Collaborative Virtual Environments for Analysis and Decision Support

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The virtual office has been a dream for decades. Computer supported collaborative environments move us toward this vision by providing services such as integrated desktop conferencing, shared applications, and workflow management. They have been successfully applied to distance learning and collaborative design. In this article we report on the successful creation and application of a place-based virtual collaboration environment [1] for distributed analysis and collaborative planning in mission critical environments for intelligence and defense. We describe a set of collaboration object services inspired from this experience. We outline empirical evaluations of the system's impact in two domains, the two largest virtual environments in the US government. We conclude by describing lessons learned from these experiences that might facilitate successful future deployments.

CVW and JCS

Figure 1 illustrates the elements of the Java Collaborative Virtual Workplace (CVW) used for distributed analysis and collaboration planning. CVW, available via open source (cvw.sourceforge.org), provides an integrated suite of facilities that enable synchronous and asynchronous collaboration, including text chat, audio and video conferencing, shared whiteboard, and shared and private data spaces. CVW provides persistence of sessions via recording user interactions as they occur within the context of shared virtual rooms. Drawing upon the lineage of Multi-User Dungeons (MUDs) and incorporating the MUD Object Oriented (MOO) Client Protocol (MCP), CVW provides location independence and transparency as well as a room metaphor to support context management. Elements of CVW's design have found their way into government systems (e.g., Odyssey Collaboration Services[1]) and commercial products (e.g., Ezenia!'s InfoWorkSpace[2], Collabraspace Rooms[3]). A Palm CVW client provides wireless access to the virtual space. A secure version encrypts client/server communications as well as audio conferences to provide the kind of security necessary for sensitive interactions among globally distributed work teams. Akin to Redhat-like services provided for Linux, a CVW Consortium has been formed by industry to provide product support[4].

To facilitate reuse and dissemination of place-based collaboration facilities, we have generalized the original services of CVW to create the Java and CORBA-based Joint Collaboration Services (JCS) [2]. In our research and pilots, we have discovered that three important abstractions are central to all collaborations: *conference*, *context*, and *participants*. These three elements are explicitly represented in the JCS software (jcs.mitre.org), an open source toolkit for creating collaboration environments. In JCS, contexts are the persistent, objective focal point for organizing activities (including conferences), participants (human and software), information, and applications. Contexts typically contain a list of participants, a conference manager, and a folder of user-published objects. An example of a context is a virtual room with users, documents and tools. However, many items can serve as contexts including a joint plan, a process, or an organizational element. Conferences are defined by a roster of participants, their roles, and means of communication (e.g., multicast audio/video/text). Role-based access control regulates the ability to join a context or conference. It also controls the ability to manipulate participants or artifacts within them. Participants are either human or software agents with particular roles (e.g., administrator, facilitator, expert) with associated rights within particular contexts. To promote standardization, an Object Management Group (OMG)

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[1] atticus.spawar.navy.mil/odyssey

[2] www.infoworkspace.com

[3] www.CollabraSpace.com/rooms.shtml

[4] cvw.sourceforge.net

collaboration working group was created to establish interoperable collaboration services for which we authored a preliminary set of collaboration services [3] resulting from an initial reference implementation [4].

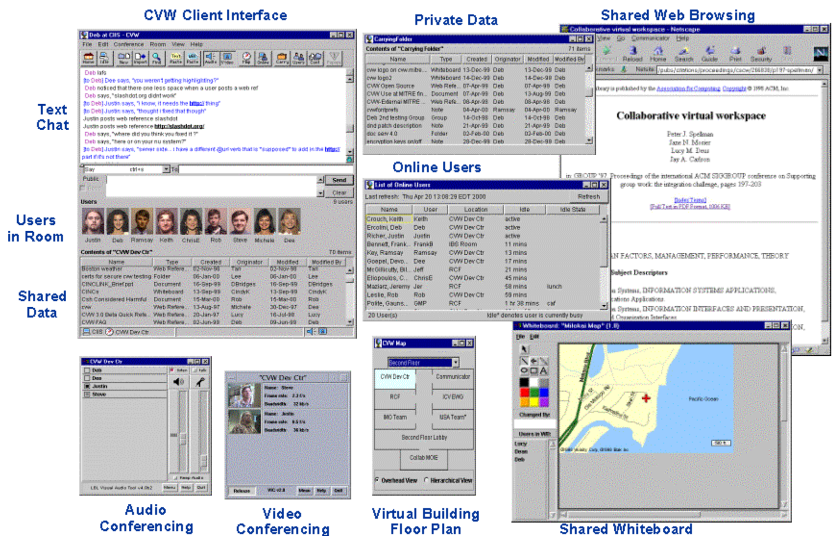
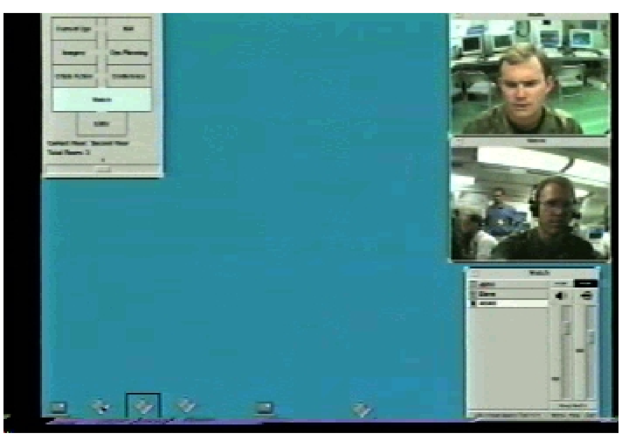


