Teamspace: A Simple, Low-Cost and Self-Sufficient Workspace for Small-Group Collaborative Computing

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ABSTRACT
Most current interactive group workspaces are prohibitively expensive and difficult to install and use. At the same time, the demand for such spaces is rising dramatically along with the increasing number of electronic media-based meetings, presentations, projects and papers. Teamspace is a prototype for a public interactive workspace designed to be easy for novice users to understand and learn. It addresses the challenges of economics, installation, recovery, robustness and reliability in a way that simplifies and empowers the group work user experience.

Categories and Subject Descriptors
H.5.3 [**Group and Organization Interfaces**]: Collaborative Computing

General Terms
Design, Economics, Reliability, Human Factors.

Keywords
Interactive workspace, group work, user experience, ubiquitous computing, collaborative computing.

1. INTRODUCTION
In many environments, such as universities, we have seen a stark departure from the marked dependence on public computing resources prevalent just five or ten years ago. Widespread individual laptop ownership has fundamentally changed how individuals collaborate, transforming the notion of a public computer space from that offering computer access to one that provides group workspaces involving a number of diverse devices, operating platforms, software applications and media. The challenge is to provide interactive support for collaboration among team members using data and computing resources on separate computers working together on a single document, task or application.

Building further on our previous Interactive Room Operating System (iROS) [2,5], we have developed Teamspace, an innovative server-driven laptop workspace. Teamspace facilitates collaboration through one or more large displays visible to all group members, representing the notion of a "public desktop," together with two iROS components, PointRight [3] to control the public desktop from any connected laptop computer, and Multibrowse [4] for filesharing, all in a relatively simple software program that is easy to both install and use.

2. HOW iROS FACILITATES COLLABORATION
Efforts at collaboration using traditional computing paradigms typically result in one of two outcomes: 1) group members crowd around a single computer where only some can reasonably view the screen and only one can control the input devices, or 2) group members divide the workload, then proceed to work in isolation on their own computers, sending results to a single person designated to compile the disparate results. Neither of these real-life group situations is optimal for effective teamwork. In contrast, an effective system provides both shared and private spaces. IROS achieves this with the following:

(a) *Event Heap*. A general framework for managing events.
(b) *PointRight*. Pointer redirection that allows a pointing device on any machine to serve as a pointer on any other. In the context of Teamspace, PointRight is used to control the public desktop from any connected laptop computer.
(c) *MultiBrowse*. Multibrowse enables any file or URL from one machine to be actively "pushed" onto the display of another.

3. TEAMSPACE: EMPOWERING THE USER EXPERIENCE
The original iROS and other existing solutions for group work require extensive and expensive installation and maintenance by technical staff, which can be a prohibitive overhead for widespread adoption. Teamspace builds upon the iROS framework, packaging key components in a simple, easily configurable, cross-platform end-user application requiring little or no technical administration or maintenance.

3.1 Installation and configuration
The experience of installation is designed to be straightforward and simple. Users follow step-by-step instructions on how to connect to the Internet via wireless or wire connection, then download the Teamspace software. No user-specific configuration is required, and once installed and running, Teamspace adopts a familiar instant messenger window metaphor displaying the names of all connected laptops.

3.2 Multibrowse
Multibrowse serves as the link for data sharing from public to private, and vice-versa (see Figure 1). Implicit, of course, is the assumption that receiving machines have the appropriate applications necessary to read or modify files; MultiBrowse merely allows the sharing of data.

3.3 PointRight
PointRight enables connected laptops to control the mouse pointer of the public computer. Individuals can gain control of the group screen by moving their laptop mouse pointers beyond the top of their laptop screens, causing the pointer to reappear on the group display. Because there is only one mouse pointer per group display, Teamspace users must rely on social protocols to resolve pointer contention. In practice, this has not been problematic and in fact fosters increased communication.

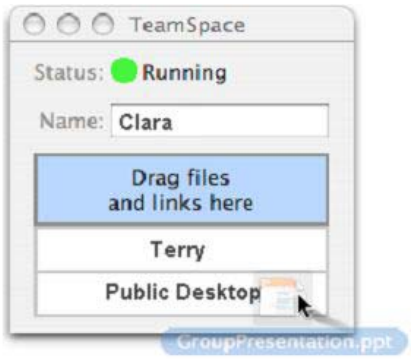

Figure 1. Dragging and dropping file or URL icons into the Teamspace window will cause them to be multibrowsed to the corresponding destination machine, which may be one of laptops connected to the space or the public desktop itself.

3.4 Sessions and security

Open casual public workspaces such as Teamspace require security and access control that does not require pre-registration and yet prevents unwanted incursion or snooping. The key element is physical co-location: people who are in the space should have access, while those who are not currently there should not. We address this through two mechanisms: line-of-sight login and session expiration. In the current setup, a person wishing to log in to Teamspace provides a user name, then must type in a password generated by the server onto the group display, thereby restricting login to people in the space. Once a session ends, rights are revoked, so users who have left a space will no longer have access in a new session. As with cursor control, we need only simple mechanisms, together with social protocols.

4. USER STUDIES

In order to learn how casual users utilized Teamspace, we conducted two types of user studies on fifty undergraduate students representing a wide range of technical and non-technical majors, all with no prior experience using iROS:

i) "Random." Teams of three to four paid volunteers were arbitrarily formed and given a specific group task
ii) "Existing." Previously formed student teams working on real, existing group projects for courses, student clubs, etc.

Figure 2. In total, five student teams participated in each study mode. All sessions lasted between one and two hours, were observed by the researchers, as well as videotaped. In general, participants found Teamspace understandable and easy to use.

4.1 Random Groups

We were surprised at the quantity of time participants spent offline, getting to know one another and formulating ideas verbally. Users tended to work relatively independently, only collaborating at the beginning (to divide the work) and end (to compile the work) of the study session. During these moments of collaboration, they tended to multibrowse to the public desktop (and not each other) only. In general, PointRight was used by a single individual assuming responsibility for compiling the group's work; often, which individual would play this role was determined by pointer contention that ensued early in the session.

4.2 Existing Groups

Participants from existing groups, sharing a common external purpose and already familiar with one another, were much more apt to collaborate, not only on the project at hand but also in learning the Teamspace technology. These users tended to multibrowse throughout the session both to the public screen and to one another's laptops. One unexpected result was that multiple sends from different sources sometimes resulted in loss of information or communication.

These participants felt considerably more comfortable vying for the group screen pointer, resulting in increased collaboration on the group display and a more frequent switching between private and public workspaces.

5. FUTURE WORK

From the prototype and preliminary rounds of user studies, we have identified several additional issues that need to be addressed with regards to session boundaries, additional Teamspaces located within the same network (configuration), multiple group displays, and ease of server installation. We hope to delve more deeply into questions of how people utilize shared versus private spaces, or how multiple displays can be leveraged for greater context and collaboration. Future user studies may investigate specific group work tasks such as pair ("extreme") programming, joint writing, and small-group teaching. Finally, we would like to note that a third-party, the ETH Swiss Federal Institute of Technology Zurich, became interested in the technology and have successfully run Teamspace at their location.

6. ACKNOWLEDGMENTS

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