EMERGING TECHNOLOGIES IN A PARTICIPATORY DESIGN STUDIO BETWEEN CARLETON UNIVERSITY AND PENNSYLVANIA STATE UNIVERSITY

Michael Jemtrud
McGill University, Montréal, Canada
e-mail: michael.jemtrud@mcgill.ca

Katsuhiko Muramoto, Sonali Kumar
Pennsylvania State University, USA
e-mail: kxm15@psu.edu, suk189@psu.edu

Danielle Wiley
Carleton University, Ottawa, Canada
e-mail: daniellewiley@hotmail.com

Abstract

The research project investigates the use of a network-enabled platform (NEP) involving a combination of technologies that include: high bandwidth network infrastructure; high-performance visualization and compute cluster solutions; Storage Area Network devices and servers; standard and high definition tele-presence/communication infrastructure; co-located immersive environments; and a range of modeling and imaging applications. The NEP enabled student teams in multiple locations collaborate via on-demand, synchronous access to project data, visualization, modeling, simulation and multimodal interpersonal communication tools through a web service based dashboard interface that hid the logistic and technical complexities to the user.

As a preliminary report on a proof-of-concept design studio conducted during the spring semester of 2007 between the Carleton Immersive Media Studio (CIMS) at Carleton University in Ottawa and the Immersive Environment Laboratory (IEL) at Pennsylvania State University, the paper first describes the implementation of this network-centric collaborative design platform. The report articulates the "staging" of the conditions of possibility for a dynamic interplay between technological mediation and the reality of making, then compares the use of high bandwidth technology with customized symmetrical toolsets in the tele-collaborative educational environment, versus commercial toolsets deployed over moderate bandwidth connections. In each setting, the collaborative environment is assessed according to issues encountered by students and design outcomes. The effectiveness of the digitally mediated collaborative studio is also gauged in terms of student reaction to the learning process via feedback surveys and questionnaires.

Keywords: design, collaboration, tele-presence, visualization, broadband

Introduction

The process of making a building is inherently collaborative due to the diversity of design, engineering, informational and construction professionals involved. Geographically distributed and digitally mediated work environments exacerbate the complexity of the design process but simultaneously provide immense opportunities. Recent improvements in visualization and communication technologies challenge traditional location-dependent partnerships and open up new possibilities for rich modes of creative activity and collaboration.

During the spring semester of 2007, student teams in two locations participated in a collaborative digital architecture studio, between the Carleton Immersive Media Studio (CIMS) at Carleton University, Canada and the Immersive Environment Laboratory (IEL) at Pennsylvania State University. The experimental design studio investigated the use of a tele-collaborative educational environment in which broadband data networks, high-performance rendering and visualization resources, immersive visualization systems, and supporting multimedia applications were integrated into the design workflow. The objective of the tele-collaborative environment was to create an immersive, information and communications rich environment for dialogue, group problem solving and the shared experience of participatory design. The research agenda is to build upon previous research conducted in CIMS and at the IEL on advanced networks, broadband video, visualization technologies, middleware and interface design, and to investigate how digitally mediated design can facilitate the collaborative design process in “real-world scenarios”.

This “proof-of-concept” and “capacity building” phase of Participatory Design Studio (PDS), was implemented through a series of collaborative design environments, each of which comprised a loose assemblage of geographically distributed platforms (or “scenes”), including traditional architecture studios at both Carleton and Penn State, immersive media labs, multiple communication and visualization technologies, and a web based network-enabled platform (NEP). We approached each collaborative design environment as a “staging” that introduced unique conditions for a dynamic interplay between technological mediation and making.

Background on Digitally Mediated Collaborative Design Studio

The notion of the technologically mediated collaboration has been around since the mid-1990’s as communication technologies evolved and became readily available. Due to the lack of available collaboration technologies, they had to rely heavily on asynchronous communications such as e-mail, message bulletin boards, FTP, and the Internet. Insufficient bandwidth and insufficiently powerful and crudely coordinated tools resulted in distributed task-based modes of collaboration that did not allow full participation by members of the distributed design teams. As a result of asynchronous communications, participation was reduced to “simply submitting and giving oneself over” to the process and other participants (Vaitkus, 1991). Currently the digitally mediated design studio has been employed in various forms by various disciplines including AEC, industrial design, and the automotive industry.

