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Intelligent Infrastructure Enabled Participatory Design Studio

Eucalyptus: Collaborating at the speed of light

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Abstract. A new notion of participation is at stake with advances in technologically mediated work environments. Insufficient bandwidth and insufficiently powerful, crudely coordinated tools resulted in distributed task-based modes of collaboration that did not allow full *participation* by members of the distributed design team. The emergence of Service Oriented Architectures and User-Controlled LightPaths ("intelligent infrastructure") herald the beginning of a new age where fully participatory multi-site design may become possible. This paper will briefly outline the "mise en scène" or staging of the technical configuration of the Eucalyptus project; observations and results from the creative activity of the PDS in the context of two case studies; and speculate on the implications for design activity, pedagogy, and a more robust mode of participation.

Keywords. *: participatory design studio, e-design, SOA, architectural design education, design methods, dashboard.*

Context and Introduction

The current design context from an educational and professional perspective is highly digital-mediated and increasingly distributed. Collaboration between design studios, architectural and engineering firms, fabricators and consultants, etc. often traverses (and collapses) the space and time of the globe characterized as the so-called "24/7 office". Of course this context is by no means limited to architecture and is common in industries such as aerospace, automotive, medical, petroleum, entertainment, and defence. The project, discussed herein, intends to address this development and participate in the burgeoning research and development initiative around the next generation network and the instruments and middleware that constitute this networked infrastructure.

Current initiatives in "cyberinfrastructure" (USA), "e-infrastructure" (EU), "intelligent infrastructure" (Canada) are focused on e-science applications utilizing the global 10gb lambda network available to an increasing number of research institutions. The design-centric use of this infrastructure by the research unit is unique and proposes a different and heterogeneous set of issues, tools, and devices. The integration of commodity-based applications (versus rarified, custom science applications) and the visually intensive (versus compute intensive) environment is the most obvious difference. The fundamental development that must take place is the low level transformation of applications and tools to be optimized for the new network capabilities from a workstation centric model to that of the network. The use, configuration, and control of this network through Service Oriented Architecture and web services are a necessary development to allow effective use by non-network specialists.

The theoretical and intentional underpinnings of the current research recognizes and attempts to identify characteristics of the biased nature of electronic modes of making and seeing but asks the question as to *what is possible only in the network* *driven digital realm* rather than lament on what is presumably lost from location-based collaboration. It provisionally accepts the seemingly enhanced features of a digital mediated environment such as a more thorough integrative mode, increased interactivity and responsiveness, and greater immersion in the process (Al-Qawasmi, 2005).

However, it begs the question of what *participation* is over and above mere task-based collaboration and how is it that the technology enables a richer mode of creative activity. The primary effort at present is to create the infrastructure and operative environment for distributed collaboration. The focus of investigation concerns the choreography of technologies in "staging" the spatial and temporal conditions of possibility that enable a dynamic interplay between technological mediation and the embodied reality of making.

The working scenarios that are considered in the "Participatory Design Studio" (PDS) are twofold. The first and most straight forward is the digitization and 3D digital reconstruction of existing conditions. This is accomplished through the use of a centralized site with the bulk of resources connected to distributed remote sites. It is done according to a 3D modeling and imaging protocol referred to as CIMSp (El-Hakim, 2005; Jemtrud, 2005) that includes the fusion of 3D data from models to photogrammetry and laser scanning techniques.

The second scenario is less task-based and directly engages the creative environment of multiple sites in a design project. This is more properly what is considered a "virtual design studio" or "e-studio". Resources, assets, and expertise are distributed and unified through the UCLP enabled network which includes communication technologies (H323, Isabel (http://isabel.dit.upm.es/), High Definition video conferencing); VPN; shared desktops; rendering cluster; visualization cluster; centralized repository; immersive environments; various output devices

Eucalyptus (UCLP-PDS): brief network and system view

The "User Controlled LightPath enabled Participatory Design Studio" (UCLP-PDS or Eucalyptus) is a design-specific Articulated Private Network (APN) that establishes secure, high-bandwidth, and low latency point-to-point connections between multiple sites. Through this high-end network (1-10gbps) the design specific APN consists of a variety of software and hardware tools typically location and/or workstation dependent.

