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Eucalyptus: Intelligent Infrastructure Enabled Participatory Design Studio

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Abstract

A new notion of participation is at stake with advances in technologically mediated work environments. The digitally mediated e-design studio has been around since mid-1990 and has been employed in various forms in disciplines including architecture/engineering/construction (AEC), industrial design, and the automotive industry. Insufficient bandwidth and insufficiently powerful, crudely coordinated tools, however, result in distributed task-based modes of collaboration that do not allow full *participation* by members of the distributed design team. At the very least, the present "second generation" network severely limits the applications, tools, and modes of communication that can be used in data and visualization-intense design scenarios. 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. The networks, visualization & communication tools, Service Oriented Architecture & Web Services, work protocols, and physical site designs of the Eucalyptus project being developed by the authors will constitute one of the first working examples of this future. The paper will briefly outline the 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.*

1 Context and Introduction

The current design context from an educational and professional perspective is highly digital-mediated and increasingly distributed. Collaboration between design studios, schools, 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 studio". 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 that allows for a new mode of participation between globally distributed parties.

The "User Controlled Lightpath enabled Participatory Design Studio" (UCLP-PDS or Eucalyptus) is designed for users who are interested in collaborating with each other in participatory sessions, using high-end tools that run on broadband high speed networks, and other tools that enhance collaboration. A work session consists of a set of resources including such collaborative tools and a set of users across the network. Typically a service-oriented solution is developed for integrating a system together by packaging application data through a standardized interface; this system does not deliver the collaborative application data such as video or audio streams. Instead, Eucalyptus is aimed at the meta-level; and its role is to build a system that allows a user to *specify*, *invoke* and *manage* these sessions.

Canarie's User-Controlled Lightpath Provisioning (UCLP) (Wu et al. 2003) is a Service Oriented Architecture (SOA) for provisioning lightpaths to users of CA*net4, the Canadian high-speed network developed and administered by Canarie. A *lightpath* is an abstraction of connections between two or more switches in an optical network, and typically connects two points on the network at speeds up to 10 gigabits per second. Compared with current "high-speed" connectivity rates of 40 Mb/s, the onset of lightpaths heralds a revolutionary shift and re-definition of "high-speed" networks. The UCLP project inspired and supports the Eucalyptus project. 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 (Articulated Private Network). An APN network, formed by lightpaths, is one of the resources that is included in the collaborative sessions.

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 2000).

Eucalyptus strives to facilitate the digital mediated design process characterized by the manipulation, sharing, and visualizing of large and heterogeneous data sets. In digitally-mediated projects, the users require many tools to be integrated, including video-conferencing devices and applications, 3D modeling and animation software such as AutoDesk's Maya, and visualization tools such as IBM's DCV - Deep Computing Visualization. The high-speed, low-latency APN removes the bandwidth bottleneck. Eucalyptus provides a user-friendly Dashboard for architects to control these tools and instruments with the support of an SOA.

In the subsequent sections, the overall design, including services for managing sessions, users, workflows and resources, which are the major elements in Eucalyptus, will be discussed. Also discussed are the implementation methods, followed by a discussion on issues and pedagogical and practical implications.

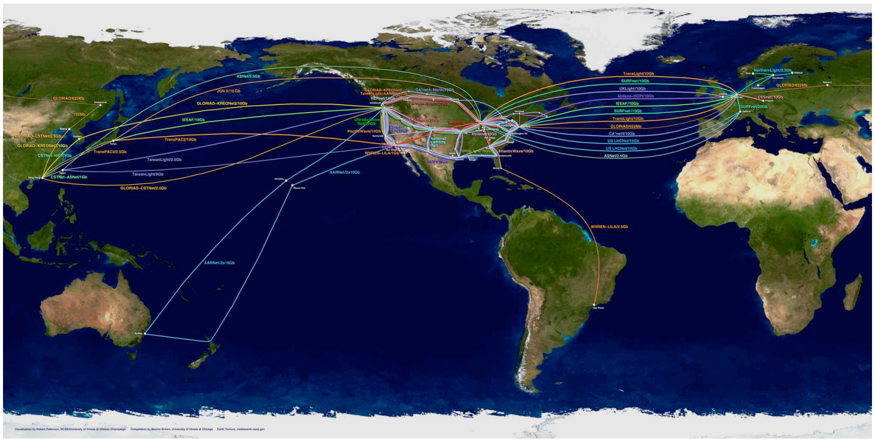

Figure 1: Global Lambda 10gb infratructure.
http://www.glif.is/publications/maps/GLIF_4096-03August2005.jpg

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

UCLP promises to overcome several limitations in previous digital-mediated distributed modes of collaboration that necessarily strive for low-bandwidth solutions due to limited bandwidth considerations. 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 Eucalyptus network consists of lightpaths spanning CA*net4 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, Eucalyptus is able to gather 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.

