Chapter 74
The Virtual Computing Lab (VCL): An Open Source Cloud Computing Solution Designed Specifically for Education and Research

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ABSTRACT

In this article, we describe the Virtual Computing Lab (VCL) with its main features and services. Also, we introduce the recent advances of the VCL system and its usage in research and education. The VCL is a cloud computing system that has been optimized for the educational services and research needs of the academic community. VCL is an open source cloud orchestration stack with a self-service portal that currently supports a large number of customers and commercial cloud, or cloud-related services and solutions. It was developed by NCSU with support from IBM Corporation. VCLs promise to support researchers and students in all academic levels to fulfill all their computing needs. In addition to supporting students and faculty members at NC State University and other UNC System universities, the NC VCL now also supports students at several NC community colleges. Also, we introduced cloud computing and service science related activities and achievements at Jordan University of Science and Technology.

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1. INTRODUCTION

Cloud computing is an emerging computing paradigm that is continuously evolving and spreading. Empowered by hardware virtualization technology, parallel computing, distributed computing, and web services, cloud computing presents a great revolution in the information and communication technology sector (Buyya et al., 2009). Cloud computing can be defined as "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" (Mell et al., 2011). There are several examples of emerging cloud computing infrastructures and platforms such as Microsoft Azure (Mell et al., 2011), Amazon EC2, Google App Engine (Chappell, 2008) and VCL (Rindos et al., 2010). Furthermore, CC helps companies to improve their IT services, it also helps in the development of applications to achieve unlimited scalability, as well as in the automaticity of on-demand services of the IT infrastructure, and increasing their revenues (Joshi et al., 2011). Cloud Computing services include: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Clients in CC might be users in other Clouds, organizations, enterprises, or might be a single user.

The Virtual Computing Lab (VCL) represents a true cloud computing solution that has been optimized for the educational and research needs of the academic community. Research began in 2002, with the first general production system launched in 2004 by North Carolina State University with support from the IBM Center for Advanced Studies (CAS), IBM corporate university relations, and IBM hardware development. It has been continuously improved upon for more than eight years, and is therefore extremely stable in production environments (Rindos et al., 2010). In 2012, the North Carolina VCL cloud (NC VCL) had delivered a quarter million user sessions to its students and faculty. Originally developed as the education and research cloud computing production system for NC State University, it now supports students at other universities within the University of North Carolina System, and many schools within the North Carolina Community College System. There are also several K-12 outreach pilots across the state. Similar education clouds based on VCL can be found in California, Virginia, Georgia and other states, as well as within the Historically Black Colleges and Universities (HBCU South) community as part of the HBCU Cloud initiative. VCL-based education clouds also can be found in Europe, the Middle East, India, China and Japan, with additional North American VCL efforts in Canada and Mexico. Its spread accelerated dramatically when VCL became an Apache open source project in 2009. On June 2, 2011, IBM announced the IBM SmartCloud™ for Education portfolio that included a set of solutions and services built upon VCL. VCL has been in reliable and secure operation in North Carolina since 2004. It has scaled today to more than 2,500 servers, supporting about 200,000 software images (services) in its library. It has easily scaled to this size over the years, becoming more efficient as the user population grows, allowing for judiciously alignment of peaks and valleys in resource demands of a large, heterogeneous user population while maximizing utilization and minimizing purchasing costs of hardware and software resources. Maintenance of the system requires about 2 full-time equivalents (FTEs). Given the energy efficiency of its chosen servers, discussed later, NC State is operating its cloud at just pennies per compute hour, with most universities that have adopted VCL experiencing annual total cost of ownership reductions in the range of 50 percent to 80 percent or more (Rindos et al., 2010).

VCL can deploy a wide range of solutions, from complex server clusters, to blocks of machines installed with all necessary software applications or middleware for a regularly scheduled class of