UCLP promises to overcome several limitations in previous digital mediated distributed modes of collaboration that necessarily strive for low-bandwidth solutions. It utilizes existing fibre network infrastructure provisioned and controlled by UCLP software designed to enable end-users to create their own discipline or application-specific IP network whose topology and architecture is optimized for their particular applications needs and requirements. To put this in context, the UCLP controlled 10gb lambda network is referred to as the "third generation" network representing a significant 30-year transformation in how we use and conceptualize the Internet.

The PDS network consists of lightpaths spanning CA*net 4 associated with one Gb/s channels that are bonded (i.e. grouped) to achieve channels with an effective bandwidth of 4-10 Gb/s. Through this high-speed network, the PDS gathers a variety resources, assets, and expertise in a manner that effectively collapses the space and time of the work environment and creates a "next door" phenomenon over large geographical distances.

Lightpaths offer high bandwidth and low latency; PDS utilizes this combination by deploying distributed tool configurations for which would be prohibited by a layer 3 gigabit network latency. One example is transmission of uncompressed high-definition video using Pleora Technologies' EtherCast™ devices (www.pleora.com), which are ordinarily designed for deployment on a LAN. Another example is a distributed configuration of a PC cluster supporting IBM's Deep Visualization Computing (www.ibm.com/servers/deepcomputing/visualization), where geometry and pixels are computed on separated machines usually having InifiBand cluster connectivity; in PDS they will be connected by a lightpath. In addition there will be exchanges of data between the Render Farm, SAN, and a variety of communication platforms located at the various sites.

Service Oriented Architecture (SOA)

Users configure the PDS network; i.e. it makes use of user-controlled lightpaths (Wu, 2003). A Service Oriented Architecture and graphical user interface referred to as the "dashboard" makes participation, control, and intelligence possible. The SOA and web services is the key development of the present funded research which renders the network transparent to the user and enables him/her to easily configure and access the resources available within the APN.

SOA is an application architecture that invokes interfaces to accomplish coordinated tasks in which the interconnected protocols and basic processes are established by the SOA. Web Services (WS) is a way of integrating web-based applications that allows the applications to automatically interface. The UCLP provisioning Web Services allow users to dynamically assemble a set of lightpaths into a private end-to-end optical network, a so-called APN. SOA and WS are operating system independent. PDS Web Services are implemented in Business Process Execution Language (BPEL), authored with IBM WebSphere Integration Developer and executed with WebSphere Process Server (v6.0).

SOA middleware is the one of the most innovative components of PDS, providing a new state-of-the-art trade-off between system flexibility and ease of use. All the core functions of PDS are provided by Web Services, either as a single service or a combination of services. There are three categories of users identified: the physical network administrator, the UCLP user, and the end-user. The end-users are students, architects and designers who are participating in the design. The physical network administrators are responsible for administrating the optical network and managing the lightpath resources. The UCLP user works with the end-users, and is capable of assembling the lightpath resources to create an APN for the end-users. A user's access restrictions are based on his/her role within the project.

The PDS SOA hide the tools' logistical complexities from users, allowing them to simply select the combinations most suited to the task at hand through the dashboard. PDS innovations include enabling commercial tools for long-distance use, and structuring each tool's computational components as Web Service resources so that that many different complex Web Services can be built from them, nevertheless providing the user with simple selections from preconfigured solutions.

SOA and web services allows for a heterogeneous composition of network-enabled resources that "uncouple applications and data from any specific machine or location" (St. Arnaud 2004). Thus, SOA allows the integration of applications and data to the network rather than being tightly bound to operating systems. The workstation becomes subservient to the network rather than the reverse situation typified with the current network configuration.

It also increases the level of control by the end users, since APN creation is no longer dictated by network administrators, but by the user (e.g. the design teams) possibly with the assistance of the technical staff on site. The high-speed low-latency APN removes the band- width bottleneck. Nevertheless, the design team requires many tools to be integrated, including video-conferencing devices and applications, 3D modeling/animation software, rendering management software, and visualization tools such as IBM's DCV. Inspired by CANARIE's vision (St. Arnaud 2003), PDS will provide a user-friendly dashboard for architects to control these tools and instruments with the support of an SOA.

