Networked 3D Virtual Computing for Collaborative Environments in Science and Education: Towards VCL 3.0

IOANNIS PAPAPANAGIOTOU, JOHN VIJAY DEVIDE AND MICHAEL DEVETSIKIOTIS
Dept. of Electrical & Computer Engineering, NC State University

MITZI MONTOYA-WEISS
Dept. of Business Management, NC State University

The objectives of this paper are to study the communication, education and social networking challenges for providing a large-scale multi-user virtual collaborative environment with technologies delivered via the VCL. We are investigating the transformation that is currently undergoing in the WWW, from Web 2.0 to Web 3.0 and the correlation with the next generation VCL 3.0. Our research both from the network engineering and the educational point of view suggests that 3D immersive virtual worlds support deep learning and help learners make meaning in ways similar to those used outside of virtual environments. Focusing on these two aspects, our trials at NC State University during the Spring semester of 2008 have shown that the VCL can be transformed from one person static reservation scheme, to a multiuser e-collaborative platform using 3D Virtual Worlds immersive tools. Users can share a remote desktop reservation, with other application material in worlds where multiple entities can participate.

General Terms: VCL 3.0, Web3.0, e-collaboration and e-learning, VCL over 3D VWs

1. INTRODUCTION

In today's worlds of corporations and employees re-engineering themselves to keep up with an ever changing economic and market environment, training has become one of the top issues. Universities at a similar pace are trying to offer newer methods for more efficient education. Thus internet education is gaining stronger and stronger recognition due to its specific benefits over traditional classroom teaching. Recently however the evolution of technology let the educators add one more dimension to the synchronous e-learning process. Now the student is truly an actor of a 3D virtual world, in which he does not only watch and participate, but also interacts. Valuable tools from the learning and education perspective (e.g. documents, presentations, simulators or the VCL) can now be transformed to tools over 3D worlds in which people can synchronously collaborate, innovate and co-create.

Our main focus will be on defining (1) a set of methodologies for evaluating the *networking* and *social requirements* of the collaborative environment needed to support real-time shared discovery, learning, and workforce development;

Authors' addresses: Ioannis Papapanagiotou, John Vijay Devide and Michael Devetsikiotis, Department of Electrical & Computer Engineering, NC State University, Campus Box 7911 - 27695; Mitzi Montoya-Weiss, Department of Business and Management , NC State University, Campus Box 7229 - 27695.

and (2) an initial framework for "VCL 3.0" that enables ad hoc, synchronous communication and 3D collaboration capabilities.
The evaluation methodologies and framework for VCL 3.0 will be informed by *deconstructing* and studying the dynamic networking, computing, social and temporal elements that enable collaboration in VCL-based virtual workspaces. The paper is organized as following. In section 2 a framework of 3D virtual collaborative environments in education and extensions from the classical two dimension e-learning type of education are analyzed. In section 3 the croquet based platform and the advantages over the legacy solution are presented forming the path towards section 4, as the future formulation of VCL (named as VCL 3.0).

2. NETWORK 3D VIRTUAL COMPUTING FOR COLLABORATIVE ENVIRONMENTS IN EDUCATION

2.1 3D Synchronous e-learning

The addition of synchronous aspects makes the e-learning process an interactive process where the students can choose from voice, chat, text or virtual movements. Other tools have been also introduced such as white boards, breakout rooms, application sharing and Q&A, which help drive interactivity. Recently however the evolution of technology let the educators add one more dimension to the synchronous e-learning process. Now the student is truly an actor of a virtual world, in which he does not only watch and participate, but also interacts. 3D Synchronous Learning, because of its truly immersive qualities, interaction is not disembodied and serial: it is embodied and parallel.

In [KARL TAPP] the notion of interactivity (I) and Immersion (I) to achieve Engagement (E) that compels learners and essentially teaches them the content is depicted by an equation

I*I=E

Seven sensibilities that differentiate the way 3D synchronous learning contextual learning experience is provided to the user are defined: 1) Sense of Self, 2) the Death of Distance, 3) The Power of presence, 4) the sense of space, 5) the capability to co-create, 6) the Pervasiveness of Practice and 7) the Enrichment of Experience

2.2 Properties for Education in 3D Virtual Worlds

In the following we are analyzing some of the new properties when education is offered through a 3D virtual tool and finally the notion of presence, and how the distance between the instructor and the student is minimized.

