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Clouding Technologies for Training

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Abstract This paper presents a new approach to the organization of computer training on the basis of the private training cloud prototype designed and developed by the staff of Software Development Department at ITMO University. Modern IT technologies were used to create a private training cloud prototype which made it possible to consolidate high-performance computing tools, combine different classes of storage devices and offer these resources to both educators and trainees on demand.

Keywords Virtualization, Clouding, Public and Private Clouding

1 Introduction

Today the cloud is used everywhere. The progress in Information Technologies made cloud technologies extremely popular. Almost all major IT vendors offer a variety of cloud solutions and services. The vast majority of modern computer-related courses require substantial computing resources, large amount of memory and high bandwidth network connections. Therefore cloud services are a natural choice of infrastructure to use in many curricula.

Based on the services which cloud computing platform provide to its users, they can be classified according to the following models [1, 2, 3]:

- Platform as a Service (PaaS) provides a client with a cloud infrastructure where client's software and applications can be placed. Usually such platforms also come with a set of tools for writing, testing, and deploying applications.

- Infrastructure as a Service (IaaS) is a service which allow a client to use cloud infrastructure to independently manage computing resources, storage systems, networks,a nd other fundamental resources.

- Software-as-a-Service (SaaS) offers software which belongs to the provider for use by its clients. Cloud provider usually retains control over the major physical and virtual cloud infrastructure and manages networks, servers, operating systems, and storage devices.

Cloud solutions have drawn substantial attention over the last years, and substantial efforts have been made to research different models and architectures of this computing paradigm. However, using clouding in education presents challenges which are different from other uses of shared infrastructure approaches. Our primary motivation was to identify these challenges, analyze them, and present such a solution which could be easily reproduced in an educational setting.

2 Virtualization in Education

The majority of courses aimed at teaching modern computer technologies require high-performance workstations to provide the best learning experience for students. For some disciplines it requires two or more computers for each person. Clearly, it requires substantial effort to install, maintain, update and upgrade classrooms with multiple physical machines. Besides, each machine is only used a fraction of its ability, so the utilization ratio remains very low.

To some extent virtualization tools are able reduce the number of physical machines required to provide training to each participant of the educational process. At the same time the tools supplied by different vendors get increasingly complex. Consequently, planning, deploying, and integrating these solutions demands careful consideration and the knowledge of each product's requirements and particularities. Quite often, heterogeneous systems and networks are studied in the most current computer training courses. In this case it is necessary to have two or more network-enabled physical computers connected for every student and teacher.

3 Using Clouding

As mentioned earlier, given that computer laboratories load is not distributed equally within the training schedule, some of the computing resources are inevitably left idle which means that they are used inefficiently. Balancing the load is not possible in many cases since the requirements for different computer courses vary greatly.

Virtualization technologies are receiving increasingly large amounts of cloud computing funding. The advent of virtualization approaches substantially broadened the notion of a service. With such a service-oriented mindset, many existing solutions ca be rethought of in terms of the service: software as a service, platform as a service, infrastructure as a service and so on.

The biggest advantage of cloud technologies is that during peak load periods the computing resources can be promptly received and then returned back to the resource pool when demand decreases. An important property of this model is that a consumer will be charged only for the resources that have been actually consumed. There is also an added benefit for the consumer since cloud computing does not require making large investments to acquire and maintain a dedicated own infrastructure. A cloud computing solution allows building a system which would be able to withstand peak loads of its clients and maximize its efficiency by utilizing most of the resources [4].

4 Public and Private Clouding

According to [5] there are several types of clouds depending on the purpose of creating a cloud infrastructure and the location of its components.

A public cloud is one in which all the necessary computing, communication, and infrastructure hardware is based outside of the client's premises. In other words, there is some other party, often called a Data Processing Centre (DPC) or provider which provides all cloud computing services to the client. In this case a reliable high-speed network connection with the provider is required.

Private clouding is more flexible but it requires that at least some of the hardware physically resides on the client's premises. It provides a benefit of greater control over which technologies are used and how data is processed. Besides, the dependency on external communication channels is a lot less significant in this case than with a public cloud.

5 Educational Private Clouding

A study has been conducted to determine the organization's requirements for computing resources which are necessary to support the educational process. It revealed that a lot of high-performance hardware is needed while only a small fraction of that computing power is going to be utilized to its full potential. It would lead to the resources being loaded unevenly with occasional high load spikes and prolonged periods of underutilization. The solution to this problem is to use one or more (to provide full fault tolerance) data centers which offer computing resources to be consumed on demand. Since the equipment is going to be placed on the client's territory, this solution then falls into the private educational computing cloud category.

Implementing a private computing cloud for the purposes of teaching computer-related courses gives an opportunity to consolidate high-performance computing tools, combine different classes of storage devices, and provide these resources on demand. A large part of workstations for trainees and instructors can be supplied with merely a thin client capable of just providing a link with to the virtual machines running in such a private cloud. Of course, some workplaces for researchers and instructors would still require standalone high-performance workstations and servers. However, the major part of the total educational process can be transferred to the cloud.

