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Interactive Collaborative Environments (ICE): Platform Independent X Application Sharing and Multi-Media over Wide Area Networks

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ABSTRACT

Platform-independent Interactive Collaborative Environments (ICE) technologies include support for simultaneous display and control of unmodified X application software by two or more people, at separate locations, using different workstation hardware. Audio and video provide remote collaborators with the ability to discuss what they are all simultaneously seeing on their workstations. Remote pointing and marking capabilities are also provided independent of the application.

We briefly describe our X application sharing work, and requirements for supporting tools, including multi-media. Finally we review some of the pilot project network applications of our work to robotics and manufacturing environments.

KEYWORDS: X Application Sharing, Multi-Media, Wide Area Networks, Groupware

INTRODUCTION

The proliferation of workstations and associated engineering software provides an opportunity for a fundamental shift in how we structure collaborations between members of complex projects. Effective collaborations among team members is essential to timely problem solving. As organizations become geographically dispersed, a need arises for a mechanism to transcend distance.

ICE technologies provide virtual co-location. Humans will always want to have face-to-face meetings on occasion, but problem solving need not be postponed when remote collaborations via networked workstations can result in quick team decisions. Larger teams of specialized experts can be virtually assembled to look at a particular problem even when it is impractical to physically congregate.

Having home resources at hand during problem-solving sessions is another benefit to remote collaboration. Defining group procedures across organizations, and remote training on other people's tools are other side benefits to using ICE technologies, which help build a team consensus between participants at different locations. Audio/Video links have special contributions to offer, for example, remote demonstrations of prototypes or on-going machine operations can be reviewed, and all the added information conveyed by gesture and expression can be used to enhance the quality of team interactions.

INTERACTIVE COLLABORATIVE ENVIRONMENTS

Simultaneous display and control of unmodified X application software by two or more people, at separate locations, using different workstation hardware is a heterogeous conference: a homogeneous conference uses the same workstation hardware for all people in the conference. Heterogeneous conferencing is crucial when communication is between different organizations which have chosen different workstations and software applications to support their particular jobs.

Application independent sharing allows people to use their native tools. When standard unmodified X applications can be simultaneously seen by any team members needing to discuss the application content, then any of the information from different, specialized single user applications can be shared with other team members for quick critiques and reviews. Only the author of the workproduct under review needs to manipulate the application, although others can point things out, and make direct modifications if they are familiar with the tool (or become familiar with common functions by watching the expert). Thus, engineering drawings and documents can be quickly modified in early, small reviews by teams of design, analysis, manufacturing and fabrication personnel operating at separate locations, sharing information interactively, using their native tools.

Sandia's X Application Sharing Technology

To support fast response by Sandia's design and production teams in our heterogenous development environments we have developed patented sharing code which is portable to multiple workstations (platform independent). Our code supports heterogeneous conferences, and is also application independent: we do not modify the applications to provide the sharing capability, and hence, we can share any standard X applications. For more detail about various methods to implement sharing for X applications, see [1-6].

Additional Tools to Support Remote Multi-User Communications

We also provide a user interface access to invoke the sharing code. A user first sets up a conference by contacting other participants by phone or e-mail to arrange a meeting time and topics. At the start of the meeting, a user invokes the control user interface . Currently, this main interface is available only to the person starting the conference (although it can also be shared), but all participants get access to the remote pointer. To begin a collaborative session, the user selects the other displays which will participate in the session. Once the participants are chosen, the application to be multiplexed can be chosen from the application list, or the desired application typed in.

Communication between users typically uses continuous telephone conversation, or audio/video through the workstation, as well as pointing to things with the remote pointer (R-pointer), or marking with the R-marker. The R-pointer and R-marker are application independent pointing and marking tools. These are important since often the cursor for an application doesn't communicate position from the server back to the client, and therefore cannot be shared.

When the telephone is used for the audio link, headsets are provided so users have their hands free. Currently, when we have needed multi-media links we have been using commercially available video-conferencing hardware and software which is platform dependent, and therefore restricts us to conferences with homogeneous workstations; platform independent audio/video work is underway at Sandia.

