

# Cloud platforms and virtualization technologies in education

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**Abstract.** The article discusses the use of cloud platforms and virtualization technologies, including those based on virtual machines from Microsoft, Amazon, Google, Yandex, Mail.ru for organizing universal training workstations for students with the unification of system and application software for individual study. The main advantages of using cloud-based software over traditional academical one in the educational environment are considered. The great attention is paid to the issues of organizing a virtual workplace in order to increase the effectiveness of training both in the educational organization and outside the classroom. The materials presented were tested at the Department of Computational Mathematics and Methods of Teaching Computer Science in the classroom by the authors of the article.

## 1 Introduction

Today, cloud technology is one of the most topical areas in the development of information and communication technologies. This direction started its grow from cloud services for storing, synchronizing and sharing data, such as Dropbox, Google Drive, OneDrive, Yandex Disk, Cloud Mail.ru and other similar services. At that time, these services allowed only to store information and exchange it via the Internet. Then, cloud-oriented operating systems and virtual desktops were introduced, which, in addition to accessing files, allowed creating desktops with access to various software - mail clients, calendars, office applications, image editors, etc. The main advantage is that physical resources of the client device are practically not used, while working with such virtual desktop services. The only need is the resources for launching and running the browser to access Internet services.

Remote access to virtual desktops is possible from any device, for instance, mobile, laptop, tablet or smartphone with access to the Internet. The main disadvantage of cloud-based operating systems and virtual desktops is limited number of used software.

Novadays, one of the main tasks for an educational organization is to provide an opportunity for future specialists to continuously improve the knowledge in information technology due to rapidly growing market requirements to their skill [1]. The implementation of such an approach requires the use of new teaching aids, including those based on information technology.

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Earlier, we conducted research on the use of cloud technologies and virtualization systems in education [2, 3, 4]. They showed positive dynamics and high efficiency of using cloud services of various kinds and virtual technologies in the formation of Information and Communication Technology (ICT) competencies while teaching the basics of information technology.

The purpose of this research is to create and test the effectiveness of using universal training workstations based on cloud systems and virtualization technology.

At the first stage, a workplace model based on cloud applications and virtualization technology was developed. The model included the selection of cloud platforms for organizing virtual workplaces, the development of a scheme for the interaction of teachers and students, the definition of tools for assessing the effectiveness of its application in the student learning system.

Currently we perform the second stage, which consists in the application of the model of universal training workstations based on cloud applications and virtualization technologies in the student learning system.

National Institute of Standards and Technology - NIST, in report «NIST Definition of Cloud Computing v 15» [5], defined cloud computing as a model that enables convenient network access to shared custom computing resources (such as networks, servers, storage, applications, services, etc.).

A virtual desktop is a virtual space that expands the capabilities of the desktop of a PC or a mobile device thanks to specific software. Thus, this eliminates the actual limitations of the available workspace of desktop, allowing opening at the same time more applications and using additional workspace of the system used.

However, cloud systems and platforms have taken the next stage of development, and public virtual machines based on cloud platforms for deploying virtual desktops have appeared. There are a number of cloud platforms that can be used to create virtual machines in the cloud: VMware vSphere, Amazon Web Services, Microsoft Azure, Google Cloud Platform, Yandex. Cloud, Mail.Ru Cloud Solutions and others. Using these systems, the developers realized the possibility of obtaining a full-fledged workstation with administrator rights in the environment of traditional desktop operating systems. Extensions of the physical parameters of the computer, such as RAM, the number of processor cores and the amount of hard disk, became available. There was an opportunity to choose the installed operating system - a variety of operating systems from Microsoft and various dialects of Linux.

In fact, it is not so important for the user whether the computer he is using is physical or virtual. The main thing is that it works correctly and can perform the required user tasks. If the physical and virtual servers are not much different in their functionality, then according to other criteria, a virtual server has a number of important advantages. When planning a server configuration, it is very difficult to predict the real load on it during further operation. But the virtual system allows changing its power almost instantly compared to physical one. It is very difficult to sell a physical server that has become irrelevant in terms of key characteristics, but with virtual servers as you need at the moment: create new ones, modify existing ones, delete old ones.