Private cloud solutions rely on components supplied by one of the vendors which offer private computing cloud products. There is a relatively small number of major IT companies that offer such products but technical specifications, licensing mechanisms and costs vary greatly. It is therefore essential to properly analyze available solutions and select the best set of components suitable for a particular task. The landscape of available solutions also changes over time. We looked at Gartner data [6] which shows how the market of cloud solutions has been changing from 2012 to 2014. From that data it is clear that the major portion of the market is dominated by only one or two vendors. We analyzed solutions offerd by two major vendors as of 2014: Microsoft and VMWare. Based on our analysis we found that based on our scalability, reliability, performance and cost effectiveness requirements Microsoft Private Cloud was a better fit for the educational process at ITMO University.

6 Objectives

In order to implement an educational private clouding solution the following steps need to be completed:

1. Review existing virtualization and private clouding technologies
2. Develop a conceptual model and devise benchmarks to test its quality
3. Build a prototype and perform computer testing to verify that it satisfies the requirements
4. Develop at least three different hardware and software private clouding models

As a result, a comprehensive reproducible solution for private training clouds will be obtained. This educational cloud can then be integrated into the educational process of ITMO University and offered as a product to other universities and companies.

7 Resources

Computing resources: computers and network hardware; licensed software; knowledge of software and technologies; highly qualified scientific and technical staff possessing necessary competencies; partnerships with leading computer and software vendors with the purpose of advanced virtualization and cloud computing consultations; appropriate remuneration for project developers.

8 Relevance

Virtualization and cloud computing technologies are currently the most popular topics not only in Information Technologies but in other fields as well. Introducing such innovations in education gives opportunities for students to participate in advanced courses and for the University to save money and computing resources.

9 Scientific research areas

Research activity aimed at creating a private training cloud makes it possible to choose the optimal virtualization and cloud technologies from a range of possible solutions which exist today as well as to outline areas for further research and private development of technologies and products.

Successful implementation of this pilot project can be replicated to accumulate experience and knowledge and promote innovative entrepreneurial activities as well as to establish private training clouds at other departments and educational institutions. It will also be possible to implement such solutions in other non-educational organizations and in the private sector [7].

10 Main project tasks

One of the major objectives of the project was to provide an overview of existing and emerging new virtualization technologies. Besides, it was essential to create a pilot private cloud and test its scalability in various configurations. As a result, a repeatable solution for designing and building private educational clouds has been created. Such private clouds cab successfully used in the educational process of ITMO University as well as other educational institutions, private companies and enterprises from different fields [8]. It has been shown that it is possible to create a special "cloud" of units within the organizational structure of ITMO University.

11 Performance indicators

Successful implementation of this project introduced the University to cloud technologies. Applying the private cloud in educational and scientific activities allowed ITMO University to consolidate its status of a Russian leading educational institution which is providing priority directions of modernization of the Russian economy and explores new emerging opportunities.

The newly created private educational cloud will give the opportunity to consolidate high-performance computing tools, combine different classes of storage devices, and provide these resources on demand. A large part of educational and work places can be equipped with just a thin client which provides a link to the virtual machines running in such a private cloud.

Another benefit of using cloud computing to teach various courses is that it creates a unified information space which can be used to store and provide access to teaching materials and aids (course modules, lectures, recordings, lab solutions), facilitate administering tests and exams, and serve as a platform for other information related to the educational process (schedules, news feeds, announcements, etc.)

12 Demand solutions

The ability to develop cloud computing solutions and integrate them into the educational process makes ITMO University one of the leaders in IT industry. The following Table shows the trends in the development of cloud technologies over the last two years.

Table 1. Development trends of cloud computing

2012	By 2014
Hosting is the fastest growing segment of Microsoft business. Growing 4 times faster than license sales of large businesses.	Over 80% of new software will be distributed and used within the cloud [9].
The number of cloud instances is growing at a rate of 45% each year.	33% of all new software will be using SaaS model [9].
Server SPLA licenses sales is growing three times faster than other software licenses.	Cloud service providers will cover more than 20% of the cost of servers and storage systems

The following results were obtained as outcomes of the educational cloud project [10, 11]:

- A private educational cloud has been designed and implemented
- New research results have been published and made accessible for the scientific community
- Reproducible solutions have been obtained and documented, making it possible to supply them as a product

Potential customers that can benefit from the project outcomes include but are not limited to:

- Universities, institutes, colleges
- Secondary and special educational institutions
- Government authorities of all levels (federal, regional, and municipal)
- IT companies
- Telecommunication companies
- Industrial companies
- Professional and business communities

Potential partners and other collaborators capable of helping with development of future cloud computing solutions for education can be identified as follows:

- Universities, institutes, colleges
- Research institutions
- IT companies
- Private and government owned companies

13 Summary

The paper describes the process of designing, creating, implementing, and verifying the performance of a private educational cloud solution and studying its application in teaching ICT courses. Although substantial effort is put into researching cloud computing architectures and models, this is still a relatively new field. Many solution exist only as pilots,

and their properties still need to be studied and compared to alternative solutions. In this paper we considered the use of cloud computing in the educational process of ITMO University, one of the leading technical universities in the country. We found that using cloud technologies can be successfully used in education by bringing the students to the most recent advances in IT, AT the same time, such solutions are cost efficient and substantially alleviate the burden of managing the infrastructure. However, some issues still remain. First of all, it needs to be studied how to provide students with a secure access to educational materials stored in private educational clouds. Another direction of further research is the automation of access to the cloud using various mobile devices.

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