The mode of participation enabled by this technology, allows for an immediacy and contingency of real-time collaboration which does not exist in current "virtual classroom" scenarios. Ultimately, a different notion of (inter)subjectivity between maker – audience – artifact is at stake – a notion that makes it possible for the outcomes created from the participatory process to travel beyond the generation of pre-conceived outcomes

Eucalyptus utilizes the combination of high bandwidth and low latency 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 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 where geometry and pixels are computed on clustered machines usually through an InifiBand interconnect that equals typical bus speeds; in Eucalyptus they will be connected by a lightpath. In addition there will be exchanges of data between a render farm, SAN, and a variety of communication platforms located at the various sites through application and desktop sharing.

3 Service Oriented Architecture (SOA)

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 is a way of integrating web-based applications that allows the applications to automatically interface. The UCLP provisioning WS allow users to dynamically assemble a set of lightpaths into a private end-to-end optical network, or APN. SOA and WS are operating system independent. Eucalyptus 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 Eucalyptus, providing a new state-of-the-art trade-off between system flexibility and ease of use. All the core functions of Eucalyptus are provided by WS, either as a single service or a combination of services.

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

SOA and WS 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 bandwidth bottleneck. Nevertheless, the design team requires many tools to be integrated, including video-conferencing devices and applications, 3D modeling/animation software, rendering management software, simulation applications and cluster resources, and visualization tools such as IBM's DCV. Inspired by CANARIE's vision (St. Arnaud 2004), Eucalyptus will provide a user-friendly dashboard for architects to control these tools and instruments with the support of an SOA.

4 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. 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 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 and invoked through the Dashboard 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.

In the Eucalyptus project, it was decided to develop the integrated client as a desktop application as opposed to a web application for several reasons. 1) Web applications have limitations on client functionality. There is no easy way to access the local file systems. 2) The implementations of the HTML, CSS, DOM and some other tools are browser specific and they often act inconsistently in different browsers. 3) It is less convenient to maintain an accurate reflection of status of all the resources.

To maintain a desktop application over many computers is normally not an easy task. However, with the help of Java Web Start, the deployment and maintenance of Java desktop applications become easier. The advantages of Java Web Start include automatic application update, desktop integration, platform independence, Java runtime environment management, and security.

The Dashboard interface (Figure 2) is carefully designed to be unobtrusive and user-friendly. Inspired by Mac OS X Dashboard and Widgets, the PDS Dashboard is a flexible, customizable *workspace* composed of specific floating interfaces for functions such as video conferencing, file transfer or resource management, that allows each user to create the context in which s/he is working. Due to its adaptability and theoretical underpinnings, the dashboard is described as a workspace as opposed to a traditional Graphic User Interface. 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. Since the workspace is designed by the user and based on his/her workflow, it is an essential part of a user's practices.

Once logged in, the user sees the resources, assets, and people that are located at distributed locations and that comprise his/her work environment and network. The PDS Dashboard is activated (and deactivated) by a hot-key set by the user. When activated, the user's desktop is dimmed and the floating interfaces come into the foreground. This type of interface operates in the depth of the screen rather than discretely or as a window (i.e. it becomes a layer over the user's current desktop). This ensures that the desktop does not compete with the other application for space, as would be the case with a taskbar, but literally runs on top of them.

The graphic nature and the *spatial* organization of the dashboard further hides each tool's complexity from the user and becomes a contingent and responsive component in scenarios of work that are collaborative in nature – facilitating spontaneous participation and exchange. The following section will outline two proof-of-concept scenarios in the development of the Eucalyptus project.

