LEARNING SOLUTIONS WITH CLOUD TECHNOLOGIES

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Graphical abstract

Abstract

This paper presents a new approach to the organization of ICT training courses on the basis of the designed and developed a private training cloud prototype. The developed prototype was built on the Microsoft System Center 2012 resources, which allowed consolidating high-performance computing tools, combined different classes of storage devices and provided these resources on demand. We describe the implementation of SaaS private cloud model for ICT user courses and PaaS model - for ICT programming courses.

Keywords: Cloud computing; virtualization; private cloud; hybrid cloud; learning; case-based reasoning

1.0 INTRODUCTION

Cloud computing is a newly developed technology that combines virtualization resources to deliver IT services through on-demand mode and the Internet technology [1]. It's obvious that traditional training methods are insufficient to the modern educational requirements, especially in higher education [2]. It's necessary to adopt traditional approach and methods to the new data capacity and employment market requirements. Modern technologies should assist teaching process, support more efficient information and knowledge interchange. The possibilities of cloud computing for improving education efficiency is being confirmed by a number educational institutions in US (The University of California at Berkeley, Medical College of Wisconsin Biotechnology, Bioengineering Center in Milwaukee etc.), Great Britain (Leeds Metropolitan University, the University of Glamorgan, the University of Aberdeen, the University of Westminster, the London University's School of Oriental and African Studies, the Royal College of Art etc.)[3], Russian Federation (Moscow University of Finance and Law, Plekhanov Russian University of Economics, People's Friendship University of Russia etc.). All these establishments have their different educational courses, laboratories programs and researches in the cloud, because it makes them less expensive and more flexible, all the users can get access and customize their own options working with a various amount of data. Cloud computing gives business, government and educational organizations new opportunities to deploy and maintain various applications allowing for greater flexibility and less complexity [4, 5]. These technologies have a broad perspective including computing and networks resource optimization in compliance with business and educational needs. Besides the effective and reliable services, consumers can achieve flexibility, scalability, accelerated deployment and services' cost reduction [6]. Cloud technologies can also be considered as an appropriate base for new ontology learning with case-based reasoning (CBR).

This paper is based on the results of the research project "Corporate cloud infrastructure

implementation and development for highly qualified personnel system formation" in ITMO University, St-Petersburg, Russia. The project was related to the following problems: modern virtualization and clouding technologies research, training private cloud prototype design and creation for load testing, the options of typical hardware and software system for training private cloud creation, private cloud implementation in the educational process. Nowadays training cloud technologies are usually implemented in higher education programs. The main difference of this project is a practical focus not only on higher education programs, but on using a private training cloud in the professional retraining programs including ICT user, programming and system administration courses.

The paper presents the main project results and is structured as follows: Section 2 contains the essential items of building an educational process using an extending virtualization with cloud technologies. Section 3 presents a set of target features for ICT courses infrastructure, particular qualities of training private cloud deployment and implementation, the main methodical and organizational advantages of using private cloud in educational process. Finally, Section 4 concludes this paper and presents a brief outline of the research perspectives.

2.0 CLOUD TECHNOLOGIES IN LEANING PROCESS

Modern computer technologies allow of transition to new learning ontology founded on case-based reasoning and interact with machine learning approach. This approach requires high-performance workstations and scalable hardware and software. In this way virtualization tools help to reduce the number of physical machines and software deployment required for training to each participant of the educational process. It is reached by transition on the virtualized environment.

Virtualization environment allows virtual machines to be located far away from the student, for example in the data center. Each virtual machine has its own hardware settings, an operating system, installed services and applications. For the student connecting remotely, the experience will be similar to working on a real workstation. With the network support students can access their virtual desktops from any device. From the point of view of technical support, service tasks of such environment become simpler.

But a more effective way of building an educational process is extending virtualization with cloud technologies. The movement toward cloud technologies brings increased choice, flexibility, and capabilities in e-learning. With cloud technologies, we get needed software and computing resources where and when we need them. It gives technical support more flexibility to manage scaling in ways

that are largely invisible to users. The cloud technologies give us choices about how to manage costs according to our preferences. Cloud services help to reduce operating costs by pooling computing resources and allow reassigning of resources dynamically according to demand. Cloud technology helps users manage inquiries frequency and reduce the cost of IT infrastructure by less ongoing maintenance, and shorter deployment time. Cloud services can be scaled up or down according to actual needs. It would be desirable to note that there can be limitations and difficulties when using cloud environment, which consist of security issues and limited support of allowed applications to run.

There are three models most often used during creation an training cloud: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). In IaaS model students can manage hardware resources allocated to them [7].They can create networks their own, customize virtual servers and workstations and install any operating systems and software. Such model is suitable for IT technical training. PaaS cloud model allows developing cloud services and applications. It includes programming and debugging tools and application hosting services. This model is useful for developers. SaaS allows students to work with cloud resources on application level transparently. There is no need to study specific features of work in SaaS-based clouds.