Figure 1. Collaborative Virtual Workspace (CVW).

Virtual Air Operations and Intelligence Analysis

More significant than the technology, however, are the tasks for which these tools have been applied, including distributed, collaborative air campaign planning [5]. For example, Figure 2a illustrates the use of CVW within the Air Force's Joint Expeditionary Force Experiment (JEFX) in which users distributed across land and airborne units communicate and coordinate air tasking orders in a virtual environment. JEFX has grown from one site with a few users to a dozen sites and thousands of users as shown in Figure 2b. Teams are able to overcome both time and space challenges to perform their tasks faster and more accurately, with fewer resources. For example, during the 1999 exercise, users were able to complete their attack operations in half the time and targeting in approximately 30% less time than previously. Another interesting finding was the air defense and information operations teams reported an over 50% increase in awareness given their ability to share information both synchronously and asynchronously.   Furthermore, by enabling "split base" operations using the collaboration environment, far fewer personnel (hundreds instead of thousands) need be placed in the theater of operations. Moreover, virtual airspace operations can be established within 24-48 hours in contrast to the 10-15 days required to airlift personnel and equipment into a forward operating location.



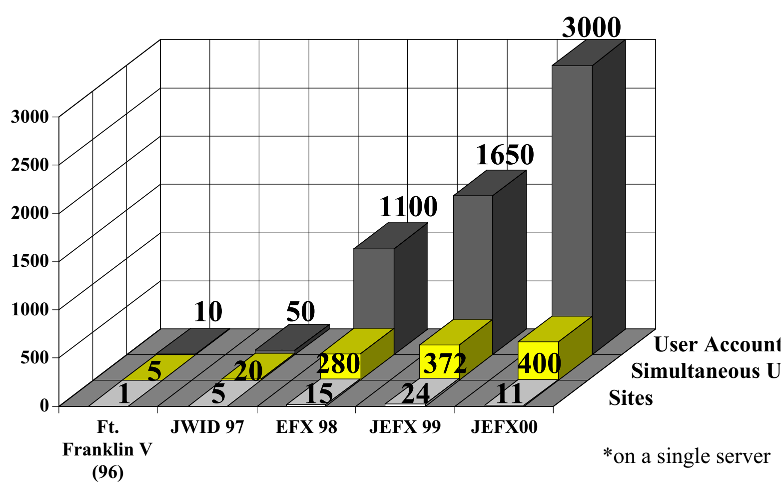


Figure 2a. CVW in use During JEFX. **Figure 2b. Collaboration Growth in JEFX**

A government organization similarly equipped its enterprise with CVW, including its crisis action cells. It currently supports approximately 4000 active users globally. Figure 3, an extract from an independent evaluation [7], illustrates the ebb and flow of usage across time. To date this has included approximately 150,000 logins, 700,000 connection hours, and at peak several hundred simultaneous users working in a virtual room. Figure 4 illustrates the correlation between level of expertise and time on line. Session length of inexperienced users (defined as those having fewer than 25 logins) is typically less than two hours long. The center pie chart shows that two-thirds of experienced users (those having over 25 logins) have sessions lasting 2 hours or more. If we consider users with over 50 logins, then over 80% have sessions lasting over 2 hours - the exact opposite of the inexperienced users pie chart. 80% appears to be a maximum. The collaboration environment enables continuous operations throughout the world including tasking, processing, exploitation and dissemination of information to decision makers. The ability to iteratively task collectors and apply cross-functional experts synchronously and asynchronously has both enhanced product quality (e.g., through multiple source fusion of expert evidence) and at the same time provided more rapid analysis as a result of transforming operations from serial to parallel.