Although the recent development of synthesized networking and media technologies has led to significant progress in enhancing collaborative environments in academic settings, truly collaborative work is still rare. Little research has been done to validate how such improvements let groups collaborate and communicate, particularly with regard to long-term use in natural settings (Viégas and Wattenberg, 2006). Furthermore, there is hardly any research done to speculate on how such a paradigm shift in the world of architecture brought by the recent development in visualization and communication technology opens up different modes of collaboration. (Maver and Petric, 2001; Marher, 2006).

Mediation and Collaboration

The primary goal of the PDS is to allow students at multiple locations to collaborate in real-time by sharing computational resources, geometry datasets, and multimedia content. Access to a high bandwidth Research and Education network allowed for low latencies and high-speed transfer rates to create a “next door phenomenon” thus effectively consolidated resources distributed across the two sites. Design collaboration is to ‘work together in a meaningful way, not just working together efficiently, but stimulating each other to contribute to the design task…toward mutual understanding and maximizing outcomes that satisfy not only own respective goals, but also those of other participants” (Achten, 2002). A primary goal was to determine effective thresholds to accomplish a phenomenologically complex participatory experience. Thus, in order for collaboration to be successful, the environment needs to foster a sense of presence among the participants and to enable transparent conversation and use of resources, and sharing of ideas and thoughts.

Facilities

CIMS at the School of Architecture at Carleton University has at its disposal a robust configuration of network and compute resources, a range of tele-communication platforms, displays and immersive environments. Through the financial and technical support of CANARIE (Canada's broadband agency) CIMS has developed a design specific "Network Enabled Platform" (NEP) to support the complex behavior involved in collaborative architectural decision making across distributed sites. The logistic complexities and configuration of the devices are made transparent to the user and virtualizes a series of workflows through a middleware "dashboard". The resources and devices include rendering and visualization clusters, storage arrays and servers, communication platforms, displays and immersive environments. (Fig. 1)

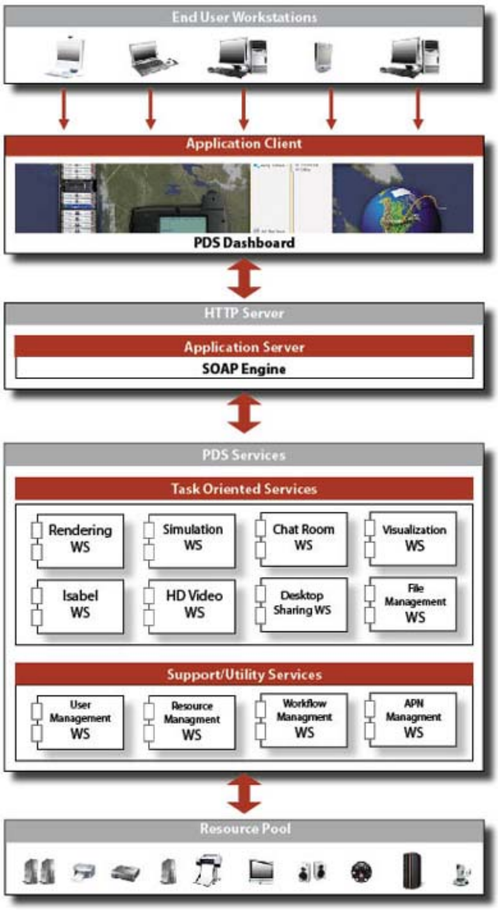

Fig. 1. Diagram of the CIMS Network Enabled Platform

The resulting Articulated Private Network (APN) consolidates a variety of resources, assets, and expertise by utilizing an intelligent network that is secure, has low latencies and ultra high speeds. It has 10Gb/s connectivity utilizing User Controlled LightPath (UCLP) software for on-demand control and configuration of the optical network. Levels of connectivity (Layer 2 and 3) in 1Gb/s increments can be obtained to various sites depending upon the user's requirements through UCLP configuration and control. Standard-Definition (270Mb/s one way) and H323 (10-30 Mb/s) video conferencing options are available as well as High-Definition (1-1.5 Gb/s) tele-presence capability for real-time analysis of physical artifacts such as drawings and models. The physical environment is reconfigurable and primarily utilizes High-Definition screens and projection devices.

The IEL at the School of Architecture and Landscape Architecture at Pennsylvania State University offers a three six-by-eight-foot, panoramic, passive stereoscopic VR display and is supported by a cluster of graphics workstations and software to allow VR-like display of student designs. Conceived as a lower-cost VR alternative to then first-generation CAVE and like systems, the IEL has evolved to support and reflect student work habits, in which VR capabilities often are used with other modeling, multi-media or presentation applications within an immersive information environment, in addition to the anticipated use purely as an immersive VR display. The IEL is also equipped with the same SD tele-presence system and is connected to the APN and its associated resources through a 1Gb/s layer 3 PacketNet connection to CIMS. The user pattern at CIMS and IEL suggested that an integrated multimodal platform would best serve at the evaluative stage during the design process, especially in a collaborative setting (Balakrishnan, Kalisperis and Muramoto, 2006).