Consideration of the existing state of affairs in the organization of educational process revealed the need for large quantities of high-performance computing with uneven loading.

Up-to-date learning ontology can't be effective without case-based reasoning, that requires application of learning paradigm with sustained learning using data storages and software applications that realize sets of reasoning methods with the purpose of getting relevant knowledge from the experience, inserting a case into an existing knowledge database, and matching it with similar cases [8].

The solution to this problem lies in the utilization of one or more (with account to ensure full fault tolerance) data center, provisioning computing resources with the possibility of consumption on demand located on consumer's territory, i.e. a private educational computing cloud. This will give an opportunity to consolidate high-performance computing tools, combine different classes of storage devices and provide these resources as needed. A large part of educational and work places can be equipped with a thin client, as it will only provide the link with the private cloud services.

Our first step to realize the learning ontology is a project of learning information transfer to the learning cloud. Our first step to realize the learning ontology is a project of learning information transfer to the learning cloud.

In this project were used computer and network equipment,   licensed software, knowledge of

software and technologies, highly qualified scientific and technical staff with relevant competencies, partnership with leading suppliers of computer and software vendors with the purpose of advanced virtualization and cloud computing consultations.

3.0 LEARNING CLOUD PROTOTYPE

ICT courses connected with the project can be divided into three groups: user courses, programming courses and system administration courses. According to each group's purposes there was a need in creating a different infrastructure with appropriate hardware and software. By now the project prototype includes SaaS private cloud model for user courses and PaaS model -- for programming courses [9].

Benefits of cloud technologies are obvious. You get more flexibility and an easier access to advanced resources. The best starting point is virtualization, which enables effective use of existing resources.

We investigated the server virtualization solutions vendors, marked and selected the most suitable product reasoning from its parameters and cost. Hardware configuration was chosen according to vendor's recommendations and the most suitable and advantageous was IBM solutions - IBM System X Servers, IBM Blade Servers, IBM Storwize storage systems. It offers comprehensive systems management tools including advanced diagnostics, easy deployment, integration and management are obtained due to a single point resources control.

The Software decision was based on testing of several popular cloud platforms. We considered productivity, cost, and simplicity of the configuration, supported functions. As a result we chose Microsoft and its private cloud solution - System Center 2012 R2 Platform [10].

To implement learning cloud project we used the following components, which are illustrated in Figure 1.

- The key component of private cloud infrastructure was Microsoft System Center Virtual Machine Manager 2012 R2. We used it to configure and manage our virtualization hosts, networking, and storage resources in order to create and deploy virtual machines and services.
- System Center Orchestrator lets us automate the creation, monitoring, and deployment of resources in our environment.
- To implement solution for change and configuration management we used System Center 2012 Configuration Manager (SCCM). SCCM allows deploying operating systems, software applications, and software updates, running hardware and software inventory, and remotely administering software systems.
- To avoid security intrusion, System Center 2012 Endpoint Protection was used. It allows centrally

deploying and configuring the antivirus software, configuring antimalware policies, managing Windows Firewall settings, automatically downloading the latest antimalware definition files to keep client computers up-to-date.
- System Center 2012 Data Protection Manager was used to enable data protection and recovery.
- Productivity and performance criteria were monitored by Microsoft System Center Operations Manager 2012 (SCOM 2012) that can monitor network routers and switches, including the network interfaces and ports on those devices and the virtual LAN (VLAN).
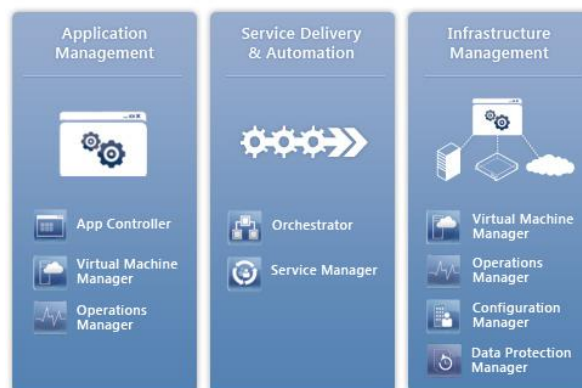

Figure 1 Learning cloud project components

To create SaaS infrastructure, a pool of Windows Terminals Servers was used that enables to make programs that are accessed remotely through Remote Desktop Services appear as if they are running on the end user's local computer.

For our programming courses we need a platform including Microsoft Visual Studio .NET, Microsoft SQL Server, web servers and some other software. Also there is a need to grant administrative privileges to software developers for example for web-server and db-server configuration. All the concerned problems were decided by using virtualization technologies in PaaS cloud model. There were created pattern sets of virtual machines the software appropriate for the programmed learning process. Each student has an access to virtual machine based on the pattern, so in case of error conditions the system can be restored in a couple of minutes, as shown in Figure 2.