- *Shared Experience and Shared Learning*: As shared experience is defined the interactions of people from different places at the same world (time and place are the same for all users). As shared learning we define the engagement of multiple users in educational activities. Thus, live Virtual 3D Worlds enable rapid knowledge sharing and instant access to information.

- *Co-creation and Collaboration*: Users can collaborate on the same document/file on the same time, as they were doing in real life. Social rules, such as who writes first, are similar to real life thus coordination is easier than traditional tools.
- *Social Environment*: 3D Worlds can be places were students and teachers can "hang out" and can exchange information while being at home. They allow users to establish interconnected communities and form an unlimited knowledge base. This concept converts the traditional online teaching methods to a social experience.
- *Innovation and Simulation*: the capability of co-creating and collaborating leads to the concept of virtual innovation. Students in a more flexible world can innovate and learn. They are capable of making simulations, getting feedback, demonstrating complex concepts and inviting others to participate in their scientific/artistic creations.
- *Incentives*: Participating in a 3D world is similar to participating in a social real time event. Socializing with other people may create incentive for students to learn and find people that have similar interests or find experts on a field of study.
- *Informal Learning*: VWs are the best places for a user to acquire knowledge randomly else called Informal Learning process and is defined as the learning process that takes place serendipitously, by random chance.
- *Use of Avatars*: Avatars are the Virtual People (the user's image on this world). Thus the learning experience is personalized and increases user's interaction and involvement.

2.3 Educational Challenges

Using VWs as a collaborative and socializing platform can provide great opportunities for the education of Distance Education students. However there are various challenges that the educators are going to face.

Technical Requirements and knowledge: 3D VWs require advanced graphic representations and thus the user PC must be equipped with the appropriate graphics processor. Similarly multimedia input/output devices (speakers & microphones) are prerequisites and have to be tested before beginning any session, course or lesson.

Internet Accessibility Issues: High Bandwidth Internet connection is also required. Especially for sessions with many people, Internet Bandwidth is an issue so that everybody can collaborate without significant lag.

Steep learning curves: Cooperation and co-creation in virtual worlds may increase the learning curve to an unexpected level compared to legacy methods.

Dealing with troublemakers: Troublemakers can be divided into two categories, internal and external. Internal troublemakers are those people that are willing to help or are creating "noise" through e.g. an echo in their speakers, an open microphone, or different technology perception level. External troublemakers are those people that participate in the session in which they do not belong (sometimes they can be eliminated by not providing access in a virtual place but there are also cases in which the instructor does not have the authority to lock a virtual room).

Difference between real and virtual collaboration: Participation in a virtual session tests the ability of the students to socialize and interact through a different world than the reality. Some of the social rules alternate and thus the students and the instructor must have identified them in order for the session to be successful.

Our experience through this integration is that 3D VWs provide an engaging and entertaining learning experience. Students are faced with a variety of real-time situations in which they can make their mistakes and be guided correspondingly. This enhances their ability to project themselves into the activity, and goes belong traditional ways of learning. During the evaluation trials we compared and analyzed most of the well known Virtual Worlds. In the following, the Croquet based platform is presented as that software that would encompasses the characteristics of the next generation web.

3. THE CROQUET BASED PLATFORM

Collaborative social computational environments such as virtual worlds and the networking capabilities that support them, present an entirely new way for innovation teams to interact and work. How teams will collaborate and work effectively within collaborative simulations and virtual worlds is poorly understood as are the demands/requirements that those dynamic teams place on underlying network and computing architectures. We expect that the progression from static two-dimensional ICTs to dynamic collaborative simulations/virtual worlds as the primary interactive digital environment supporting Virtual Organizations activity, will transform the nature of the interaction and knowledge exchange processes among team members.