Participants and Projects

Total of 32 students (16 from each institution) participated for this project. They were all enrolled in the third year of five-year professional degree in architecture at the respective institutions. Participants were all under 25 years of age, and four participants were non-native speakers. The software used during the projects ranged from PowerPoint, PhotoShop, Form•Z, 3D Max, Maya AutoCAD, and other modeling software. The PSU students had intermediate level skill on Form•Z, while the CU students had entry-level skills that developed to an intermediate level through the duration of the project.

Total of two collaborative design projects were given during the semester; a small helicopter museum at Penn State (VLM), duration of 6 weeks and an addition and renovation to the School of Architecture at Carleton University (SoA), 8 weeks. The students were organized into groups of 4, with 2 students from each school for the VLM. For the SoA, some groups were combined or reorganized, resulting in a variety of group size (4, 6 and 8). The VLM utilized Access Grid, while SoA exploited the potential of the National LamdaRail (layer 3, PacketNet with 1Gb/s connection) and CA*net 4 (Canadian broadband layer 2 with 10gb/s lightpath connectivity) allowing Standard Definition videoconference, Web Service access and control of the APN devices through the dashboard, and utilization of Deep Computing Visualization, Remote Visual Networking (RVN) solution.

"Stagings" of the Digitally Mediated Environment

The goal in "staging" a digitally mediated environment is to achieve "smoothness." In a "smooth" digital environment, the technological interface ceases to be a hindrance to collaboration and begins to facilitate the communication, creation and representation of an architectural idea. In the context of the PDS, components from the network, middleware, and applications to the compute resources, communications platform, and physical environments are considered the foundation for a given 'staging'.

The stagings, however, are identified reflexively, as they were not wholly determinable *a priori* to the implementation of the studio. While we began with a basic approach for a network-centric collaborative platform, this platform had to remain open to the emerging requirements of the student participants, to the inevitable logistical barriers and to the integration of new technologies as they became available through the course of the semester. Each staging thus developed, through improvisation and adaptation, into a loose ecology of technologies, locations, facilities and communication protocols.

Project 1 (VLM – PSU local site) with Access Grid

Since the proposed project was located at PSU, the Penn State students took responsibility for documenting the existing condition of the building and its existing context. They transferred these assets to CU students via FTP sites. The information conveyed consisted of Form•Z digital models, pictures of existing conditions, conventional architectural drawings in PDF format (site plans, building plans, elevations and sections) and video documentation. This first staging was comprised of PSU and CU "conventional" architecture studios; tele-presence suites at CIMS Lab (Sony HDR-FX1 HD DV camcorder and UB1204FX Audio Mixer) and IEL (Sony EVI-

D100 remote camera, ClearOne RAV 900 conferencing system with loudspeakers and 3 ambient microphones); a broad range of supplementary pair-to-pair communications, including instant messaging, email, phone plus a FTP site. (Fig. 2)

Fig. 2. Collaborative Session at the IEL and CIMS

Scheduled videoconferences were held once a week for the first three weeks and twice a week for the rest of the project. After the initial meeting session, the students communicated their design intentions via Access Grid conferences, using primarily PDF format with images from Form-Z models and scanned hand drawings, as well as some AutoCAD and other modeling software. The Access Grid conference was easy to operate and robust enough to serve for productive conversation and exchange of concepts and critiquing, thus contributing to the establishment of a common ground for the projects. Most of the design collaboration on the projects, however, was task-based collaboration and happened asynchronously for the duration of the project.

Observations from Project 1

The focus-group study at the end of semester indicated that audio delay prevented team members from fully experiencing spontaneous idea exchange and generation. In addition, the digital media presentation tools such as PowerPoint leave much to be desired. It was helpful in explaining each other' ideas, but did not allow participants to think and act together. As it is acknowledged in the previous studies on the differences between remote sketching and computer modeling software during the design process (Maher, 2005 &2006), most of criticisms were that computer-based presentations tend to be formal and rigid, not allowing spontaneous exchange of ideas and interpretations necessary between participants, especially at the early stage of the design process.

