Implementation of Virtual Computing Lab (VCL) to enhance ODL delivery mechanism - a case study of high-end technology usage

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Implementation of Virtual Computing Lab (VCL) to Enhance ODL Delivery Mechanism - A Case Study of High-end Technology Usage

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Abstract

Massive technology advancement sweeps across the globe, opening up opportunity to extend various utilities and services to the students and educator in the glimpse of a moment in education field. Open distance learning (ODL) would not be the same anymore with the use of these technologies in its perception. Virtualization of computer resources is the key areas of technology that contribute tremendously in providing enhanced ODL education.

As a result, it provides us the opportunities to improve and enhance the quality of delivery mechanism. The delivery mechanism of an open distance learning (ODL) transformed with the use of these technologies. The cloud computing is offering a niche in utilization of high-end technology in ODL and thus enable new ways in providing the needed services to the stake holders. These paradigm shifts provide a platform to improve education quality and enhance resource sharing of educational materials among the education institutions. In providing information technology (IT) resources in ODL environment using a cloud computing model, we can derive two-fold benefits. Firstly, with the usage of internet we would able to connect the students and the educators to latest software utilities, hardware resources, educational materials and services supported by advanced IT experts. Secondly, it support the green technology concepts that drastically shrinks the costs of IT resource management perspective which are the power, infrastructure, cooling and expert personals. At the same time it also gave the gaining edge on the IT resource sharing of software licenses, server utilization and hardware requirement.

In our report here, we are proposing a workable model of IT resources sharing using the cloud computing technology in ODL environment. Our work is based on a case-study of the successful implementation of cloud computing resources sharing known as Virtual Computing Lab (VCL) at North Carolina State University. We analyze overall implementation strategy, system design, IT resource usage record and user acceptance to support our proposal. A similar prototype was assembled locally and now in the deployment stage with limited access right is available at Universiti Malaya.

Finally, we are reporting the implementation of a VCL prototype at Wawasan Open University (WOU) in providing the advanced IT resource support for the School of Science and Technology (SST) using the cloud computing technology. In conclusion, we would highlight the capacity of

the VCL that can be harvested to enhance ODL delivery mechanism and the benefits for the individual participating institution.

Introduction

Technology advancement plays a very important role in all areas of human life of this information technology (IT) era, generally with the computing progress made for last several decades. On top of that, specific IT technology progress in the last few years on the cloud computing (Armbrust et al., 2009) and virtualization (Vouk, 2008; Perez-Conde & Diaz-Villanueva, 2010) had caught most people's attention irrespective of their professionally or personally concern.

Educationist had made tremendous effort to incorporate these technological progresses to the classroom environments to enhance deliverance and performance improvements. Technology influences the education process that ranges from the needs, interest, proclivities, current knowledge and learning style of learners up to the roles, responsibilities, support provided, interactions and information/resource sharing on the part of the educators themselves. Education paradigm shift would play a vital role to transform the way these technologies used to improve the performance and enhance delivery quality between the learner and educators (Tam, 2000; Maxwell, 1995). Traditional face-to-face and distance learning mode of education deliverance had made tremendous contributions to the advancement of knowledge in all fields. The incorporation of the IT in the education field opens up a new perspective and widens the horizon to provide higher quality of education beyond the geographically limitation. Open distance learning (ODL) had evolved tremendously with these technological advancements that enable us to extend the access of various utilities and services for educational usage instantaneously (Brusilovsky & Peylo, 2003).

Computing advancement provided various changes in the deliverance mode with new models of e-learning style, web-based education, computer-supported collaborative learning, and computer-networked communication learning that have many insights for improvements (Jones & Isroff, 2005; Brusilovsky, 1999; Anderson & Garrison, 1998). These paradigm shifts provide a platform to improve education quality and enhance IT resource sharing and educational materials between the education institutions. Simultaneously it also gave the advantage boundary on sharing IT resources whereas providing state-of-art facilities for the ODL community would be impossible or can be very costly. Through the revolutionary Internet technology paradigm shift, we can afford to distribute most advanced software and hardware resources/platform, educational material and IT based services the ODL community in any part of the globe even when there are lacks of advanced IT expertise (Rindos et al., 2010)

The frequently used virtualization techniques provide the abstraction on the availability of computing resources and computational capacity to support our proposal above. The cloud computing paved the needed infrastructure and platform to realize this virtualization. Resources abstractions have been very critical in securing performance improvement and higher acceptance by the end users in cloud computing (Armbrust et al., 2009). Various resources have been made

available to enhance cloud computing and relevant technology utilization to highest order with the support of virtualization.

