantity and speed requirements of video-audio applications. Even today’s ISDN technology does not provide the necessary degree of co-presence to support synchronous collaboration tasks sufficiently.

Modern ATM technology provides the bandwidth required to support a rich set of interaction facilities. Full body video transmission can be set up while projecting virtual backgrounds, artifacts and other information necessary to provide the participants in the cooperation process with sufficient knowledge at the same time.

A synchronous collaboration system that provides high degree of co-presence is TELEPORT [6], developed by GMD-VMSD. In addition, TELEPORT integrates several key features, such as: a semi-real, semi-virtual meeting space, a wall-sized display supporting mono and stereoscopic viewing, viewer tracking and real-time rendering, compositing of video-textured surfaces within 3D geometric models.

However, TELEPORT sessions are expensive and must be carefully prepared. Thus an agenda of the co-presence session must be agreed on in advance including the participants of the meeting. Artifacts needed for the co-presence session such as documents, spreadsheets, tables etc., should also have been prepared prior to the meeting.

The preparation process might involve participants from different organizations in different locations. For the preparation phase of the co-presence meeting we decided on using the BSCW Shared Workspace system [2][3][4]. BSCW (Basic Support for Cooperative Work) is a system developed by GMD.FIT, which provides support for cross-platform information sharing for groups of users over the World-Wide Web. The basis of the system is the BSCW shared workspace system - a centralized shared information system integrated with an unmodified Web server and accessible from standard Web Browsers.

To make the prepared artifacts available in the co-presence session we were investigating how a Shared Workspace might be integrated into the TELEPORT system. The approach presented in this paper provides support for co-working before, during and after the co-presence session. Once the preparation phase is completed, group members from different sites are ready to meet in the TELEPORT display rooms in each site. In our approach, during the co-presence session information in the form of electronic documents, presentation material and shared workspaces is displayed on a virtual projection wall which is blended together with video imagery from remote participants into the virtual extensions of the display rooms.

The following sections give an overview of systems that provide similar functionality and then briefly present the two developed systems, namely TELEPORT and BSCW. Furthermore, our approach for co-presence and co-working is described in section 4 by the use of two examples, the distributed seminar and distributed meeting cases. The technical approach is also given at the end of this section. Finally, section 5 concludes this paper.

2. RELATED WORK

Applications to support the collaborative work in working groups integrate information processing and communication activities. Following [16] we can roughly divide these applications depending on time and space categories (Table 1:). So called SameTime/ Different Places applications allow members of the working group to collaborate in dispersed locations at the same time, Different Times/Different Places

Co-presence and Co-working in a distributed office

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Abstract

Today's technology and advances in telecommunication rapidly change the way business is carried out, making it a globally distributed and thus a more electronically-based process. Support for interaction, coordination and group work in the emerging distributed businesses should be adapted accordingly, both in terms of the way it is carried out and in terms of the tools used. CSCW systems, video-conferencing and electronic meeting systems, facilitate the process of preparing and carrying out meetings, and at producing material via a group effort in a distributed business. However, the limitations of desktop video conferencing are clearly revealed when body language and eye contact become important. In this paper two systems, namely TELEPORT and BSCW, are integrated in order to provide support for co-presence and co-working. TELEPORT is an experimental teleconferencing system aimed at enabling small groups of people, which are geographically separated, to meet as if face-to-face. The system "merges" real and virtual environments, and by the use of wall display surfaces and viewer tracking provides the sensation of a face-to-face meeting. TELEPORT developed at the Visualization and Media Systems Design Group of GMD, by S. Gibbs, C. Breiteneder, and C. Arapis [6]. The prototype has been used in various applications areas including teleteaching, where teaching material has been incorporated within the merged real and virtual environments. The BSCW system, developed at GMD FIT group, provides basic facilities for collaborative information sharing, activity awareness and integration of external applications for a variety of platforms over the World-Wide Web [2]. In the approach presented in this paper, the BSCW system is used for preparing and changing any material necessary for a TELEPORT session and most importantly for supporting the brainstorming, structuring and evaluation of ideas during the session. Real-time composition of live-video, synthetic backgrounds and electronic documents is then projected on the wall-sized display of TELEPORT.

1. INTRODUCTION

The worldwide nature of today's market has forced many companies to decentralize their organizational structures. Optimally tailored working environments are required for computer-supported cooperative work. One stream is to provide real-time collaboration tools to geographically dispersed teams in order to facilitate meeting support. Often the situation arises that a person working on a business process needs external help or expertise to fulfil the task. As of today the person will try to phone the expert or at best have a desktop conference with audio-visual connectivity plus the use of shared documents. Several desktop video conferencing systems have been described in the literature [1][5][7][21] and commercial products are available. In addition, a variety of groupware is used to support the increasingly complex and elaborate business processes of today's organizations [18][10][9].

In a distributed business there is an equal need for support for group work. However, the definition of a group or a meeting is somewhat broader than that of a non-distributed one. In particular, group members might be geographically separated, resulting a different-place same-time (synchronous), or different-place different-time (asynchronous) group working situations. Recently there has been a shift in focus, in CSCW research, towards systems which support both synchronous and asynchronous collaboration. As argued in [13] synchronous and asynchronous CSCW

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