The PDS provides users across multiple sites the ability to effectively participate in a digital design session comprised of and defined by the tools and devices included in the APN. Users are provided a variety of shared resources, including the underlying high-speed network, cameras, displays, immersive environments, visualization and rendering clusters, centralized storage, sound equipment, large data files, shared desktops, and software applications for communicating and for creating, visualizing the artifact being designed.

PDS Dashboard

The PDS dashboard is implemented as a web application. A user can access it from any workstation connected to the Internet (or the APN). The functions of the PDS dashboard are supported by a set of underlying services, shown as the PDS Services block in Figure 3. The services have been divided into two groups: task-oriented services and support/utility services. Support/utility services are generic and support the task-oriented services. For instance, the User Management Service, which is a utility service, authenticates each user; users with the proper security certificates then are granted access to task-oriented services, such as accessing files through the File Management Service.

The dashboard, which can be project or group specific, is a flexible, customizable GUI that allows each user to create the context in which he/she is working. It functions by adding intelligence to the mediated environment and remove actions such as configuration, establishing protocols, and the logical launching of applications in a coordinated manner. Once logged in, the user sees the resources, assets, and people that comprise his/her work environment.

The dashboard monitors resources and gives permissions if those resources, such as the rendering farm or work file, are available. Communication options from text messaging to High-Definition video conferencing and display are made invoked through the GUI as long as the request does not violate rules of availability. It can be temporally customized to allow more direct access to resources that are conditioned by the process such as training material at the beginning or texture folders during the compositing process. Applications are launched within their proprietary interface although the WS manages some configuration and preferences.

[169_jemtrud_fig03.tif]

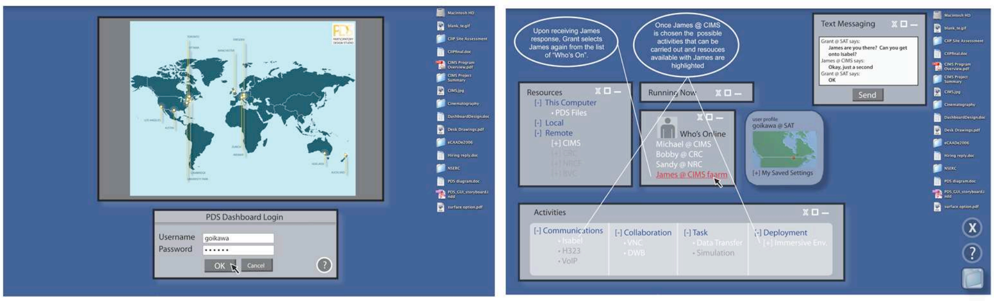

Figure 1. PDS Dashboard Log-in page and Activity page

Participation: PDS mise en scène and intersubjectivity

The PDS's target user community is architects and designers, although the design is generic and applicable to different user communities. Architecture, urban and industrial design are examples of advanced professions requiring collaboration of a diverse team around powerful visualization and modeling tools. Free-flowing multi-person participation is the key to successful creative activity and problem solving at each stage of the design process. Maver (2001) successfully characterizes the contingent and comprehensive nature of design by stating, "Architectural design is a multi-faceted occupation which requires, for its successful performance, a mixture of intuition, craft skills and detailed knowledge of a wide range of practical and theoretical matters. It is a cyclical process in which groups of people work towards a somewhat ill-defined goal in a series of successive approximations."

The presentation of the components that constitute the PDS, from network and middleware to the physical environments, are seen as an act of "staging", or the crafting of a mise en scène intended to allow a dynamic, customizable, shared, and real-time manipulation of a heterogeneous set of 3D and time-based assets from applications such as Building Information Management to video post-production. A broadband network (i.e.1-10Gb/s) is ideal for transferring the bandwidth-thirsty multimedia content.

The notion of "participation" in the framework of large-scale design activity has key aspects that distinguish itself from simple task-based collaboration. The hierarchical model of the design process is the convention from which architects and designers have been working for nearly 300 years. New technologies and the combination of those technologies hold the possibility for a significant transformation of working, notions of authorship, realization, etc.

