Perspective Layered Workspace for Collaborative Work

Hidekazu Shiozawa   Jun-ya Noda*   Ken-ichi Okada   Yutaka Matsushita
Department of Information and Computer Science, Keio University
3-14-1 Hiyoshi, Kohoku-ku, Yokohama, 223-8522 Japan
Email: {shiozawa, okada, on}@mos.ics.keio.ac.jp

Abstract

Visual shared workspaces for synchronous groupware will be always staying on users' screens in the near future. Users will be moving frequently between their personal spaces for personal and asynchronous work and shared spaces for communication and synchronous cooperation. For supporting such situation, this paper proposes a new technique to visualize workspaces as a set of layered virtual screens in pseudo-3-dimensional graphics. In this way, groups' shared workspaces are shown as background of users' personal workspaces like as looking from a top personal layer down to a bottom public layer. This 3-dimensional perspective visualization is also suitable for transmitting everyday awareness. Therefore, the visualization has potential to be the user interface of integrated groupware platforms.

1. Introduction

Computer supported cooperative work (CSCW) will be brought into your everyday working styles in the near future. Nowadays many workers are already working on their personal computers, and the computers are connected with high-speed networks. After this, such networks will become more high-speed, then usually you will be using some video conferencing system for a bit of communication, and documents and materials will be managed in shared databases, which may have some graphical interfaces.

As CSCW or groupware systems become widely used in your everyday work like this, evolutions of user interfaces towards supporting such situation will also be required. In this situation, two types of software can exist simultaneously on your computers: personal application software already used for many years, and groupware supporting cooperation and awareness in various new ways. We think that these two types of software should be distinguishable from

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* Working for Sony Corporation since April 1999.

each other, and should also consist seamless and integrated environment for usability.

In order for users to share their information and transmit their own awareness, synchronous groupware realize visual shared workspaces established on the display areas of computer screens [4, 9]. Such shared workspaces, which are often implemented with windows of GUI (graphical user interface), may hold some shared documents and shared canvases, then the system allows multiple users to access those shared information synchronously, and make aware of other participants' behaviors with some visual effects.

In the future, visual shared workspaces will be always staying on your desktop. You will be working in your private spaces for personal work, while working in shared spaces for synchronous collaboration and communication. So, you will move between these two kinds of spaces frequently. This paper proposes a new information visualization technique for such environment of groupware systems.

2. Visual Shared Workspaces

Previously in order to realize synchronous groupware, sharing of two visual workspace methods in Figure 1 have been widely used [1, 3, 5, 10, 16, 19].

Figure 1 (a) illustrates a type of tiling method. This type of method shows both user's personal workspaces and shared workspaces simultaneously by dividing a screen or
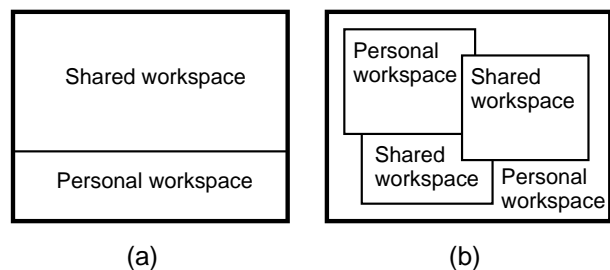

Figure 1. Conventional techniques for visual shared workspaces: (a) tiling (b) windowing.

a window to several regions. However, in this way, quite a large area is used for showing a shared workspace, so the size of the personal workspace is very restricted.

Although this method can be adaptable for the applications that need to show shared workspaces only on users' request, this is not suitable for the situation of our proposal: the new collaborative environment which shows shared workspaces always staying on users' screen and thus enables users to be aware of co-workers' everyday activities.

On the other hand, Figure 1 (b) illustrates a type of (over-wrapped) windowing method. In this way, each shared space, or application software, are individually shown as a single window. Therefore, each window can be moved freely by users, and personal spaces and shared spaces are completely integrated and thus become seamless.

This method, however, may bring some confusion to users, since traditional personal applications and new collaborative applications are hardly distinguishable. For example, you may configure privacy settings only concerning your personal workspace, but it can be difficult for the system to provide visual interface of intuitive configuration in such a completely seamless visual aspect.

Thus workspaces should be divided according to sharing levels of information, like real world offices that consist of private spaces, such as workers' private rooms, and public spaces, such as meeting rooms and library rooms. Such spatial division and visual effects are considered very comprehensive to provide users' security and privacy [8].

