ContextWall: A multi-user workbench for independent work, peer-to-peer interaction, and whiteboard collaboration

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ABSTRACT
ContextWall is a Single Display Groupware system based on the focus plus context screen architecture. The display consists of multiple high-resolution computer screens that are seamlessly embedded into a larger projected display. ContextWall supports three different collaboration styles. First, the embedded hi-res displays allow users to use the system for independent work. Second, users can interact peer-to-peer by acquiring material from or dropping material into the other user's portion of the workspace. Third, ContextWall provides the large display required for electronic whiteboard interactions. ContextWall offers many of the properties offered by wall-size hi-res screens, but at lower hardware effort. This paper discusses implementation issues and first experiences with ContextWall.

Keywords
ContextWall, CSCW, focus plus context screen, single display groupware, electronic whiteboard.

INTRODUCTION
The majority of electronic whiteboard systems, such as i-LAND [6], make a clear distinction between group interaction and private work. Group interaction typically evolves around a common electronic whiteboard, while private work typically takes place on the individual users' personal machines. Some researchers have questioned this distinction. Augmented Surfaces [4] allow notebook users to reach into a shared virtual space using their mouse cursors. Single Display Groupware (SDG) generalizes this concept by providing multiple users with input devices to the same computer, allowing them to simultaneously interact with display content [5]. The increased screen space requirements resulting from such interactions may be satisfied by wall-size hi-res displays. However, currently available projection array-based systems (e.g. [3]) are too costly and space-intensive to make their way into widespread use.

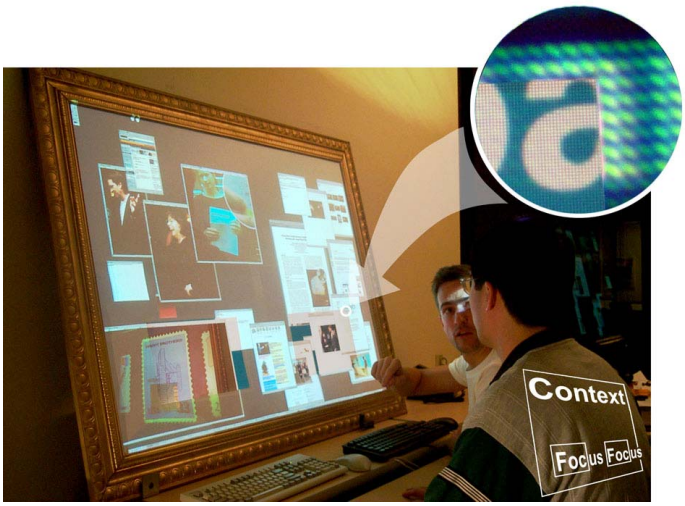

Figure 1: ContextWall prototype. The iconic illustration (bottom right) shows the location of the two embedded focus screens. The callout shows the different resolutions of focus and context areas.

CONTEXTWALL
ContextWall is a new type of SDG system offering personal space for independent work, shared workspace for SDG work, and large display space for electronic whiteboard collaboration. In order to achieve this, ContextWall extends the concept of focus plus context screens [1] into the multi-user case.

Figure 1 shows our ContextWall prototype for two users that is currently installed in an office at Xerox PARC. The display consists of two hi-res *focus displays* that are seamlessly embedded into a low-res *context display*. The context display is implemented using a projector located behind the users and a projection surface made of foam core. The prototype runs a single instance of Linux across the entire display. Customized software (see Implementation section below) is used to display screen contents, such as windows, across focus and context regions, such that the scaling of content is preserved, although its resolution varies (see callout in Figure 1).

Both users have their own keyboards, mice, and mouse cursors. Mouse cursors can move across the entire display plane, including the context area and the other user's

focus display, and they can be used to manipulate content anywhere, e.g. to drag windows around.

Implementation and Limitations

The setup uses one PC to drive each focus display. These PCs are connected to a networked Linux server that runs VNC server (http://www.uk.research.att.com/vnc) to create a shared frame buffer that includes both focus areas and the context area. VNC viewers on these PCs are used to create the focus images and the reduced context image. Details about the display hardware and the VNC setup can be found in [2].

Each user's mouse drives its own VNC mouse cursor, but since Linux supports only a single mouse cursor, users have to take turns when providing input. Users have to click their mouse in order to make their VNC cursor control the Linux cursor. We opted for this limited functionality in order to rapidly obtain a prototype that would allow us to experiment with this new display concept. We plan to overcome this limitation in our next prototype that will use the Beach software [6] instead of Linux.

INTERACTION BETWEEN USERS

In the short time we have run our ContextWall, we used it to experiment with several activities, reaching from independent work to more collaboration-oriented activities. Figure 1 shows a scenario involving two users cooperatively designing a web site. The left user works on the graphic content of the site, selecting, editing, and combining image material. The right user writes text, formats web pages, and creates the link structure of the site. These activities are reflected by the distribution of visual material and applications on the screen. Image material and image processors are arranged surrounding the graphic designer's focus screen; Web browsers, text and html editing tools are primarily found in the other half of the screen.

During their work on the website, the two users undergo different modes of cooperation.

Private mode: When creating content, both users are working primarily on their own. In this mode, the ContextWall works very much like two independent focus plus context screens. The additional context space allows users to work on large visual documents, it provides users with orientation and context, and it also allows users to keep an eye on email and to-do lists located in the user's periphery.

Peer-to-peer mode (asynchronous interaction): When a user requires help or finds material relevant to the other user, both users can engage in peer-to-peer interaction. In this case, users may reach into the other user's focus space to acquire content, they may drop material into the other users' focus space, or they may drop material into the periphery of the other user to provide the material without interrupting. Exchanging material generally does not require duplicating any content or starting an application; instead, users will typically hand over the application window holding the respective material.

Group mode (synchronous interaction): If additional users join the discussion, participants may move away a step from the display in order not to block each other's view. Readability is then achieved by resizing windows and scaling window contents, as supported by the zoom function in the applications we used, e.g. Star Office.

DISCUSSION AND FUTURE WORK

Despite the fact that ContextWall is a patchwork of multiple display units, we experienced the resulting display as straightforward and easy to use. One reason is that individual display units are integrated seamlessly. Another is that the ensemble of all display units behaves like a monolithic display—the behavior of both windows and mice remains unaffected by the differences in resolutions. Since interactivity between users is achieved by unifying all users' workspaces, the sharing of displayed content and the access to other users' content becomes intuitive and the transition between personal and interactive modes becomes smooth.

In addition to being a collaboration system, ContextWall lends itself well to individual use. A single user may use the whole ContextWall as a large personal workstation display—ContextWall then works as a blend of focus plus context screen and multi-headed display. Other users can join anytime as switching to collaborative is straightforward. Logged-in users can simply move their windows aside to make space for joining users, very much like cleaning up a physical workbench or conference table in order to make space for new arrivals. By distributing display space only among logged-in users and by allowing users working on space-demanding tasks to claim larger pieces of the shared display space, display resources are exploited effectively at all times.

We plan to study interaction behavior in more detail as soon as we have the Beach-based version. We also plan to experiment with different form factors including table-like arrangements.

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