Participation is ultimately an issue of fostering embodied intersubjectivity specific to the creative act and the material world. The spatial and temporal conditions of possibility for making are radicalized by the PDS. In considering the evolution of the PDS, it was determined that the "staging" of the participatory context must respond to the following factors:

(1) Task-based activity must be facilitated as a baseline requirement. An agreed upon palate of tools corresponding to the skill sets of the actors must be readily "at hand". A robust communicative sphere is a primary component;
(2) Contingency is a fact and determining characteristic of creative activity. The *mise en scène* must allow for a high degree of response to good and bad contingencies. As such, it is a form of thinking "in situ" that is the defining characteristic of craft;
(3) The interplay of the subjectivities involved between the designers, audience, and artifact is the fundamental aspect of rethinking notions of working together in the context of the presumed transformation of a technologically mediated environment. The staging must enable and facilitate, at a low level, the dynamic and reciprocal relationship between the creator, audience, and artifact itself. This is a continual negotiation between intentionality and contingency.

Ultimately, a different notion of (inter)subjectivity between maker – audience – artifact is at stake and it is with this altered notion that enables the possibilities created from the participatory process to travel beyond the generation of pre-conceived outcomes.

PDS Deployed: first steps

CIMS-LaJolla: iGrid 2006

Initial configuration and testing occurred in September 2005 as a demonstration for the iGrid2005 conference where the Jonas Salk Institute for Biological Studies, built by architect Louis Kahn in 1965 in La Jolla, California was digitally reconstructed over a 4-day period. It consisted of a small team "on site" with minimal resources (two laptops, 8mg pixel camera, video camera) connected to a central lab with significant compute and personnel resources. The UCLP configured lightpath connected CIMSlab-Ottawa to the conference site.

At iGrid, the two groups of students worked together in real-time to model in Maya and ShapeCapture, to render scenes and composite the animation. "Being there" was critical in order to experientially characterize the site for effects, ambience, and in storyboarding the HD animation. Distance collaboration was facilitated by high definition videoconference and shared access to applications running from the host lab through DCV, desktop sharing, and VNC. The demonstration was an important milestone in the evolution of the project, which has evolved from the relatively simple demonstration to an operational distributed environment.

The lessons learned from this initial proof-of-concept were many. The major realization concerned the "problem of the speed of light". Lightpaths' high bandwidth results in a large bandwidth-delay product [7]. Since many of the PDS tools will use TCP/IP to transport large datasets, optimization of the relevant TCP/IP implementation parameters will be essential.

The positive value of the PDS scenario and workflow was equally evident. The minimal on-site resources proved sufficient because access to intensive compute resources in Ottawa was immediate through the lightpath. The team in La Jolla was able to set up the animation, use the rendering farm, and transfer large data sets as if within the internal network. The video conferencing systems and desktop sharing made effective communication and participation by all the students. As a result, a sophisticated, accurate, and high-resolution artifact was created efficiently with more effective results.

Upon completion of its first stage in December 2006, PDS will be made available to the university and research community for practical use and further evolution. (www.igrid2005.org/program/symposium_keynotes.html)

CIMS-Montréal: Boulevard St. Laurent

Presently, two studio sites (CIMS_lab-Ottawa and Montréal) and the CRC BADLAB are connected by way of lightpaths in the current PDS. NRC-Ottawa and NRC-Fredericton are connected to the PDS through a standard CAnet*4 connection. The host site, CIMS_lab-Ottawa, contains the main infrastructure including: concentration of designers and applied researchers; a 14-blade cluster (rendering farm); high-performance visualization cluster (IBM Deep Computing Visualization); application server and a central archives/storage; reference material, peripherals, as well as standard tools such as drawings and digital whiteboards. A range of video conferencing systems from individual to H323 and high definition systems are available between all sites. A visualization cluster drives immersive environments located at the remote site from the host site over the high-speed network. CIMSlab-Montréal is located at the Society for Arts and Technology (SAT; www.sat.qc.ca) and contains the same video conferencing systems, two workstations, and three immersive environment configurations.