3. New Workspace Visualization

In this section, we propose a new visualization technique to show shared workspace intelligibly. This new visualization shows multiple workspaces as layered virtual screens, and it is inspired from the layered architecture of CSCW data management.

3.1. Multi-Layered Architecture

Before describing our new proposal on workspace visualization, we describe the layered architecture of CSCW management, which we have proposed in [15, 20], in order to realize an effective management of the resources in collaborative work environments. In the architecture, collaborative workspaces are in forms of multi-layered structures.

In collaborative work environments, there generally exist personal resources, which is related to individuals, and workgroup resources, which is shared by group workers. More generally speaking, a workgroup may belong to a bigger workgroup, so these relationships can construct a kind of hierarchy.

Although users are often working in their personal workspace, they sometimes need to refer to information also
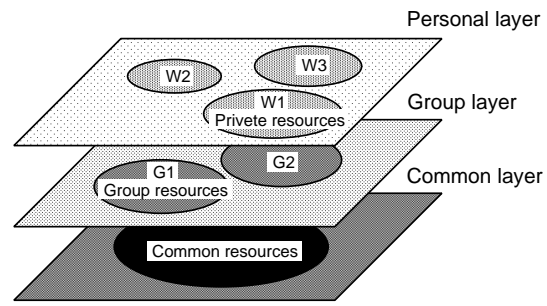

Figure 2. Multi-layered architecture.

in the workgroups that they belongs to. Moreover, they may need to refer to the information also in larger groups that their groups belong to. For simplifying the problem, hereafter, we go with the example of this three-leveled layered workspace and call each layer, respectively, personal (private) layer, group layer, and common (public) layer.

From these considerations, collaborative workspaces can be represented as multi-layered structures like as in Figure 2. In this architecture, layers are virtual locations to manage resources in a CSCW system, and it can be considered that there may be several layers in a system. Private resources and shared resources that we mentioned earlier exist on a personal layer and workgroup layers respectively. Of course, like relationships of workgroup resources, some workgroup layers can belong to common layer.

3.2. Perspective Layered Workspace

We propose a new visualization technique based on the conception of the layered workspace. This method visualizes a workspace from the viewpoint of each worker in Figure 3 that it constructs visualization like as looking from a top personal layer down to a bottom public layer. In this
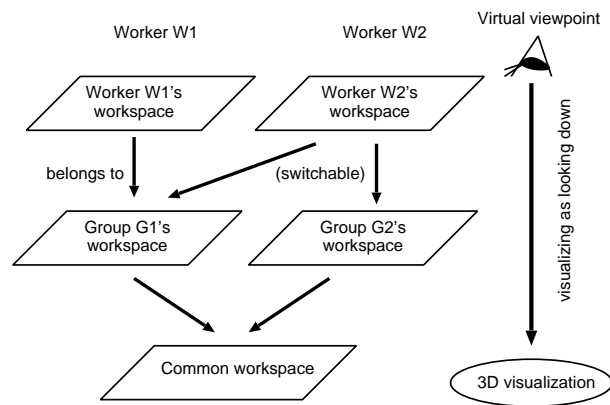

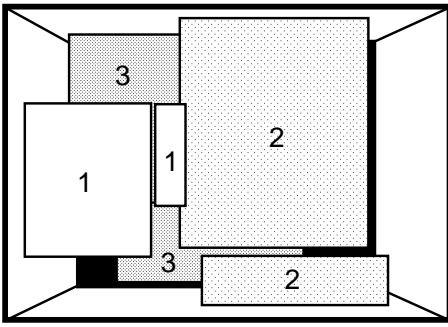**Figure 3. The conception of visualizing multi-layered workspaces.**

Figure 4. The perspective layered visualization; 1: on personal layer, 2: on group layer, 3: on common layer.

visualization, personal application software, which are most frequently used, are shown in front position on the screen, while software supporting group work are shown behind the personal ones. Therefore, the multi-layered workspaces are shown as layered virtual screens in 3-dimensional display (Figure 4).

In other words, this visualization utilizes the visual parameter of depth on a screen for representing the sharing level of information, since the more widely shared information are visually located on the further positions from users. Although it is considered a 3-dimensional visualization, it can be implemented with pseudo-3-dimensional graphics using combination of shrinking and overwrapping of screen images.

Displaying information that is frequently accessed or referred by users at successively closer positions is a known technique of 3-dimensional information visualization [6, 17]. In that field, various methods for showing information spaces on limited sized screens have been proposed. In 3-dimensional visualization, the perspective technique is mostly utilized for representing degrees of reference and interest [7, 13, 14], and the visualization that we propose also utilizes it. Personal workspaces will be more referred and manipulated by owners than shared workspaces, so it is natural to visualize personal information closer than that of group.