Traditionally, most of the existing training computer laboratories are equipped with proprietary software from Microsoft and, less commonly, free software that includes Linux operating systems [6]. Besides, application software, including office software, are used from the same software families: Microsoft Office, LibreOffice. At the same time, it is not relevant software what is already installed on personal computers, laptops, tablets, smartphones and other personal devices of students.

The current situation with the organization of universal educational workstations can be changed and effectively improved, taking into account the possibilities of using cloud

applications and virtualization technologies. There is no need for significant free space on the local disk, and the performance requirements for a personal computer or mobile device are minimal, since cloud technologies are inherently undemanding to the software and hardware resources of connected clients.

The problem of the efficiency of using cloud platforms and virtualization technologies was considered in a number of papers by both foreign and Russian scientists. Jarumon Nookhong's research revealed good results on the effectiveness of using individual learning using cloud technologies and social networks to improve problem-solving skills and ICT literacy among students [7]. A Sadaf Ashtari research presented the results for students' perceptions of the effectiveness of cloud applications in higher education. As expected, students were partially familiar with cloud services and talked about their effectiveness in terms of accessibility, ability to exchange data. However, most were deterred because of data privacy concerns and fear of losing their data [8]. Mercedes Barrionuevo [9] discussed about the power of virtualization in terms of creating virtual labs. As one of the proposed goals of the research, it was to identify opportunities for students to work independently with virtual laboratories outside of classrooms. But during the research it turned out that not all personal computers of students had hardware support for virtualization (less than 40%), and, as a result, most of the personal computers of students were not able to fully participate in the experiment. Albert Huang in his paper introduced the course "Network and Telecommunications Management" with the use of virtual machines [10]. The course was based on students using VirtualBox virtual machine. Students noted positive results, while training on virtual machines, and the author emphasizes the limited use of virtual machines even 20 years after their invention.

However, in these studies, not sufficient attention was paid to the organization of universal workstations based on cloud applications and virtualization technology in the environment of cloud platforms and mobile systems, such as based on virtual machines from Microsoft, Amazon, Google, Yandex, Mail.ru.

## 2 Materials and Methods

To solve these problems, we propose to replace and unify the traditional means of information technology: a powerful personal computer, the availability of which is not possible for all students, operating systems, which, as a rule, differ among students the presence of one or another software installed on personal computers, laptops, tablets, smartphones or other students' devices - by means based on cloud platforms, mobile virtualization systems and technologies.

Currently there are four types of virtualization [11]:

- desktop virtualization, thanks to which several desktops can be organized and managed on one server;
- network virtualization, which is intended to divide the network bandwidth into different channels, and then assign them to servers;
- software virtualization, which helps separate applications from operating systems and technical devices;
- storage virtualization, through which several users gain access to a storage device that includes several network attached storages.

One of the most popular virtualization systems is Oracle VM VirtualBox, which was also used by Albert Huang in the research [10]. It has intuitively clear interface, and it is quite easy to master its functions without using any instructions. Another well-known virtualization system is VMware Workstation, which is designed for professional use. Unlike the Oracle VM VirtualBox, this application has the ability to emulate a basic input/output system. Some cloud platforms, such as Amazon Web Service and Microsoft

