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**VIRTUALIZATION AND PROBLEMS OF TRAINING IT
SPECIALISTS**

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Abstract

In the era of digitalization of all branches of human activity, there is an increasing need for the training of highly professional specialists in the field of information technology. Without mobile communications and Internet access, modern society cannot exist. Current trends require a corresponding increase in the quantity and quality of staff. Therefore, educational institutions are faced with the task of training an increasing number of specialists with all the necessary knowledge and skills in the field of information technology. The presented article is devoted to improving practical training of students in IT areas. It briefly outlines the problem of practical training associated with the need to provide each student with the full administrative rights necessary to complete educational practical tasks. This is contrary to security requirements that limit user rights to the minimum. As a solution to this problem, the use of virtual machines is proposed. The results of applying this approach confirming its effectiveness are presented.

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1. Introduction

Virtualization, as an approach to the organization of computing, is currently finding increasing application in various fields of activity. Large companies such as Microsoft, VMware, and Oracle offer users to use their virtual machines for a small fee (implement “cloud technologies”) (Borisenko, 2015; Fogel, 2020; Oracle Higher Education Cloud, 2020; Your Oracle Database in the Cloud, 2020).

The advantage of virtualization is the low cost of equipment and service personnel. Using Web-based interfaces for organizing terminal access (“thin clients”) almost completely removes resource limitations of client equipment. In this case only a network connection and a terminal access client are required, which, in turn, significantly reduces equipment costs (almost any equipment is suitable, including mobile devices - tablets, smartphones, etc.), and also eliminates the need to keep service personnel (Bekenova & Ramazanova, 2013; Bergström, 2020a; Cloud Services at the University, 2020). Virtualization provides reliable operation, simplifies the administration of these virtual machines, the implementation of modifications and the deployment of new systems.

2. Problem Statement

In universities that train IT specialists, there is a problem that they use general-purpose computer classes in which students of all specialties study. While there is no IT in the list of these specialties, everything is fine, since in most cases application packages are used in training. These packages may work under very limited user rights. Therefore, in such classes, users are given minimal rights, which ensure the class is always operational, since none of the students can accidentally or intentionally ruin the system (Christoforou et al., 2015; Conde et al., 2013; Mishnev & Puptsev, 2018).

As soon as students of IT specialties come to the class, a problem arises that is related to the fact that the curriculum contains many disciplines related to system configuration. In order to perform tasks related to administration, students need the appropriate rights. Since students are just learning, they make mistakes that in most cases lead to inoperative system configurations.

To restore the system after such studies requires a large amount of work of a qualified administrator, and, often, fixing these errors leads to the need to reinstall a whole system.

There is a conflict: to ensure the efficiency of computer classes, it is necessary to limit the user rights, and for the training of IT specialists all rights are necessary, but this calls into question the workability of the class. This problem has no solution in local computer classes.

3. Research Questions

This article discusses the issue of resolving the conflict between the requirements for granting full administrative rights to IT students and the requirements for the continuous working capacity of the class, necessary for the organization of the educational process as a whole.

The analysis of the hardware and software required to solve the problem above is carried out.

A way is determined to qualitatively train students in working with various operating systems, building computer networks, programming issues (in the field of software testing), modeling real production situations, issues of comprehensive information protection, etc.

4. Purpose of the Study

This work aims to:

- finding the optimal approach to the organization of practical training in the special disciplines,
- studying the issues of creating a virtual classroom and the impact of such a solution on the learning problem,
- providing IT students with an environment suitable for the practical study of professional and special disciplines.

5. Research Methods

The only possible solution to this problem is to train IT specialists in virtual machines: to give each student their own virtual machine with unlimited administrative rights.

In this case, the crash of the system due to incorrect actions during administration and configuration of the system will lead to the inability to work for only one student; public computers will remain fully operational.

Correction of student errors is done by simply replacing the virtual machine. It only takes a few minutes to resolve these issues.

This is an indisputable advantage of using virtualization tools in universities, in which computers are often very outdated, computing power is weak, maintenance staff cannot always perform their functions qualitatively for several reasons. In such circumstances, the use of virtualization can reduce hardware requirements by using them in the terminal mode as thin clients, and organize the solution of all problems in a single virtualization center, which has at its disposal a small number of high-performance virtualization servers served by a small staff of highly qualified employees.

In the study of many disciplines, the use of virtual machines is indispensable (Bergström, 2020b; Davydova et al., 2017; Kerimbayev et al., 2017; Smolka, 2016; Titovskii et al., 2019). For example, modeling situations of a real enterprise, that cannot be created in an educational institution.

Such opportunities will give students a deeper and more versatile development of the skills acquired through theoretical training. When studying programming, the use of virtual machines provides a more competent approach to testing, debugging and trial operation of the developed software product.

The use of virtual machines is indispensable in the study of courses related to computer networks (Misnevs, 2010; Popello, 2017; Titovskaya et al., 2019).

The use of virtual machines contributes to the study and gaining practical experience in administering various operating systems, such as Windows, Linux, FreeBSD, etc.

Using virtual machines, it is possible to develop skills for working with various workstations (Catalin, 2012; Despotovic-Zrakic et al., 2012; Nicholson, 2020).

The use of virtual machines is also indispensable in the study of information security issues. The implementation and use of various security policies, their testing without threats to a real computer, undoubtedly, bring students a qualitatively new level of knowledge of the subject.

6. Findings

The first step in this direction has already been taken at the Department of Information Technology and Mathematical Support of Information Systems at the Krasnoyarsk State Agrarian University: a virtual machine server has been organized on which students' personal virtual machines are stored.