Conferencing Procedures

Successful implementation of ICE technologies force organizations to resolve some procedural and workstyle issues, since directly interacting with others involves a closer cooperation. For example, the passing back of all event from the servers implies all servers' input are active at once. People in the small, informal review and problem solving sessions seem to have no trouble with "control" by group communication. Audio protocol such as "let me drive now", and "OK, I'm done", have developed. We also have noted a reluctance by some people in the conference to directly make changes on a drawing or document created and "owned" by another. Instead, suggestions are pointed out using the pointing and marking tools. Larger group collaborations such as tutoring sessions and formal meetings invite more control mechanisms [2], and we provide for limiting input if desired. Although a client can be locked by confusing input streams, this hasn't been a problem if the people in the session are even minimally cooperative, trying to achieve a group product, and is less a practical, than technical concern.

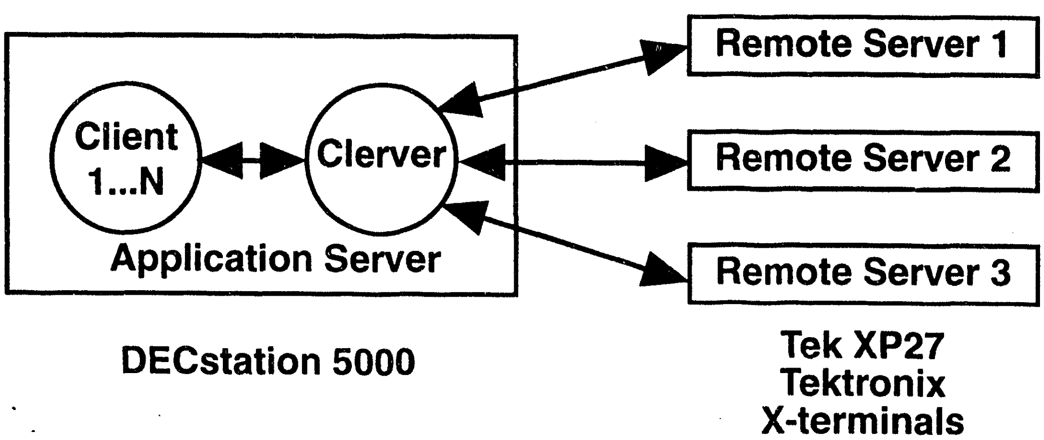
Security procedures are up to the different organizations which want to collaborate remotely. What remains on a machine that is used for between cities communication once the session is done? What encryption mechanisms are needed on the network? Do session participants have to remain at their workstations throughout a session or provide for privacy of their screen when absent? These are the types of issues needing agreement by each organization.

How often should files be saved during a collaboration, and what version control and other company based record -keeping interfaces need to be addressed are other issues affecting the way the group will operate. How to provide ICE capabilities to a large number of individuals brings up issues of workstation placement and ownership. How to provide quick remedies for problems experienced by users, and prevent problems with simple guidelines and easy to use interfaces are other procedural issues.

General Network Configurations to support X Application Sharing

Sandia's platform independent approach to the application sharing code allows the multiplexer code (Clerver: part CLient, part sERVER) to be run in varying configurations in the network. The Clerver multiplexing code can be located on the same machine running the application with all the servers located remotely (Figure A), which might be the choice in an organization with a centralized application server.

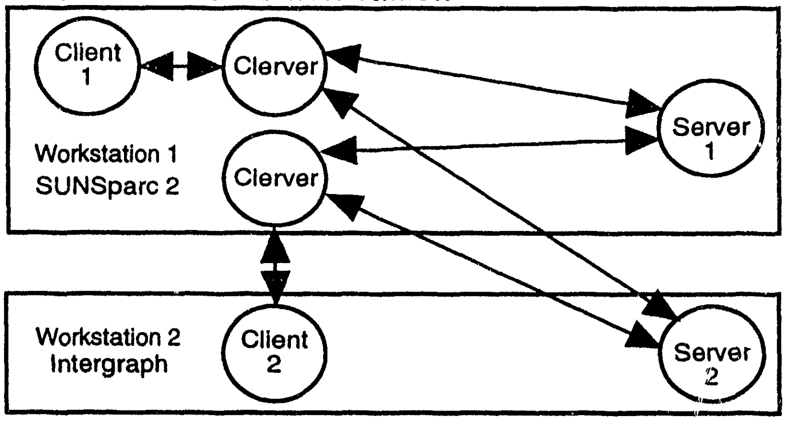
A) Clerver on an application server machine