The combination of this virtualization and the internet based application deployment model given birth to the Virtual Computing Lab (VCL) conception. In this notion, we would emulate the virtual machine sharing for a wider section of the community with web-based access privileges. This VCL perception using cloud computing was first conceived at North Carolina State University (NCSU) with a collaboration proposal with IBM Virtual Computing Initiative in 2002 (Moothoor & Bhatt, 2010). The conceptualization of VCL was expanded. There are case studies to verify the benefits derived using this innovative approach which are made available and presented later. Moothoor and Bhatt (2010) had simplified the architectural layers of the VCL cloud services, incorporating infrastructure, platform, software, application and cloud itself as shown in Figure 1.

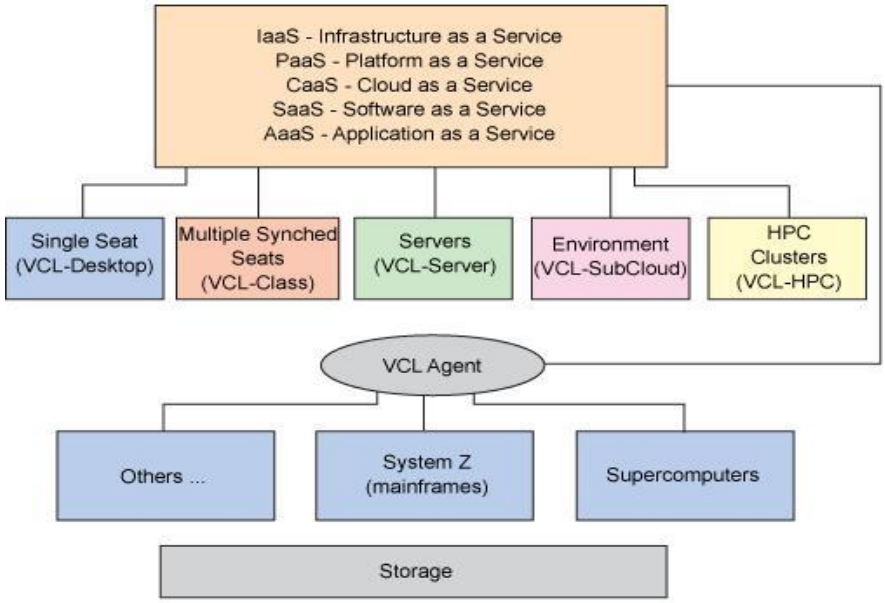

Figure 1: VCL Cloud Services Recommendation.

Background

The cloud computing technology was penetrating into various organizations to eliminate the higher costs of IT accessibility through maximizing machine utilization; reduce system administration and infrastructure costs. Adopting a similar approach to enhance education community's capability in providing quality services and up-to-date technology utilities to all grades of learners using these new technologies was the goal of NCSU initiative.

This proposal was launched in 2004 to address the need of NC State students for information technology (IT) access that were deprived of their supercomputing center, which was designated to support its Higher Performance Computing (HPC) research community (Moothoor & Bhatt, 2010). The initial VCL deployment was targeting the NC state K-12 students' IT needs of

individual general classroom lab and other education services (Schaffer et al., 2009). The NC VCL cloud with general purpose server pools provided 24x7 typical desktop or application environments. With about 30,000 students' population of NC State during regular semester, VCL supported 500 simultaneous general-purpose users on daily basis for in classroom use, homework and class projects (Rindos et al., 2010).

The VCL provided flexibilities with different schools' requirements of usage size and patterns. The VCL allowed the professor or authorized students to create and store their own special purpose images. Different levels of user support are easily made available using VCL. The K-12 and K-20 students can be provisioned to use the VCL based on their needs. At the same time, a HPC researcher also can request for a cluster of machines to support his computational intensive works.