This approach to the organization of training gives students additional knowledge and skills in servicing computers, since students install all the necessary software independently.

In addition, the problem of restoring a virtual operating system is solved by simply replacing the disk image, which takes several minutes.

Students can work with their virtual machines from any computer on the department's local network. Since there are Wi-Fi access points on this network, students get access to their virtual machines from personal laptops, tablets, etc.

From a psychological point of view, when a student realizes that this virtual machine is his property and he has a responsibility for its functioning, he becomes interested in working with it, reconfiguring parameters, etc., which leads to an additional expansion of his professional horizons.

From an administrative point of view, the use of virtual machines reduces the requirements for computing resources.

The hardware of the virtual machine server at the Department of Information Technology and Mathematical Support of Information Systems today consists of an Opteron 6378 processor (16 cores at 2.4 GHz), 64 GB RAM, a hardware RAID controller serving a RAID0 array of four HDDs.

This server is running the CentOS operating system. KVM (Kernel based Virtual Machine) is used as a virtualization environment - a standard virtualization environment built into the kernel in almost all modern Linux OS, based on the Libvirt library with QEMU.

Access to virtual machines is carried out using the standard remote desktop connection utility using the RDP protocol (Remote Desktop Protocol is Microsoft's standard protocol for working in terminal mode).

Virtual machines are running Windows 10; all other software packages (such as Pascal, Delphi, Oracle RDBMS, MS Office etc.) are installed by students as needed.

Long-term operation revealed a number of specific features of the described virtualization server that distinguish it from generally accepted requirements: in student tasks, each processor core can serve up to two or four machines without a noticeable increase in the system response time.

Figure 01 shows the screen for simultaneously starting sixteen virtual machines (the left window is the virtual machine manager). The right window (the system monitor window) shows the graphs of the processor load (upper graph) and RAM allocation. The processor load graph shows that after the launch of operating systems in all virtual machines, the processor is idle 70% -80% of the time, which is the basis for the statement about the possibility of servicing three or four virtual machines with one processor core.

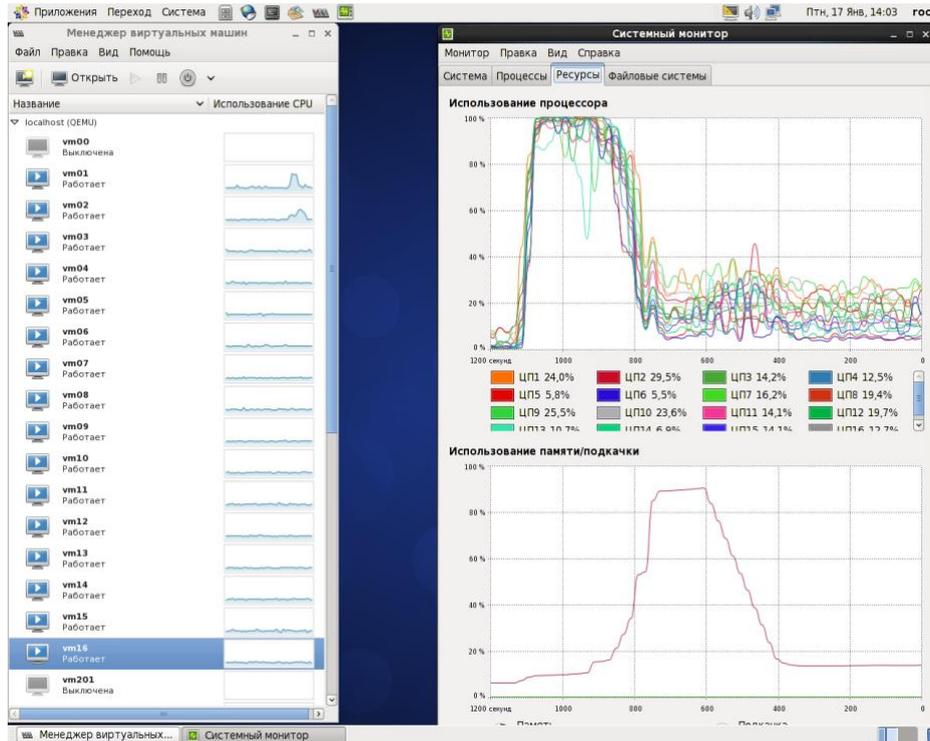


Figure 01. Virtual machine startup screen

The memory allocation graph shows that the amount of memory allocated to a virtual machine does not limit the total number of simultaneously running virtual machines. As follows from the graph, for approximately 10 minutes, unused portions of virtual machine memory are unloaded from RAM, the allocated memory is reduced, which frees up space for starting new virtual machines. Thus, the total amount of memory allocated for virtual machines can significantly exceed the amount of server memory.

KVM developers recommend terminal access to virtual machines via the VNC protocol, which is significantly slower than direct connection to virtual machines via RDP. This point has not been specifically investigated, but, presumably, the reason is the difference in the volumes of transmitted network traffic.

During operation, it was found that the main consumption of processor time by virtual machines, as can be seen from the processor load graph in Figure 01, occurs during booting and shutdown of the operating system, so the most effective mode of operation is to keep all virtual machines turned on.

7. Conclusion

This article shows that the virtual machine server does not require significant hardware resources, for example, for several dozens of virtual machines one sixteen-core processor is enough (in practice, the simultaneous operation of 40 virtual machines has been tested).

Students are very positive about using virtual machines; the only question that most often arises is related to Internet access to their virtual machines from home.

This question essentially determines the near future of virtualization at the university. To ensure constant access for students to their virtual machines, the participation of an information technology center in the organization of a VPN server is necessary.

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