3.3. Supporting Awareness

The conception of degrees of reference and interest and its utilization for information visualization are found to be useful for transmission of users' awareness information. The awareness is, in the field of CSCW, a conception of being unconsciously aware of other person's behavior and activities. Awareness often naturally brings about conscious communication.

In synchronous groupware, like environmental informa-tion of the real world, transmitting users' awareness information with proper intensity is effective for collaboration and communication [11]. In the real world, when users are centering on something important, they might not be aware of others' gazes or auras. Furthermore, bulletin boards or televisions in public spaces are showing such background information in relatively weak intensity.

The visualization that we propose is very suitable for purpose of such awareness transmission. It applies the conception of degrees of reference and interest to show users' awareness. The conventional visualizations show shared information only when users request. We propose the visualization that can show shared information and their modification always in the background (indeed as screen background).

3.4. Traveling in 3D Workspaces

A worker often belongs to more than one workspaces including the personal space and at least one group workspace, so generally workers may belong to several workgroups simultaneously. CSCW environments should support users' intelligible switching from one workspace to another, and in the user interfaces of visual shared workspaces, the switching operation should be done also with visual and graphical operations.

In our perspective visualization, users are able to intuitively change workspaces with 3-dimensional moving operations such as forward, backward, rightward and leftward movement from their positions. We think that these operations are very intuitive for users, because, on their screen, these operations can be performed with effective visual feedback.

As the Figure 5 shows, when users want to mainly deal with their group level information, they may move forward in the 3-dimensional space. Then, their personal workspaces become invisible on computer screens and the group workspaces are shown on top of screens. Thus, it becomes easy for users to deal with the group level information. Furthermore, users can move more forward for dealing with public workspaces, and backward for their personal spaces again.
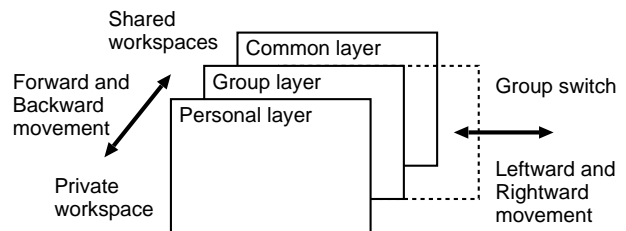
Also in the visualization, 3-dimensional rightward and

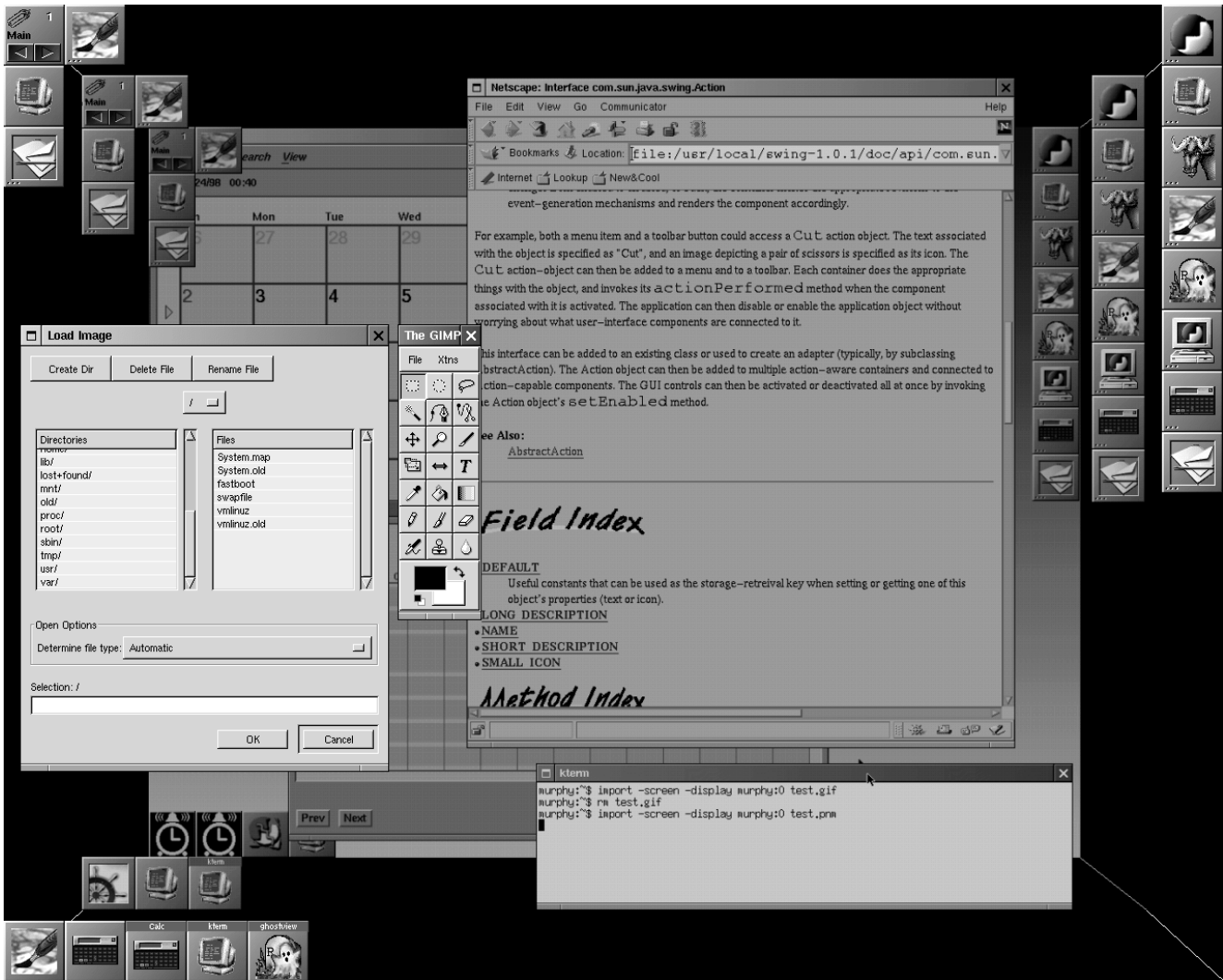**Figure 5. 3-dimensional moving operations.**