Presently, work is being done between the two sites in constructing the urban model in much the same way the Salk Institute was created according to the 3D imaging and modeling protocol. Laser scanning will be done in the late spring that will challenge the collaborative work over the network due to the large file sizes and complexity of manipulation. The fusion of the various data sets will occur through the participation of people at differing sites with varying skill sets and expertise. Development of the SOA, web services, and dashboard will continue and progressively include more sites and clients through 2007.

[169_jemtrud_fig04.tif]

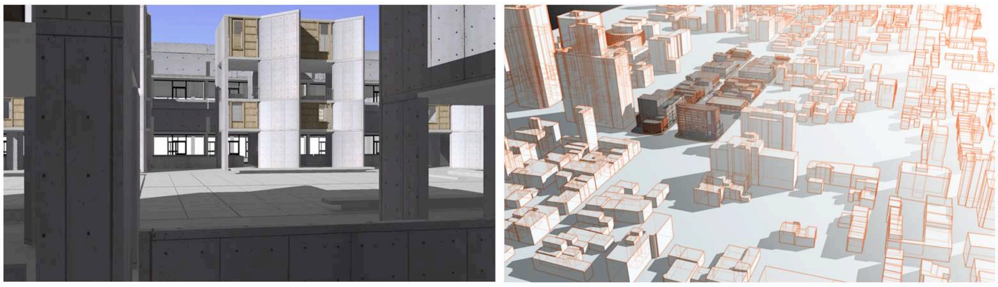

Figure 2. Salk Institute and Boulevard St. Laurent models

Pedagogical and practical implications

The pedagogical and professional implications of this new vision of network-based work environment cannot be understated. By seeing work environments as truly network-enabled, the present research questions collaborative and participatory work in general. Assuming such network capability is a thing of the near future, the value of the research is in a new conception of working. The way in which this environment and its tools are configured and constructed impacts the very nature of how we see, think, and make the world *together*.

The implications of the UCLP-enabled PDS for distributed design scenarios are varied and significant. No longer is network-based collaboration subservient to local workstations, application, and operating systems that ultimately require low bandwidth solutions for network-based collaboration. Designers can use the tools they would typically use in a proximate situation over a distributed network.

Development of the SOA and web services will allow easy configuration and access to pooled resources at multiple sites creating a global, design-specific APN ("next door" phenomenon). Sophisticated and phenomenologically rich communication scenarios, access to wide ranging expertise and deployment infrastructure including large scale augmented environments establishes a creative environment unavailable to location dependent studios. The question is not "what is lost" from distance but what is only possible in such a situation where, through technology, time and space are collapsed in the service of creative and productive goals.

The possibility of sharing compute resources at a truly effective level (i.e., not limited to low-bandwidth solutions) will allow organizations (universities, institutions, offices) to have access to infrastructure that is cost prohibitive from an acquisition and support perspective. Those institutions, countries, and companies who place a priority on the network rather than the "black hole" of hardware can share access to network-capable resources, typically unavailable at any single institution.

As seen in both examples, "on-site" work requires minimal resources when being there is critical to the successful completion of the project. The compute load is placed on the network thus relieving the burden of locale based and consolidated infrastructure.

Real-time interactivity and a more immersed and experientially rich design process are possible. Collaborative tools beyond the typical screen must be developed to respond to this larger environment. With "intelligent" SOA and web services designers can customize teams and work environments making present technical hurdles transparent to the user thus allowing the team to more freely participate in creative activity. Dashboard and customized GUI will allow for a spatialization of a global work environment that is more "immersive" and multi-modal including sound, haptics, fabrication, etc. The expansion of presentation and deployment of robust assets is a larger discursive sphere for a greater amount of stakeholders from professionals to the general public.

The ability to freely involve experts located at geographically remote locations for design development and review provides exciting possibilities for education and professional activity in training and design. Greater expertise can be culled between stakeholders who can interact with experts distributed across the globe. In fact, this is already the case to some extent when a large architectural firm has offices in LA, Beijing and engineers in New York and London, fabricators in Spain, urban planners in Tokyo. At present, such collaboration is typically limited to video conferencing and transfer of files at best. It is based on a conventional understanding of communication and task-based collaboration.

What is being suggested here is that not only can one achieve a more robust technologically mediated and experiential work environment, but that given this emerging paradigm of work, we must also re-think the fundamental nature of participation.

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