The application of 3D virtual world technologies in support of VOs is receiving much interest in light of recent advances resulting from the deployment of massively multi-user online environments that have been principally designed for entertainment such as World of Warcraft and Second Life. The limitations to collaboration that are imposed by existing server-based commercial approaches to establishing large-scale “metaverses” are not well understood. Most commercially available virtual world technologies are tightly purpose-built as highly server-dependent entertainment venues with little end user flexibility. Contrary to those, Croquet is a powerful development environment infrastructure that is purely object-oriented, enabling creation and deployment of deeply collaborative multi-user online applications and metaverses on and across multiple operating systems and devices. Derived from Squeak (a variant of Smalltalk 80), Croquet features a peer-based network architecture that supports communication, collaboration, resource sharing, and synchronous computation between multiple users on multiple devices [SMITH 2003, LOM 2004].

Legacy Virtual Worlds software platforms, such as Second Life and Forterra, do not create a computational environment that belongs to its users and uses a client server model for replicating the virtual world. However such an architecture requires topologies with 24/7 servers, high efficiency processing units and high bandwidth connections. This client-server model is what it makes next to impossible to imagine re-creating a full-scale earth within Second Life (known as the “servers’ dilemma”). In Croquet based platforms all the computations are done on the user’s side, taking into account the spare resources of local computers.

Croquet is said to be that tool when it comes to the future internet since it is basically an operating system, with an embedded virtual machine, running on top of any other operating system. Croquet can create any interface with applications on the host machine and user can share those applications collaboratively even if that application was not programmed to do so. It can interface with application on the host machine and users can share those applications.
Unlike the legacy closed licenses environments, Croquet is an Open Source in which the Worlds are built by users who can integrate their own applications. Our evaluation method and experiment focused on how to use the Shared Desktop Functionality, on which VCL is based on.

4. VIRTUAL COMPUTING LAB

"The Virtual Computing Lab (VCL) is a remote access service that allows to reserve a computer with a desired set of applications for yourself, and remotely access it over the Internet" [VCL].
The VCL makes this possible by giving the users remote desktop connection to application servers which are loaded with desired application, on-demand. The advantages of VCL include anytime-anywhere access to applications, transparent to users, ease of system configuration and management, and scalability.
The underlying concept of VCL is virtualization. *Virtualization* is a broad term used to imply abstraction of computing resources. There are several types of virtualizations namely application virtualization, platform virtualization and para-virtualization. VCL is concerned with platform virtualization, where the hardware is controlled by host software (virtualization software) to enable multiple OS's to run in isolation. The concept of para-virtualization is used in cloud computing characterized by API calls to a *hypervisor* software that manages the whole system.

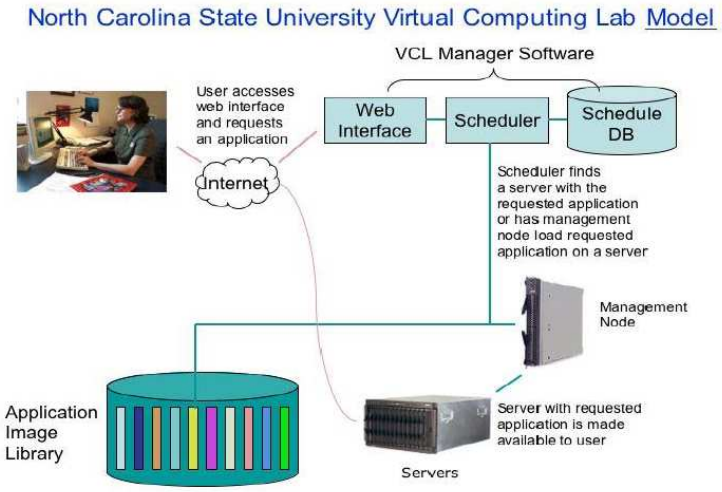


Fig..4.1 NC State University Virtual Computing Lab scheme

4.1 How the VCL works

A set of application servers, application image stack, management node and VCL manager software form the basic modules of VCL. IBM bladecenters are used as applications servers and IBM Tivoli manager along with a set of other tools like VMWare, xCAT, VNC forms the VCL Manager software. VCL also includes an application images stack, from which the image of required application is loaded. An image is the bundle of preconfigured set of applications and an operation system.