Figure 6. Overview of the system.

leftward shifts of users are metaphors of switching group workspaces that they belong to. Users can visually change workspaces with these 3-dimensional moving operations.

4. Implementation of the Prototype

In order to examine the availability of the pseudo-3-dimensional workspace visualization illustrated above, we have been developing the system based on this conception [18]. This section describes the implementation of the software with several screen images.

4.1. Overview of the System

Figure 6 shows an example of how the system is used. In this example, there are two layers of shared spaces, workspaces for a group and for all groups, behind the

layer of the personal space. The personal space exists on top of the screen and transparently occupies the entire screen, and the shared workspaces are shown in perspective according to their sharing levels. Figure 4, mentioned above, also shows in which layer each window exists in Figure 6. An image processing software (GIMP), a web browser (Netscape) and a calendar software (Plan) are being launched respectively in the personal workspace (top front layer), the group workspace (middle layer), and the workspace shared by all groups (bottom layer).

4.2. Visualization Techniques

In Figure 6, the entire image represents a personal desktop screen and also an image of computer screen itself. In other words, the most front layer (personal workspace) is realized with conventional window systems of GUI. Group

workspaces are shown as virtual root windows, or background wallpapers, of personal workspaces, that is, the system draws some another window systems in the virtual root windows repeatedly.

As well as in the top private layers, the system allows users' transparent windowing operation in background group layer by forwarding system events such as mouse operation to the virtual root windows. In addition, since windows in group workspaces are shared objects of all users who belong to corresponding groups, any user connected via network can also perform windowing operation such as opening and moving.

In this implementation, group workspaces are drawn 7/8 smaller and 20% darker than personal workspaces, by processing image of virtual screens in memories, and more, common workspaces are drawn, as well, 7/8 smaller and 20% darker than group workspaces. These visual effects enable users to comprehend in which workspace each window is shown.

Although recursive layering of workspaces more than three levels are even possible in the implementation, such excessive visualization is probably not meaningful for ordinary users.

4.3. Operations in Workspaces

Moving operations in 3-dimensional spaces for intuitive switching of workspaces have been also implemented. If a user wants to go forward from his personal space to a group workspace, the user may move the mouse pointer to a top edge of the screen and click the button, then the user can move to one more deeper layer. Similarly, if a user wants to go backward to personal workspace, the user may click bottom edge of the screen. Furthermore, if the user has more than one personal spaces or belong to more than one workgroups, the user may click right edge or left edge of the screen, to move between the workgroups of same level.

Users can also transfer images of individual application windows among workspaces, so they can put copied images of windows in their private workspace onto group and public workspaces. By this feature, the system provides a way for users to bring out their private windows for others, and to put the copy of public information on their personal spaces.