An incremental process was used to introduce and enable various departments or campuses to accept this VCL concept services. By 2009, the VCL was supporting up to 250,000 students with 2,000 actual physical servers which are able to host 4-5 thousands of virtual servers and over 800 software images simultaneously. This is done gradually with the support of policies in put forward by the NC State Office of IT (OIT). Later the VCL was introduced to other universities within University of North Carolina (UNC) system and schools in the NC Community College. In 2009 alone, the VCL delivered 220,000 user sessions for NC State students and faculty.

The NC VCL deployment model was based on the private clouds model in order to encourage the sharing of the resources among the stake holders. Here in the VCL cloud implementation, NCSU demonstrated their ability to combine their respective facilities to create a single private cloud which in turn can be dedicated to single group or groups of users based on their demand and requirements. All these resources are made available for free the stake players. This encourages more institutions to participate in the initiative.

This VCL-based model was proven workable with the annual total cost of ownership (TCO) was reduced 50 percent. This was possible with bulk discount of large-scale software license purchases made for state wide usage rather than by individual institutions or schools. A more detailed description and analysis of the evidence of cost effectiveness with cloud computing implementation based upon the NC State VCL model was presented in Dreher, Vouk, Sills and Averitt (2010).

With the success of this pilot VCL-based education cloud, others follow suit; California, Virginia, Georgia, Tennessee, Columbia and other states, as well as the Historically Black Colleges and Universities (HBCU) community with its own Cloud initiative. Further on, VCL-based education cloud was expanded to Europe, the Middle East, India, China and Japan, with Alberta and Ontario Canada joining the bandwagon (Rindos, Dimitrios, Doria & Moranta, 2010).

The VCL-based education cloud implementation can benefit various quarters; students, faculty and IT administration as a show in Table 1. One significant benefit using this approach is the access option from anywhere and anytime is very applicable to the ODL delivery mechanism mode.

Beneficiaries	Benefits
Students	• Raises computing resource accessibility, even in underserved districts • Increases availability and integrity of data, applications and research materials • Adds mobility • Reduces client application and system resource footprint • Amplifies application and computing performance • Improves server and data storage capacity • Offers convenient web access to the VCL
Faculty	• Grants accessibility to virtual machines • Schedules delivery of assignment instructions, study materials, syllabi or software • Enables faculty to create custom images for specific course, independent of (and not conflicting with) other faculty course images • Unites departments and campuses to eliminate information silos to deliver comprehensive educations
Administration	• Standardizes applications and processes • Provisions software, resources and management of data • Lightens the burden of software version control • Reduces total cost of ownership by nearly 50-90 percent • Lowers the need for in-house IT staff • Cuts resource management costs including power and cooling • Raises server utilization and software licenses, reducing purchasing requirements • Brings greater virtualization • Optimizes resource allocation

Table 1: Benefits of VCL for Multi-beneficiary

A similar undertaking of VCL deployment for the undergraduate students was taken at University Malaya in year 2010. A comprehensive presentation on this project was presented at National Advanced Cloud Computing Workshop in April 2011 with demonstration of the prototype system usage and description of the overall benefits.

Our main objective in this endeavor is to eliminate the dependency of WOU to physically limited lab facilities at its Regional Offices (ROs) to support their students' IT requirements. WOU ODL students' requests for IT resources, application software and operating systems (OS) vary from semester to semester based on the courses offered and number of students at different ROs. It is quite a tedious and time consuming task for the IT personnel to administrate these entire requests as there are lacks of experts at the ROs. This compromise the smoothness and efficiency of the facilities made available for certain courses on time. Besides that all the lab facilities are limited physically on the number of PCs available for all the needed applications, especially different types of OS. Also the constraint of time when these resources can be accessed freely which is of course very much limited with the location of these resources and
WOU's students' accessibility. A value added feature that WOU could offer their students are

the availability of these IT resources from anywhere at anytime which is not possible with present arrangement at the ROs.

With the implementation of VCL at WOU, we would like to provide each of our students with their own set of virtual machines that they can access from anywhere at anytime using their own portable devices, such as laptop, PDA, iPad and Smartphone.

Implementation of VCL

The conceptualization and implementation of NC VCL is the fundamental model used in the VCL implementation at WOU to support our ODL community. The main components of the VCL are the Management Node, VCL demon service, Database Server and Web Server.