When a user places a request for an application from the VCL web interface, the VCL scheduler receives the request; it looks for a server loaded with the requested application among the application servers set. If it finds a server with the requested application, that server is assigned to the user. In case a server with the requested application is not found, the scheduler makes the manager node load the requested image on to any of free servers available and grant that to the user for the requested amount of time. At the end of the requested time, the user can choose to either extend the connection or release the connection. Currently, the blades are pre-loaded with the most popular applications but a predictive scheduling policy can also be implemented.

4.2 Limitations and Extensions

Although the VCL minimizes the distance between a program and the user, it does not yet support collaboration among users. Especially if the target group is based on distance education taught classes the current scheme makes incapable the formation of groups. For this reason we believe that 3D Croquet Based Virtual Worlds may extend the current scheme into an *ad hoc, synchronous communication and collaboration* environment, similar to the pace set by the next generation internet environment, named as the "Web 3.0".

Web 3.0 shall provide access to multiple knowledge partners and diverse types of data that enable on demand assembly of the necessary resources and expertise as needed. Thus, social structures in a Virtual Collaboration environment are not static, but rather they continuously evolve to bring in new information and to respond to changes in task, environment or situations.

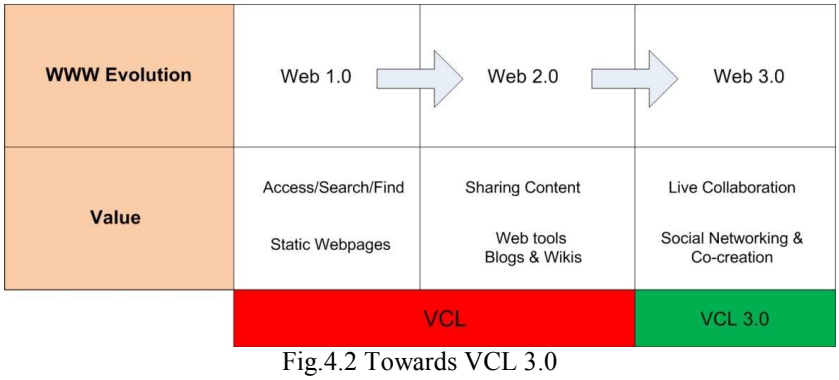
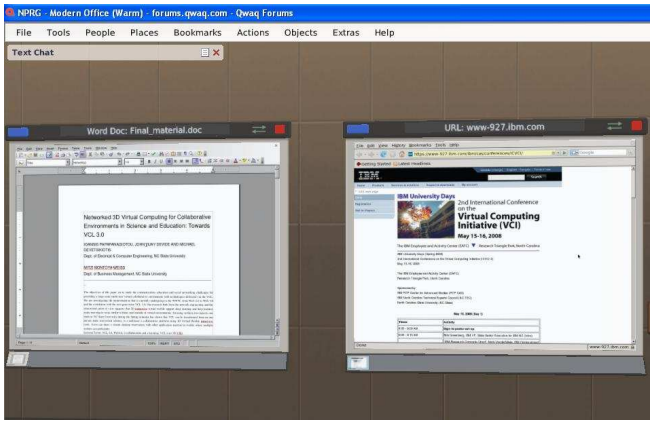