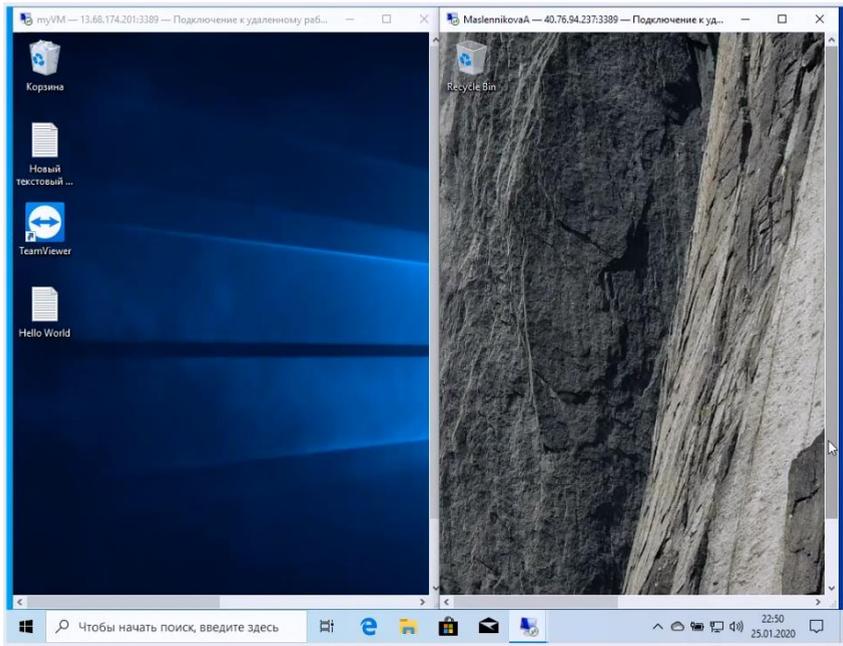
Azure, can provide users with access to virtual computers that are no different from physical devices, but have a great advantage: users can access from anywhere where Internet connection is available. For example, Amazon Web Service can offer up to 136 types of virtual machines to launch. Thus, one can organize remote work, while all data is stored on the server and is protected from erasing on loss. This type of virtualization depends on access to the Internet, but it is very convenient to use. Currently, Microsoft Azure can provide its customers with more than 600 services. Among them there are services for computing, data storage, data management, networking, messaging, media services, etc. For instance, the Virtual Machines service enables the user to run virtual machines on Linux and Windows, while the platform allows the creation of machines of various configurations that differ in their characteristics and functions. The user can choose the option that suits his needs the best: low-cost option, but limited in resources, or a powerful computer for high-performance computing, the cost of which will be much higher.

Russian companies Yandex and Mail.ru Group also offer their solutions in the field of creating virtual machines and remote virtual desktops on the base of the cloud platforms Yandex. Cloud and Mail.Ru Cloud Solutions respectively. These platforms offer various categories of cloud resources, for example, virtual machines, storages, databases, graphics adapters, etc. One can manage the resources of each category using the appropriate service remotely from any device with Internet access.

In the research conducted at the Department of computational mathematics and computer science teaching methods, lessons were organized and conducted using remote virtual desktops created in the CloudTop cloud service (Figure 1) and the Microsoft Azure cloud platform (Figure 2).



**Fig. 1.** CloudTop. Cloud-based virtual desktop CloudTop.



**Fig. 2.** Microsoft Azure Virtual Desktop Demo.

Mostly the use of Microsoft Azure features has fee, but there is an opportunity for students and teachers to access various platform services and services for free for educational purposes.

Using technology from Microsoft, the educational process associated with programming and developing web applications is complemented by new technological capabilities based on cloud computing. The Microsoft Azure platform supports working with any programming language based on the use of .NET development tools and Visual Studio. Besides, for students learning the basics of programming, Microsoft Azure provides a virtual environment for creating applications with the possibility of the development and debugging of programs right in it.

Microsoft Azure contains a package of services designed for widespread use both in education and in everyday life:

- cloud services performing their role in deploying applications and websites;
- storage service designed for synchronization, recovery and storage in the cloud;
- resource provisioning services that allocate memory and computing resources, as well as offer virtually unlimited access to information from any device;
- communication services that connect cloud infrastructures via the Internet and allow to access own web application or site from any device.

In addition to Microsoft Azure, Microsoft offers another cloud-based service, including for educational organizations - Office 365.

This cloud service has all the features that are characteristic of traditional integrated office software. It also provides a number of additional functionalities convenient for the educational sector: an integrated Outlook email client for messaging, video chat, voice chat, remote viewing and editing of various types of documents, customizable sharing of access to certain resources, and much more. The educational version of Office 365 provides Microsoft Office applications and their online version of Outlook, Word, Excel, PowerPoint, OneNote. For collaboration Microsoft has developed cloud-based versions of Exchange Online, SharePoint Online, Lync Online, which can be effectively used to

organize convenient and efficient interaction between the teacher and students in the educational process.

To gain remote access to a virtual desktop based on Microsoft Azure, a student must have a login and password to log into the system which is provided by his teacher. Virtual desktop files (with RDP extensions) are run in a virtual machine environment (control terminal) on the personal computer of teacher. Therefore, it is possible to track students' entrances to their workstations, remotely help students, check the working capacity of virtual desktops, promptly offer training tasks and monitor the process of their completion, etc. At the same time, students get access to their workstations using remote access from a personal computer or from mobile devices (tablet, smartphone, etc.). Remote access to workstations can be performed using a personal computer or mobile device using regular access to a remote system or any of the following applications: TeamViewer, Jump Desktop, Splashtop, PocketCloud or Unified Remote.