1. The Management node is the IBM-VMware Administration Engine where our IBM x3650 blade server sits and the virtual machine (VM) provisioning is done with VMware ESXi, VMware ESX Standard server, VMware free server.
2. The VCL demon service is the life line that provides the actual provisioning and deployment that coordinate communication between management node, web and database servers for the VM to be loaded until deployed at VCL web portal.
3. The open source MySQL database server store data like host parameter, management node information, schedule, images parameter and etc.
4. The Apache web server is the core of the VCL that govern all the resources and used to make request and manage the images and the users using the web portal interface.

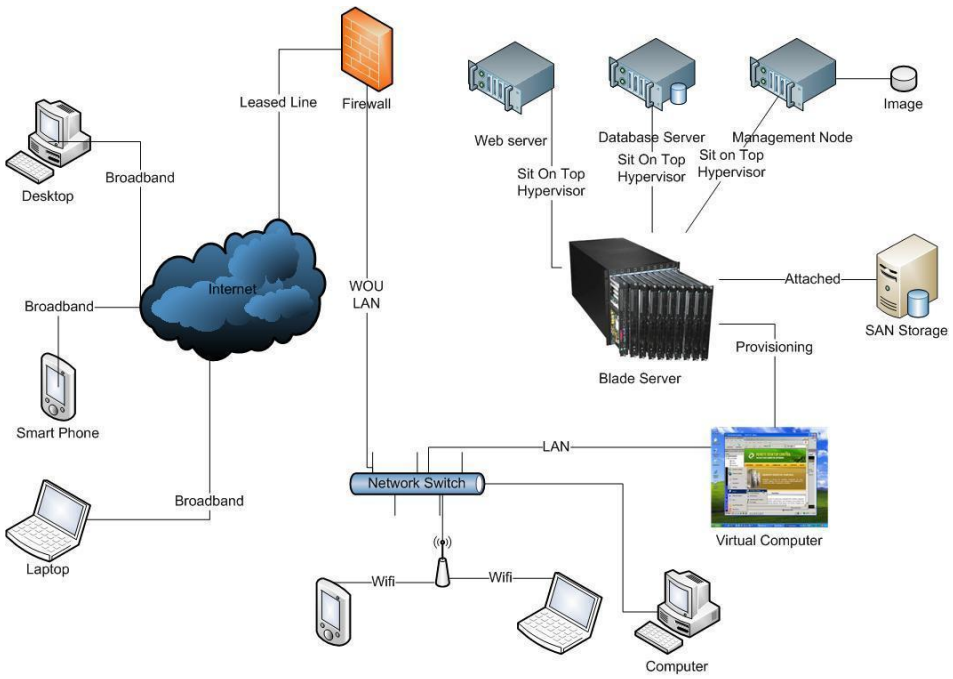

Figure 2: WOU VCL Architecture Framework

The general framework of the architecture of WOU VCL is shown in the Figure 2, consists of all the components needed for the implementation to from the VCL. We implemented VCL using the WOU virtual private network (VPN) which grants the user access right from the combination of Microsoft AD and Novell GroupWise ED authentication protocol.

The process of accessing and utilizing the VCL is been described as follows and shown in the User Flow Chart, Figure 3. We provided step by step procedures that the users have to accomplish to make a reservation and access the VM via WOU VPN to VCL server resources.

a. From the web application based in the Apache web server, a user has to login into WOU VPN to be granted the access and authentication (Figure 4).
b. The system get authentication from WOU Novell GroupWise ED. The LDAP servers authenticate the user and allow the user to access into WOU virtual private network.
c. Once authenticated, the user have all the rights to make a reservation at their convince time at the VCL web portal site (Figure 5).
d. The Management Node verifies whether the requested time slot and the resources are available before the reservation can be confirmed.
e. Once the reservation is confirmed, the user will receive the notification of username and password to access into VM desktop remotely. Figure 6 shows sample Fedora 9 provision activation.
f. When the user uses an allocated slot, the system will check whether the time allocation is completed or not. Once it reaches the timeout, the system will prompt to remind the user to save everything.
g. The session would be closed and the resources used will be released for the next user to use them.
h. When completed the session ends.