Fig.4.2 Towards VCL 3.0

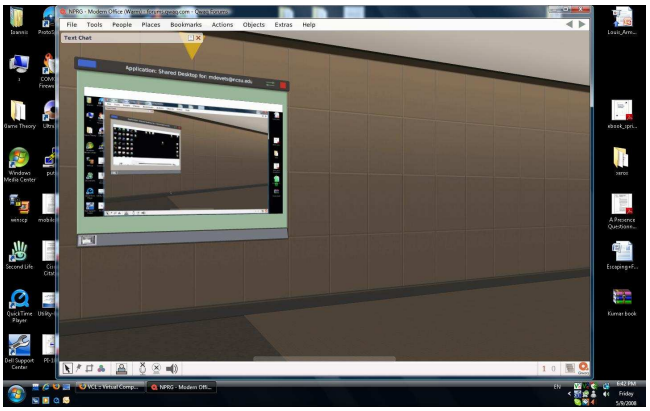
4.3 Croquet Based Remote Desktop

Qwaq Forums is built upon the Croquet platform and uses the Python programming language for scripting and standard XML interfaces for application integration [QWAQ]. Although Croquet is said to be an Open Source, Qwaq Forums is a licensed-oriented software which showcases several functionalities of Croquet, such as drag-drop content where it will be automatically uploaded and made available to other users. Share information contained in corporate applications or desktop applications which enable immediate and always available interactivity is also supported. In Qwaq Forums the user is also capable to change/create their own virtual workspace.

Qwaq Forums have enabled also the functionality of Remote Desktop application. The users can reserve a VCL machine and input the remote machine on the Virtual Worlds. This enables the users to participate on the same session. In Figure 4.3 a) sharing sample documents and a website is showcased and in b) a remote machine is shared among the users.



a) Document and Web page multi-sharing functionality



b) Sharing my machine on a virtual world with other colleagues.

Fig.4.3 Snapshots from Qwaq virtual world collaboration

Qwaq Forums sharing functionality is supported through using the VNC application. One of the benefits of the VNC solution is that it works with virtually any platform or operating system across any network, using just a simple downloadable interface or through a browser, while also supporting data encryption. VNC automatically adapts to the available bandwidth, for example by using a lower color level and greater compression over slower network connections, as well as sending updates only as quickly as the available network bandwidth allows.

5. CONCLUSION AND FUTURE WORK

We have presented an architecture in which multiple entities can participate and collaborate through a VCL reserved blade. We focused on the applications of VWs in e-learning forming an innovative socializing and educating environment. Finally we presented our proposed transformation for the VCL 3.0, based on collaboration over a multi-participating Remote Desktop through Qwaq as the commercial leader of Croquet. During our study we also implemented VNC client on the Open Source Croquet environment which could lead to a relatively economic version of Virtual Collaborations through VCL. The proposed architecture is easily implemented to the current scheme, by setting some dedicated blades as the 3D Virtual places in VCL where students and researchers can collaborate, minimizing the real distance.
Our focus as a future work will be to thoroughly understand and characterize the QoS and QoE features among peers in large scale 3D virtual interfaces and provide insights towards the improvement of future-generation meta-verse applications, taking into account the social structures of users requesting reservation in a collaborative 3D environment.

ACKNOWLEDGMENTS

The authors are thankful to the Engineering Online - College of Engineering, NC State University (Dr. Linda Krutte) for their constant support on the program and Qwaq Forums (especially Mrs. Julie Ostella) for their help and evaluation license provided.

REFERENCES

[KARL TAPP 2006] KARL TAPP 2006, “E-learning concepts and techniques”, Ebook from Institute of Interactive Technologies, Bloomsburg University of Pennsylvania, USA,

[KARL TAPP] KARL TAPP, TONY O’ DRISCOLL, “Escaping Flatland”, Guild Research 360 Report on Synchronous learning systems.

[LOM 2004] J. Lombardi and M. P. McCahill, Enabling social dimensions of learning through a persistent, unified, massively multi-user, and self-organizing virtual environment, in Proc. of the 2nd IEEE Annual Conf. on Creating, Connecting, and Collaborating through Computing, Jan. 2004, Kyoto.

[QWAQ] www.qwaq.com

[SMITH 2003] D. A. Smith, A. Kay, A. Raab, D.P. Reed, Croquet – A Collaboration System Architecture, in Proceedings of the First Conference on Creating, Connecting and Collaborating through Computing (C5’03) 0-7695-1975-X/03, IEEE Computer Society Press.

[VCL] vcl.ncsu.edu