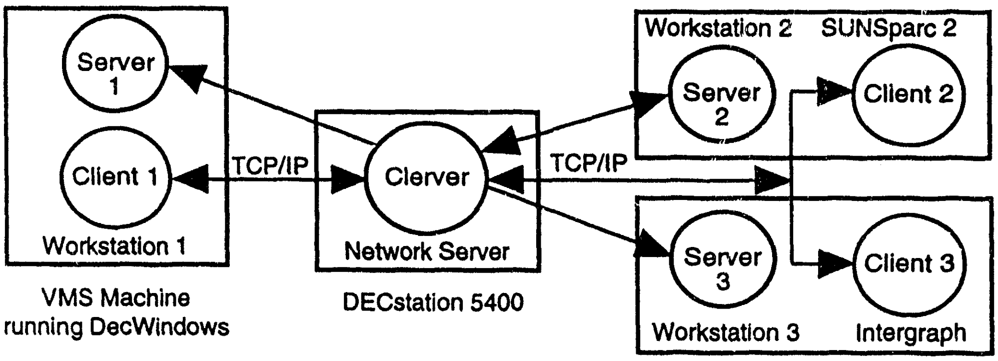
DISCLAIMER

The Clerver can reside on any machine which will take place in a session (Figure B): at least one workstation with the Clerver code must always be included in a conference. Clerver can be on a separate machine from any of the clients that will be multiplexed, which is the configuration when sharing is provided as a network service (Figure C).

B) Clerver on one conference workstation



C) Clerver as a network service



EXAMPLE SANDIA PILOT PROJECTS ICE NETWORK EXPERIENCE

Local Ethernet and PBX connections: The first local pilot project using shared Anvil applications between designers in one building to fabrication personnel in another building in Tech Area 1 at Sandia, Albuquerque site, in Feb. of 1991, using a 1 megabit PBX ethernet connection (Figure C). SGI and SUN workstations, and PCs running X terminal software are being used by concurrent engineering teams to review the automated assembly drawings and robotic code generation implicitly produced directly from CAD models, and NC programs used for deburring.

T-1 and partial T-1 links : Anvil was run over 56 Kbytes of a T1 leased line from NM to MO production facilities in August, 1991 (Figure B). The AcePlus CAD product and Intergraph workstations have also been tested in ICE work environment. A Los Alamos/Sandia link shared Pro/ Engineer CAD drawings between SUN workstations starting in September, 1992 (Figure A). Other T-1 links have been used, the longest being between Albuquerque NM,and Washington D.C.

T-3 links: The supercomputing intersite link between Sandia CA and Sandia NM uses Asynchronous Transfer Mode (ATM) switches with security encryption linked by intersite DS3 trunks.

When Pro/Engineer applications were shared between DEC-5000 workstations with multi-media capabilities in October, 1992 (Figure B), network use peaked at 2 Megabytes /Sec during the most active link use, with about 10 frames/sec of video being sent between the workstations. The network delay for a ping averaged about 42ms, and users quickly adjusted to the short, but perceptible audio delay by pausing before speaking, to avoid interrupting one another. Similar links were used from Sandia NM to Supercomputing '92 in Minneapolis, Minnesota, and SUNs conferenced from Sandia CA to Supercomputing '93.

Frame Relay, and Internet

Frame relay technology is being used to support high bandwith connections for short periods of time. ICE sessions are also being run over the internet, as Sandia consults with industry partners over cooperative work, at lower costs.

CONCLUSION

Currently available communication links are already used for very effective transactions. As the network technologies improve to support high bandwidth on demand, at reduced costs, smaller companies will be able to join resources with others for effective teaming on common problems using ICE technologies.

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