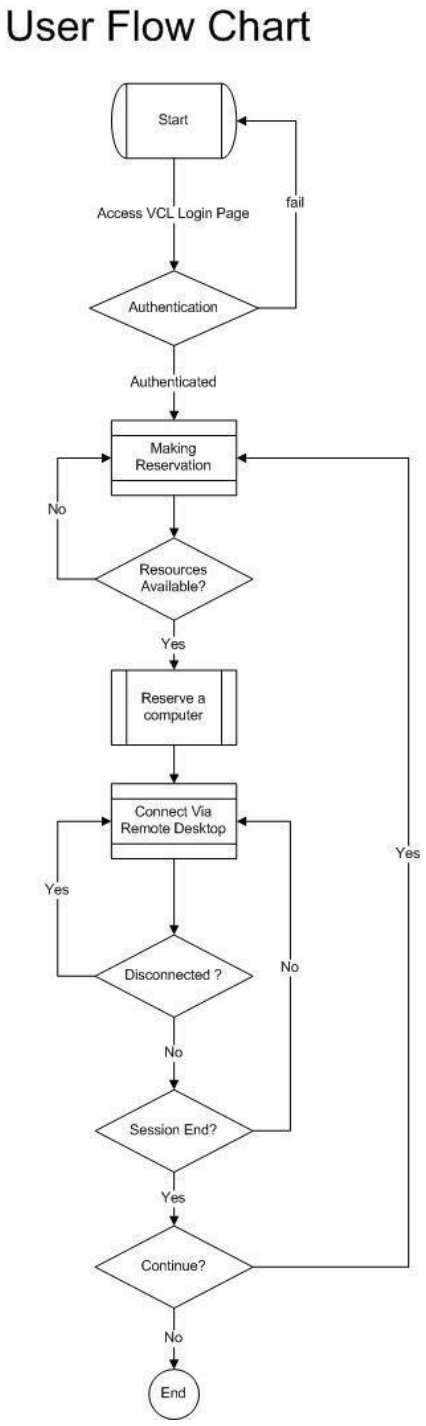

Figure 3: VCL user access process

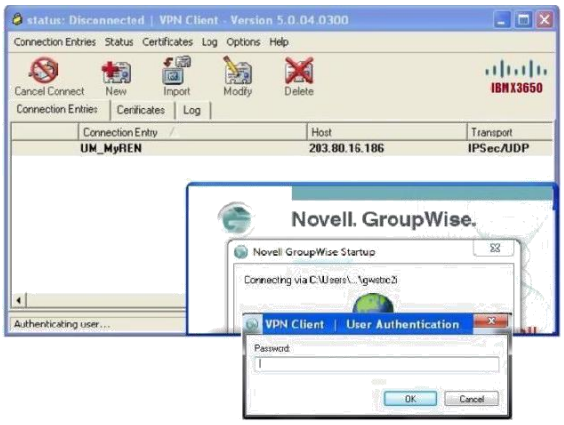

Figure 4: WOU Novell Groupwise VPN Client User Authentication

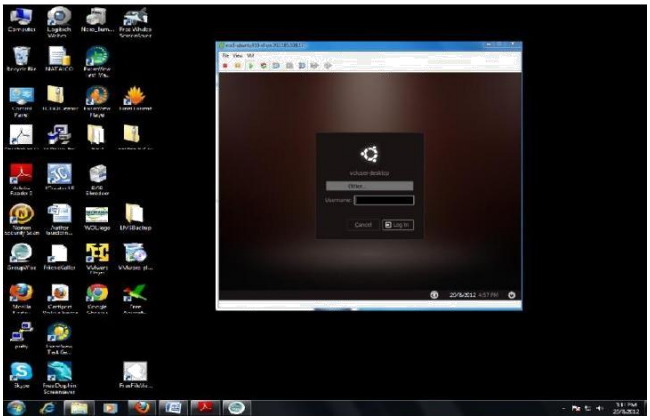

Figure 6: Virtual Machine Desktop – Fedora 9

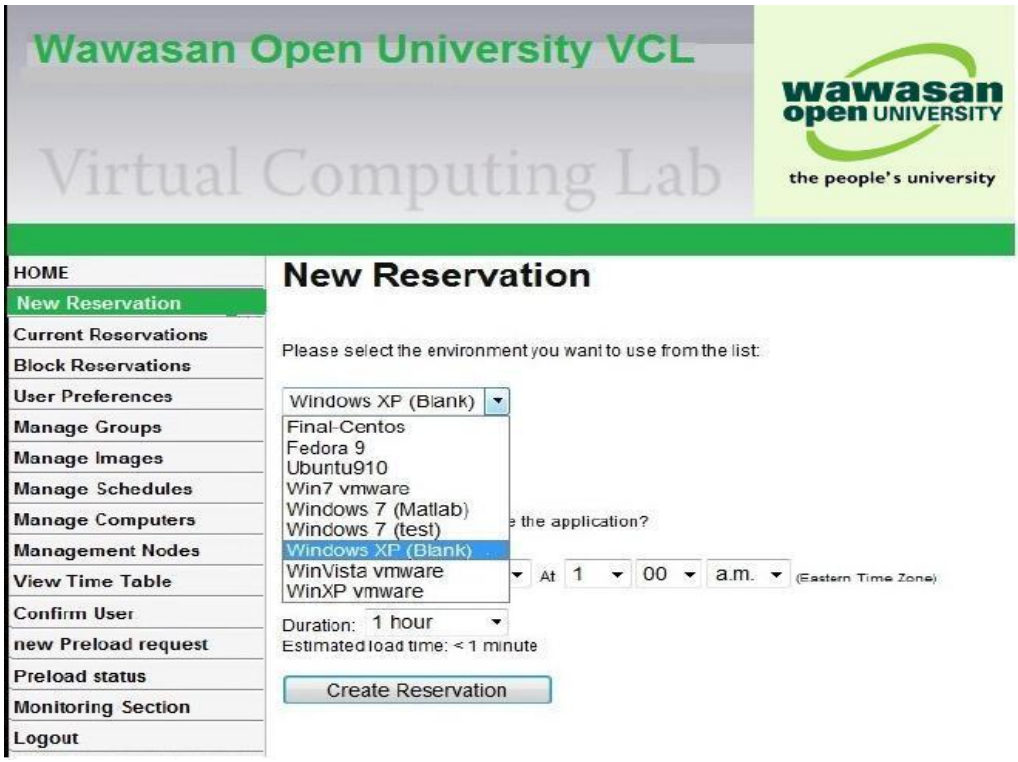

Figure 5: VCL Server Resource Reservation Web Portal Interface

We had implemented the VCL successfully on IBM x3650 blade server. We performed the initial provision and deployment with a small set of specific application software, software development kits and operating system to identify the robustness of the system to cater the IT needs of WOU SST. We used JDK LE version, Visual Web Developer 2008 Express Edition and Fedora 9. All of them are freeware and one of our targets is to make this an open source private cloud (OSPC) initiative, similar to Intel's OpenStack private cloud.

The following Table 2, shows WOU SST lab facilities at all the ROs. This is our test-bed where the VCL deployment would be used to cater the lab facilities as indicated. This would verify and