We have also developed the device that displays windows only with their frameworks to provide capability for users to view other windows hidden under large windows (Figure 7). Occasionally users need to refer to documents in group workspaces, which are hidden under the personal windows. In this case, users can change windows framework shapes with an operation like iconification.
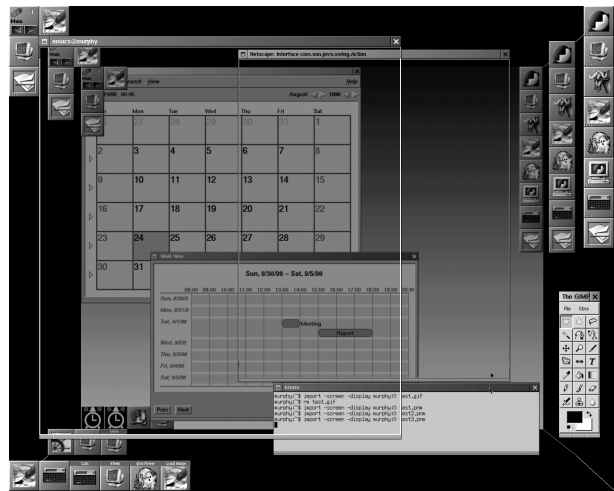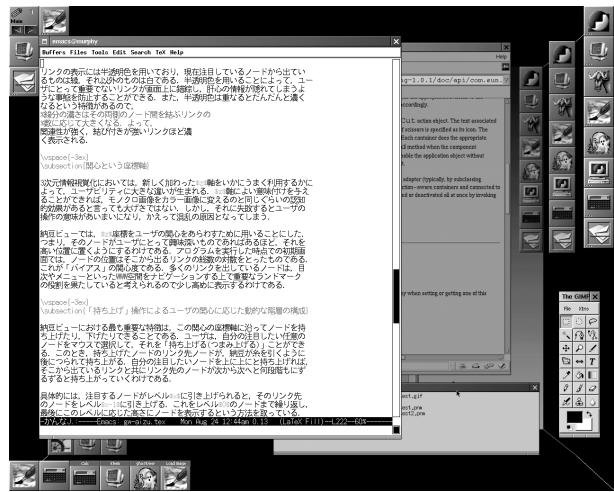

Figure 7. Framework windows for referring deeper layers.

4.4. Platform and Utilized Software

This software is developed on the UNIX client of VNC (Virtual Network Computer) [2], which is a multi-platform screen sharing program. VNC can transfer the desktop images of window systems, such as X Window System (X11) and Microsoft Windows, and provide a network-transparent operation environment, so the software also supports various VNC features.

We also utilized Window Maker [12], a window manager of X11. We have modified it to realize framework windows with the X11 shape extension. Users can enable this feature by selecting the new item "Skeltonize" in each window's menu.

In addition, we implemented individual programs such as copying images of windows between different X11 screens, displaying certain window image as a screen saver,

and opening documents in its proper workspace.

5. Future Work

At this point, the system provides basic information sharing mechanism and visualization of workspaces. We plan the following work to realize an integrated environment for collaborative work.

Providing New Application Software: Now, the system provides an environment to show existing X11-based application software. We will develop new application software for utilizing the various techniques that we have proposed more effectively.

Toward an Integrated Groupware Platform: Moreover, we want to adapt a database engine based on the layered architecture to this system. This will realize an integrated groupware platform covering form database to user interface. Thus, usability evaluation in the real environment will be possible.

More Intelligible Operations: It is needed that simpler and more intelligible operations to movement in the workspaces, to select and launch application software, and various interactive operations.

Improvement of Performance: The loads of image processing to make the perspective visual effect and screen image transfer on networks cause sometimes uncomfortable behavior. So, we are continuously improving the software performance.

6. Conclusion

This paper has described a new visualization technique that copes with the problems of visual shared workspaces on conventional synchronous groupware. The visualization shows shared workspaces as layered screens of window systems in perspective 3-dimensional graphics.

In the near future, shared workspaces for collaboration will be always staying on users' computer screen, and users will be working in their private spaces for personal work, while working in shared spaces for group work. The visualization enables users to frequently move among several workspaces that they belong to.

The visualization is also suitable for supporting various everyday awareness. It applies the conception of degrees of reference and interest to show users' awareness, and can show shared information and their modification always in the background. Therefore, the visualization has potential to be the user interface of integrated groupware platforms.

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