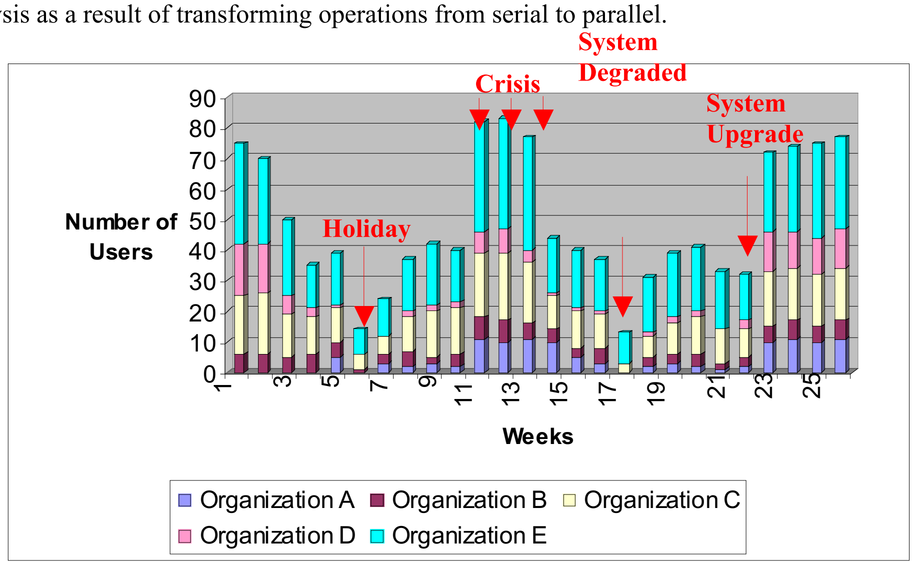


Figure 3. Unique Daily Logons

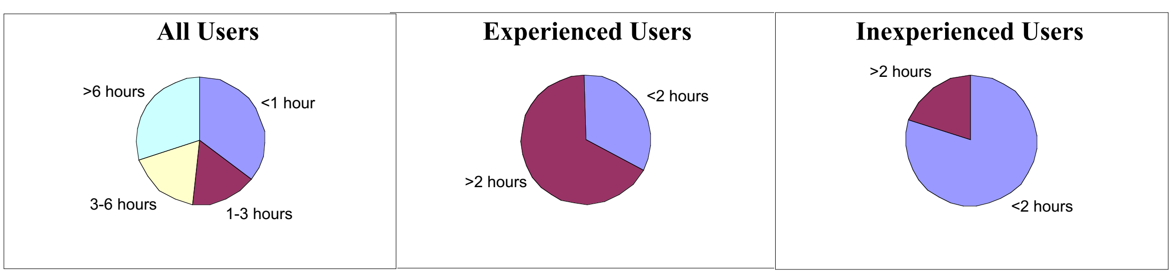


Figure 4. Length of Online Collaboration Sessions

Collaboration requirements from these and other experiences have been formalized in the Department of Defense's software requirements specification [6]. However, we are still learning from exercises and deployments. For example, in a recent exercise, operators were observed to cluster in particular virtual rooms in search of shared situational awareness. Also, conversations from junior to seniors were primarily conducted in text, whereas those from seniors were in audio.

Lessons Learned

Organizations deploying collaboration environments learn quickly that success depends on addressing issues around infrastructure, scalability, usability, and security, as well as organizational resistance to change and sharing. Indeed, while technical challenges such as communications bandwidth and human attention limitations remain, solutions such as the use of multicasting for efficient audio and video conferencing or presence/awareness services are rapidly forthcoming. The more perplexing challenges are human and organizational. Users of place-based environments soon realize that collaboration needs to include both synchronous and asynchronous interactions. They also learn that collaboration can revolutionize existing processing, changing serial processes to parallel ones and/or enabling more agile organizations. They also discover emergence of communities of interest, knowledge and social networks, challenging traditional hierarchical power structures. Biologically inspired models of organizations seem more appropriate than bureaucratic ones. Advancing distributed, collaborative organizations that can achieve the time, quality and agility benefits exemplified in our two domain examples, however, is not easy. We have extracted a number of key lessons from various uses of place-based collaboration environments and have found that critical success factors include:

1. A shared outcome, common goal or purpose.
2. A leader for each group or community. The leader can be a manager, an influential member of the group, or even a professional facilitator. However, without a leader group interactions tend to decay into chaos and become unproductive and often unsatisfying for the participants.
3. Attention to infrastructure scaling and tool usability including training.
4. A secure infrastructure and associated management processes (e.g., defined roles/relationships and operating procedures) that engender trust among participants.
5. Physical meeting/interactions in addition to virtual ones to support the creation and maintenance of relationships necessary for successful collaboration. Collocating initial training can be an ideal time to establish relationships and concepts of operations.
6. A high level champion and an environment that incentivizes knowledge sharing and collaboration.

Even enterprise's that take heed of these hard-earned lessons still face the limits of current technology and knowledge not to mention bastions of human resistance to change. Important research opportunities remaining include the automated discovery of communities of interest, secure collaboration, scaling to large communities, organizational change, and the facilitation of community.

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