endorse the achievement of our final goal in implementing VCL at WOU. These would be done in different phases that include some very high-end electronic lab software; Vissim, EMU8086-Keil MicroVision 4.0 (Philips LPC2000), MultiSim, MATLAB and pSpice in the later stage.

RO	Lab location	No. of Labs	No. of PCs/lab	No. in Library	Total PCs
Main Campus Penang	Library	–	–	Level 5: 10 Level 6: 10	20
	Learning Centre: Disted College	4	Lab 1: 24 Lab 3: 30 Lab 4: 30 Electronics Lab: 15		99
Johor Baru	RO	1	31	Library: 8 Open Access: 1	39
	Learning Centre: Southern College	3	Lab 115A: 30 Lab 115B: 26 Lab 115C: 40		96
Kuching	RO	–	–	Open Access: 5	5
	Learning Centre: Institut Latihan FTMS	1	24	–	24
Kuala Lumpur	RO	3	Lab 1: 33 Lab 2: 33 Lab 3: 33	Library: 10 Open Access: 4	109
Ipoh	RO	1	30 + 1 tutor	Library: 10 Open Access: 1	
Kota Baru	RO	1	30 + 1 tutor	10	40

Table 2: School of Science & Technology Computing Laboratory Facilities at ROs

Conclusion

We completed the deployment of some of the application software on a transitory basis only for this July 2012 semester. We realized the potential of using the VCL. The actual VCL deployment test would be conducted in January 2013 semester with real time provisioning and deployment on selected lab sessions of some of WOU SST courses as outlined in the test-bed scenario earlier at all ROs.