Project 2 (SoA Project – CU local site) with CaNet*4 and National LamdaRail

The PSU and CU students thus reversed positions, in that CU students would now be responsible for communicating the unique existing conditions of a complex building, site remote to the PSU students. Similar to the first part of the term, this staging included previously listed items as well as remote sketching programs (Open Canvas) and desktop sharing applications such as TeamSpot. Most significantly, the connection between CIMS and IEL was switched to the 1Gb/s National LamdaRail PacketNet and CAnet4, allowing the group to deploy uncompressed Standard-Definition (SD) Video using Pleora Technologies' EtherCast; PDS Web Service and Dashboard for ease of control and configuration of devices included in the APN such as the rendering farm located at CIMS and the communication platform; and DCV-RVN for real-time application sharing and high-performance visualization of assets. This PDS project is considered to be the first 'in the wild' real-life deployment of the components developed in Eucalyptus (Jemtrud et al., 2006).

During the duration of studio projects, we have experimented with several different configurations to examine the effectiveness of “staging”. The difference between the two settings was apparent. Dramatic changes were observed in students’ supplementary communications, as well as their creative use and appropriation of the tele-collaborative environment.

Videoconference

The quality of video feed was crucial to the collaborative work sessions as they contribute greatly to the ways that people can relate to each other and build a foundation of shared understanding. Although we could not utilize High-Definition (HD) Video for this experiment, SD video signal was more than sufficient for team members to observe each other’s expressions. Compared with AccessGrid which was limited to conversation only, students quickly took advantage of the quality of video feed by using physical models to explain their ideas and intentions and even quickly sketched their ideas on paper and showed it to partners during the conference.

PDS Web Service and Dashboard

Previously, there was no work being done to integrate and make the technology transparent, easy to use, and on-demand for the end users without large support and technical staff. The PDS Web Service and Dashboard brought different tool sets that encompass and streamline almost all stages of the digitally mediated process. The Dashboard is flexible, robust and relatively transparent to users and will become a powerful multi-disciplinary collaboration enabler as more “Widgets” are incorporated. (Fig. 3)

Fig. 3. Conceptual Diagram of the Dashboard

“Deep Computing Visualization” RVN

The discipline of architecture is dominated by digitally mediated tools and processes that are primarily 3D and time-based, and require sharing of computational resources, large geometrical data sets and multimedia content. Although available software at this point was limited to Maya, RVN immediately became an important element in our collaborative effort. Students were able to share 3D models of projects and examine and discuss design issues together. Manipulations of 3D models from either end were flawless even though the file was fairly hefty. Again, the potential benefit of DCV in a collaborative environment was proven. CIMS and IBM are currently working on the inclusion of Form•Z.

Overall Observations

By the outcome of the focus-group study conducted at the end of semester, the potential of the PDS promises to provide us with ideal “collaborative work space”; first and foremost interactive, occurs in real-time, and in three-dimensions which potentially allows for an expansive repurposing of assets in the organizing, sharing, transferring, and displaying of content in a more fluid, comprehensive, efficient, and effective manner. Collaborative design is an argumentative process in which designers create an environment for a design dialogue (Simon, 1981) where the project is advanced in a team environment. Schematic implementation of the proof of concept supported a free-flowing, multi-user, participation scenario based around the presentation and manipulation of rich visual design media, and as a result project emerged through a series of interactions between the members of the design team negotiating for a shared understanding via the aforementioned digitally mediated environment.

Research Directions

This research, in addition to our interest in the impact of high bandwidth connections on design collaboration, also illustrates our interest in the social and psychological aspects of this collaboration. In order to study computer-mediated communication from a social-psychological perspective, it is important to understand the importance of “presence” (Gunawardena & Zittle, 1997). The concept of presence is relevant for the development and evaluation of a broad range of media systems and as such is important for this study as well. Kim and Biocca (1997) define presence as the subjective experience of “being there” at a mediated place. Conceptualizations of presence across disciplines deal with humans as subjects. Lombard and Ditton (1997) identify six different conceptualizations of presence: presence as social richness, presence as realism, presence as transportation, presence as immersion, presence as social actor within a medium and presence as medium as social actor. They identify the “perceptual illusion of non-mediation” as the common thread among these conceptualizations, which vary widely. This can occur in two distinct ways, either the medium appears transparent or when it transforms into something more than a medium becoming social entity (Lombard & Ditton, 1997).