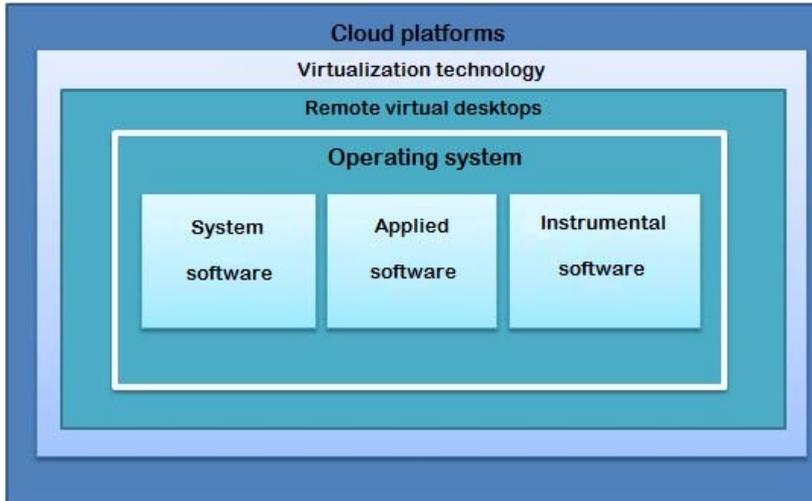
Using virtual workstations based on the Microsoft Azure cloud platform and preinstalled application software, including the Office 365, can improve the quality of training in general. It is fast enough and has a low cost to organize and provide students with functional virtual workstations that meet all the relevant requirements for ensuring information security. It facilitates the practical implementation and implementation of joint training projects for students in a secure network environment, offers a functionally rich virtual work environment, for collaborating on documents and files as part of educational tasks.

### **3 Results**

Cloud platforms and virtualization technologies are constantly evolving and improving.

Virtualization helps facilitate the work of many organizations. It sets up a virtual network, run many virtual computers on one physical device. Cloud platforms and virtualization tools also play a significant role in education, since it is possible to test various software using virtual machines, study the functionality of software (including those, which are quite demanding on computing resources), and organize joint training using personal computers and mobile devices.

The figure (Figure 3) shows the organization of access to the virtual remote desktop and its contents. In this paper, we propose a model for using remote virtual workstations for students based on the Microsoft Azure cloud platform using personal computers and mobile devices based on Windows, Linux, Android, iOS operating systems and TeamViewer, Jump Desktop and Remote Desktop Manager remote access applications from Microsoft. A virtual machine with Windows operating system installed in the Oracle VM VirtualBox environment was used as a control terminal for monitoring educational activities on teacher's part. It ran training virtual machines in Microsoft Azure through Remote Desktop Manager. Thus, student's workstation was preconfigured for work and ready to be used for educational purposes.



**Fig. 3.** Virtual Remote Desktop Access.

## 4 Discussion

The main goal of this article was to show the capabilities of cloud platforms and virtualization technology for organizing universal educational workstations for students and teachers using personal computers, tablets, smartphones, etc.

Significant advantages of using a unified approach to learning using virtual desktops are noted, which confirms the great educational capabilities of the technologies under consideration. The study also revealed that the ability to use the same workstation both at home and in class improve the learning process and students' motivation to use information technology. In addition, some students no longer have a negative attitude to setting up and preparing a workstation, because the virtual workstation is already prepared for work immediately after granting access by the teacher.

For advanced students there is an opportunity to feel like full participants in the process of setting up and working with a computer system, i.e. participate in this process from the moment of the first launch, creation and configuration of a virtual machine, installation of an operating system, connection of various services, installation and configuration of drivers and application software. All this will help the teacher and the student to take a different look at the process of learning information technology, will provide many previously inaccessible means and methods of presenting and obtaining knowledge, using the variety of contemporary personal and mobile devices, owned by the participants.

## 5 Conclusion

The research described in this article is important for developing the practice of using cloud services and virtualization technology and choosing them for the student learning system. Cloud services and virtualization technologies have unique network functionality, which are not inherent in the traditional software environment of personal computers and mobile devices. It will allow students to understand the features of modern communication technologies and cloud systems.

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