As the conclusion, we would like to highlight that the capacity of the VCL are numerous which can enhance the ODL delivery mechanism. It benefits the different stake holders in an ODL community. In long term, it is a worthy option to explore and expand the VCL for ODL usage.

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References:

Armbrust, M., Fox, A., Griffith, R., Joseph, A. D., Katz, R., Konwinski, A., Lee, G., Patterson, D., Rabkin, A., Stoica, I. & Zaharia M. (2009). A view of cloud computing, *Communications of the ACM*, vol. 53, no. 4, pp. 50–58, 2009.

Anderson, T. & Garrison, D.R. (1998). Learning in a networked world: New roles and responsibilities. In C. Gibson (Ed.), *Distance Learners in Higher Education.* (p. 97-112). Madison, WI.: Atwood Publishing.

Brusilovsky, P. (1999). Adaptive and Intelligent Technologies for Web-based Education. In C. Rollinger & C. Peylo (Eds.) *Künstliche Intelligenz* 4, Special Issue on Intelligent Systems and Teleteaching, 19-25.

Brusilovsky, P., & Peylo, C. (2003). Adaptive and Intelligent Web-Based Educational Systems. *International Journal of Artificial Intelligence in Education, 13*, 156-169.

Dreher, P., Vouk, MA., Sills, E. & Averitt, S. (2010) Evidence for a cost effective cloud computing implementation based upon the NC state virtual computing laboratory model. In Gentzsch W., Grandinetti, L., & Joubert G. R. (Eds) *High Speed and Large Scale Scientific Computing*, IOS Press, Jan 2010. 236 - 250.

Jones, A., & Isroff, K. (2005). Learning technologies: Affective and social issues in computer-supported collaborative learning. *Computers & Education, 44*, 395-408.

Maxwell, L. (1995). Integrating open learning and distance education. *Educational Technology*, 35 (6), 43-48.

Moothoor, J. , & Bhatt, A.V. (2010). A Cloud Computing Solution in Universities - *Virtual computing lab, IBM developerWorks Technical paper,* IBM Cloud Academy, *Jan 2010. Retrieved from* http://www.ibm.com/developerworks/webservices/library/ws-vcl/

Perez-Conde, C. & Diaz-Villanueva, W. (2010). Emerging Information Tecnologies (II): Virtualization as Support for SOA and Cloud Computing, The European Journal of the Informatics Professional (CEPIS UPGRADE), 11(4): 30-35, August 2010. Retrieved from http://cepis.org/upgrade

Rindos, A., Vouk, M., Vandenberg, A., Pitt, S., Harris, R., Gendron, D. & Danford, T. (2010). The Transformation of Education through State Education Clouds. IBM Global Education White paper, IBM Centers for Advanced Studies, IBM Cloud Academy. Retrieved from http://www.ibm.com/ibm/files/N734393J24929X18/EBW03002-USEN-00.pdf

Rindos, A., Dimitrios, P., Doria, D. & Moranta, V. (2010). VCL Cookbook, IBM Global Education White paper, IBM Cloud Academy, Retrieved from http://public.dhe.ibm.com/common/ssi/ecm/en/ebw03004usen/EBW03004USEN.PDF

Schaffer, H. E., Averitt, S. F., Hoit, M. I., Peeler, A., Sills, E. D., & Vouk, M. A. (2009). "NCSU's Virtual Computing Lab: A Cloud Computing Solution," Computer, vol. 42, no. 7, pp. 94-97, July 2009

Tam, M. (2000). Constructivism, Instructional Design, and Technology: Implications for Transforming Distance Learning. *Educational Technology & Society, 3* (2), 50-60.

Vouk M.A. (2008) "Cloud Computing – Issues, Research and Implementations", Journal of Computing and Information Technology (CIT) 16, 2008, 4: 235-246.