In a mediated social environment such as ours, presence can be conceptualized as a sense of “being together” or “co-existence” a rather than as “being there” (Greef & IJsselsteijn, 2001; Nass & Lee, 2003). This sense of social presence, i.e. of “being together”, is operationalized as the extent to which other beings are seen to exist in the virtual world and respond to the subject. Social presence is generally thought to positively correlate with improved task performance in collaborative virtual environments. In our research, we adapted questionnaires from Nowak and Biocca (2003), Schroeder et al. (2001) and Basdogan et al. (2000) to measure social presence.

We have gathered substantial data in this proof of concept stage of the project, the review of which is not completed at the time of publication of this paper.

Future Plans

There are plans to up-grade the connection at PSU to 5 Gb/s connection next academic year. This will allow PSU to experiment with “User Controlled Light Path” (UCLP) technology allowing participants to configure high-speed point-to-point network connections through Web Services to establish stable and low latency connections. A beta version of this application has been developed by CIMS and the next PDS project will offer an intensive “real world” application for its further refinement.

In addition, research in “staging” of digitally mediated environment will continue by acknowledging the multi-stage architectural design process: program development, schematic design, preliminary design, design development, contract drawings, shop drawings, and construction (Laseau, 1980). Each stage necessitates various requirements and different kinds of collaboration, thus different communication scenarios needs to be studied and evaluated.

We believe that further work and experimentation in exporting key elements of immersive visualization experiences will produce a new immersive collaboration paradigm, widening the audience for both collaborative and immersive visualization technologies. It is urgent that we need to use opportunities to find inherent aspects of the media, rather than simulating what is possible in face-to-face interaction.

References

Achten, H. H. (2002). “Requirements for Collaborative Design in Architecture”, Proceedings of the 6th Design & Decision Support Systems in Architecture & Urban Planning Conference, pp. 1-13.

Basdogan, C., Ho, C., Srinivasan, M. A., & Slater, M. (2000) An experimental study on the role of touch in shared virtual environments. ACM Transactions on Computer Human Interaction, 7(4), 443-460.

Balakrishnan, B., Kalisperis, L., Muramoto, K., and Otto, G. (2006). “A Multimodal Approach towards Virtual Reality for Architectural Design [re]presentation”, Computer-Aided Architectural Design Research in Asia (CAADRIA), Kumamoto, Japan.

Greef, P. D. & IJsselsteijn, W. A. (2001). Social presence in home tele-application. CyberPsychology & Behavior, 4(2), 307-315.

Gunawardena, C. N. & Zittle, F. J. (1997). Social presence as a predictor of satisfaction within a computer-mediated conferencing environment. The American Journal of Distance Education, 11(2), 8-25.

Jemtrud. M., Nguyen, P., Spencer, B., Brooks, M., Liu, S., Liang, Y., Xu, B. and Zhang, L. (2006) "EUCALYPTUS: Intelligent Infrastructure enabled Participatory Design Studio," Winter Simulation Conference Annual Meeting 2006.

Lombard, M., & and Ditton, T., (1997). At the heart of it all: The concept of presence. Journal of Computer-Mediated Communication, 3(2). Retrieved October 20, 2003, from http://www.ascusc.org/jcmc/vol3/issue2/

Maher, M. L., Simoff, S., and Cicognani, A. (2006). The Potential and Current Limitations in a Virtual Design Studio. Retrieved November 10, 2006 from <http://wwwpeople.arch.usyd.edu.au/~mary/VDSjournal/>http://wwwpeople.arch.usyd.edu.au/~mary/VDSjournal/

Maher, M.L., Bilda, Z. and Marchant, D. (2005). “Comparing Collaborative Design Behavior In Remote Sketching And 3D Virtual Worlds,” in Proceedings of International Workshop on Human Behaviour in Designing, Melbourne, Victoria, Australia, Key Centre of Design Computing and Cognition, University of Sydney, pp 3-26

Nass, C. & Lee, K. M. (2003). “Designing social presence of actors in human computer interaction”, Proceedings of the CHI 2003 Conference on Human Factors in Computing Systems, ACM Press, New York, NY. (pp 289-296)

Nowak, K.L., & Biocca, F. (2003). “The effect of the agency and anthropomorphism on users’ sense of telepresence, copresence, and social presence in virtual environments”, Presence: Teleoperators and Virtual Environments, 12, 2-35.

Schroeder, R., Steed, A., Axelsson, A-S., Heldal, I., Abelin, A., Wideström, et al. (2001), "Collaborating in networked immersive spaces: as good as being there together?", Computer & Graphics, 25, 781-788.

Viégas, F. B. and Wattenberg, M. (2006). "Communication-minded Visualization: Call to action", IBM System Journal, 45(4).