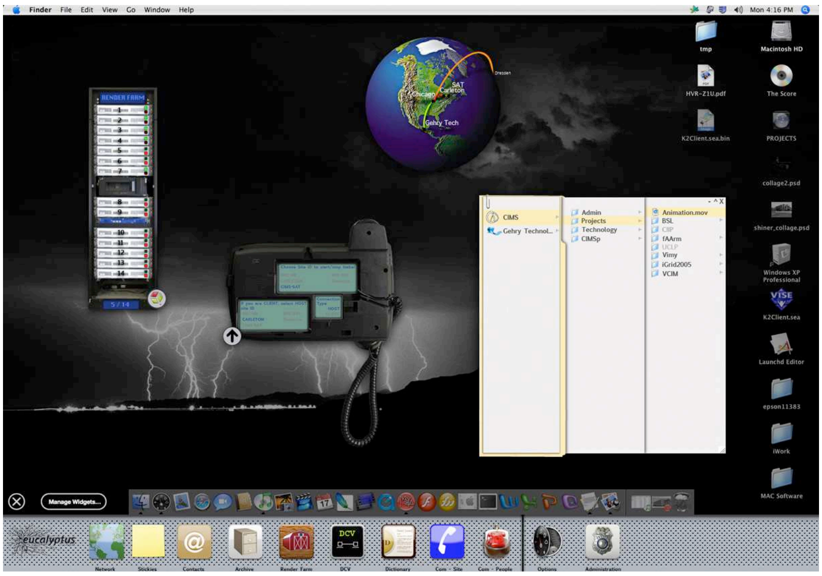

Figure 2: PDS Dashboard interface

5 Eucalyptus Deployed: first steps

5.1 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 in 1964 by architect Louis Kahn 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, an 8 mega pixel camera and video camera) connected to a central lab with significant compute and personnel resources. The UCLP configured lightpath connected CIMSlab-Ottawa to the conference site.

Graduate students from the Carleton University School of Architecture were deployed at both sites (two in La Jolla); they collaborated on construction of a 3D model of the Salk Institute according to a pre-establish 3D imaging and modeling protocol (Jemtrud 2005). Prior to the demo, the Ottawa students used architectural reference materials to construct a basic 3D model of the Salk Institute buildings. The students in San Diego visited the Salk Institute to further develop the model and animation through photogrammetric modeling, to gather high-resolution textures and site information, verify accuracies, and give concrete feedback to the entire team.

In the effort to test out the participatory nature of the scenario, 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. Since many of the Eucalyptus 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 Eucalyptus 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.

The iGrid demo brought together four Canadian research teams; throughout 2006 this combined group is working together closely to create an Articulated Private Network (www.igrid2005.org/program/symposium_keynotes.html) realizing the Eucalyptus project. These teams are the prime developers of the current research and combine different developmental aspects critical to the project.

The current status of Eucalyptus includes Carleton University's CIMSlab-Ottawa with a satellite laboratory in Montreal; the CRC (Ottawa); NRC BADLAB (Ottawa); and NRC (Fredericton, New Brunswick). Upon completion of its first stage in December 2006, Eucalyptus will be made available to the university and research community for practical use and further evolution.

Figure 3: Generated model of Salk Institute from UCLP enabled collaborative work process

5.2 CIMS-Montréal: Boulevard St. Laurent

Presently, two studio sites (CIMSlab-Ottawa and CIMS-Montréal) and the CRC BADLAB are connected by way of lightpaths for the current Eucalyptus project. NRC-Ottawa and NRC-Fredericton are connected to Eucalyptus through a standard CAnet*4 connection. The host site, CIMSlab-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. CIMS-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.

The group is engaged in the digital construction of an urban area in Montréal. It is an area under redevelopment by the city and the digital artifacts produced are being used in design proposals as well as a projection-based urban installation that re-interprets the past, present, and future condition of the city.

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. Researchers in Montreal have immediate access to all the resources situated in Ottawa. Researchers in Ottawa have immediate access to the site under investigation. With the combination of high fidelity video conferencing technologies, the participatory dynamic is heightened and work between the two sites occur as it would if there was no geographic difference. This is dramatically different than traditional distributed work scenarios. 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 PDS Dashboard will continue and progressively include more sites and clients.

The work is of four different types, each involving different combinations and configurations of the visualization and communication tools:

1. Utilization and further development of the CIMSp protocol for 3D construction and visualization of existing urban structures. For this work the Montréal site functions as a satellite of the site in Ottawa. The workers in Montréal gather large volumes of data on certain urban structures in Montréal, and work with personnel in Ottawa to integrate and visualize the data.
2. Students in Ottawa and Montreal collaborate on certain specified types of design, and present their results to a jury at both sites. In this work Ottawa and Montréal function symmetrically, with workers at both sites engaged in similar activities leading to joint outcomes.
3. The sites in Ottawa and Montréal will be used to host presentations of architectural work to diverse stakeholders and interested parties. In this work Ottawa and Montréal will function in two complementary asymmetric modes, depending of the locations of the presenters and the audience. (Testing has begun in deploying the content produced thus far on the immersive environments located at SAT). Students in Ottawa and Montréal will analyze, redesign and re-implement the physical spaces in which the work occurs, in order to enhance the overall collaborative and participatory capabilities of multi-site work.
4. Work will be complete March 2007 and conclude with a projection-based, immersive urban installation in and around SAT.

6 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 proof-of-concept scenarios, "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 now possible due to these developments. 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. The PDS Dashboard 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 and participants who can interact with experts distributed across the globe. What is being suggested here is that not only can one achieve a more robust technologically mediated work environment, but that given this emerging paradigm of work, the fundamental nature of participation and globally collaborative work can be re-defined to reflect and enable the immersed and contingent nature of the designer's work processes.

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