Figure 2 Organization learning scheme

To improve the quality of service in the private educational system, there were introduced cloud control events and incidents in accordance with the basic principles of IT Service Management.

At present we deploy IaaS services and the next planned step of our activity is developing machine learning techniques and user modelling. The main aim is to adapt the learning system to the needs of an individual student according his specialization, timetable, and learning rate. It should be adapted to the personal user interface requirements, provide access to special software and development systems with the possibility of software creating for different hardware platforms.

Besides, this learning system will include educational software with request filtering. It's necessary to design user modelling system that can receive, filter and analyse user information and requests and represent relevant learning information. At the beginning of the learning process, explicit modelling methods can be used for such personalization, and during the process implicit methods can also be included in the process [11]. It takes a lot of time to solve all these problems because we need large informational and training data sets, educational data indexation and appropriate computational complexity according to our resources [12]. Moreover, learning process requires a flexible IT-infrastructure that can be scaled on demand. With a private cloud it can be flexible and manage resources more effectively.

According to the experience there are some methodical and organizational advantages of using private cloud as shown in Tables 1-2. From the methodical point of view learning with clouding can significantly reduce the time and cost of the learning materials acquisition and improve the educational competitiveness. All the handout and guidance manuals are in the cloud storage and can be provided upon teacher or student request.

Table 1 Methodical support learning

Traditional Learning System		Learning with Using Cloud	
Advantages	Problems	Advantages	Problems
Educational materials hard copies	Expensive handout and guidance manuals	All the materials are in the cloud storage and can be provided upon user request	Internet access problems
	Much time for manuals ordering and purchasing	Low cost of the educational manuals	Technical problems
		Improving the educational competitiveness	

From the organizational point of view all the technologies and educational materials can be updated as fast as it needed and can be available for students immediately after updating. Every educational course can be started fast upon personal request and has flexible contents, schedule and technologies.

Table 2 Learning organization

Traditional System Advantages	Learning Problems	Learning with Using Cloud Advantages	Problems
Full-time study with a teacher	Subjective perception of learning with a specific teacher	Using up-to-date technologies versions and constantly updated learning courses	Technical problems
Personal contact in learning group	Possible low level of training on some complex topics	The possibility of attracting several certified teachers	Psychological problems for some students without personal contact and feedback
	Difficult training scheduling	If necessary, the possibilities to involve highly qualified specialists for training Course can be started fast upon user request	

In the Tables 3-4, the design of private clouding results is shown. We designed a cloud infrastructure for the University' faculty needs with the number of students up to 1000 per semester/year, with about

200 students working at the same as shows in the Estimated Loading and Estimated Cost columns of the Table 3.

For clouding design realization there were used three types of virtual machines (Tables 3-4): *Small* for basic or introduction courses, *Medium* for software development courses and *Large* for advanced databases courses or complex mathematical calculations courses.

After deployment of a private learning cloud prototype we received significantly higher efficiency of this solution as shows in Real Covering and Actual Cost columns of the Table 4.

Table 3 Clouding learning resources - Design phase

Virtual Machine Type	Spec	Estimated Loading	Estimated Cost, Per Student Seat
Small	1 CPU / 2 Gb RAM / 30 Gb HDD	up to 200 / 1000	$ 400 / $80
Medium	2 CPU / 4 Gb RAM / 60 Gb HDD	up to 100 / 500	$ 800 / $160
Large	4 CPU / 8 Gb RAM / 200 Gb HDD	up to 50 / 150	$ 1600 / $533

Table 4 Clouding learning recourses - Design phase

Virtual Machine Type	Spec	Real Covering	Actual Cost (Concurrent Online Students/ Total Students)
Small	1 CPU / 2 Gb RAM / 30 Gb HDD	up to 350 / 3000	$228 / $27
Medium	2 CPU / 4 Gb RAM / 60 Gb HDD	up to 200 / 2500	$400 / $32
Large	4 CPU / 8 Gb RAM / 200 Gb HDD	up to 150 / 2000	$533 / $40

When needed to be extended it can use all the benefits of a public cloud, so all the processes are taking place in a hybrid cloud model.

A hybrid cloud supports all the opportunities of both a public and a private cloud, and all the advantages of internal management and external resources can be used without adding complexity. Learning process workloads can be moved from local datacenter to service provider's datacenter without any changes in the infrastructure. All the applications can be developed and used both on-premises and as cloud resources, all the data can be distributed to storages with increased efficiency and reduced costs.

4.0 CONCLUSION

The article presents the creation and implementation technologies of private educational clouds for ICT training courses. Its development brings in benefits such as cost saving, ease of use, scalability and flexibility. As a result of using the learning cloud prototype deployment and its usage throughout a year there was an increase in the number and quality of learning courses, and a decrease in computational burden and deployment time. A future development could be issues of providing security access for students to the educational materials placed in private educational clouds, as well as the automation of cloud access with various mobile devices.

Acknowledgement

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