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**APPROACH TO THE STUDY OF COMPUTER NETWORKS**

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***Abstract***

Modern society is permeated by a wide variety of information technologies. They are represented in all areas of human life. Today it is impossible to imagine a person without mobile communications and Internet access. The current situation leads to the expansion of infocommunication networks and a corresponding increase in requirements for service personnel in both quantitative and qualitative aspects. Therefore, educational institutions are faced with the task of training more specialists with all the necessary knowledge and skills in the field of network technologies. The presented article is focused on practical training of students in the deployment and configuration of computer networks. It briefly outlines the bottleneck of practical training associated with the problem of providing each student with a fairly large amount of equipment. The use of virtual machines is proposed as a solution to this problem. A comparative analysis of possible virtualization environments is provided. The suitability of VMware Player for organizing the study of computer networks is assessed. The results of applying the approach using a virtualization environment are presented, confirming its effectiveness.

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**Keywords:** Computer networks, virtualization, virtual machine, training, network service.



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## 1. Introduction

Currently, network technologies are continually being introduced into many areas of human life. Digitalization of various sectors of activity in modern society is impossible without information and communication networks. Computer networks make it possible to communicate, store and process information, and it is safe to say that the modern world and networks technologies are inseparable. That is why there is an urgent need for training specialists in the design, development, configuration and maintenance of computer networks.

The training of IT specialists is the prerogative of higher education institutions, which often have a lack of funding to provide a laboratory base for such training. In such circumstances, aspects of practical training in the field of computer networks are often not considered in the structure of the educational process for a number of reasons (mainly financial), and students graduate from the university with only theoretical knowledge, without practical skills in the design, configuration and maintenance of networks (Matasaru et al., 2018).

## 2. Problem Statement

To meet the needs of modern society, educational institutions are forced to pay more and more attention to computer networks in the process of training specialists in the field of computer science and information technology (Matasaru & Scripcariu, 2017; Matusa et al., 2013). Moreover, graduates are required not only theoretical knowledge about the principles of building and functioning of networks, network protocols, but also an extensive set of practical skills in working with computer networks. Obtaining such skills is possible only if students individually perform practical tasks for deploying and configuring networks with a variety of topologies, a set of network services, and operating systems (Marcinkowski & Ostrowski, 2013).

To complete these tasks, each student must be provided with a set of 5-10 personal computers working under various operating systems, as well as network equipment - switches, routers, connecting cables. Obviously, it is impossible to fulfill these requirements, since, for example, for a group of 25 students, it is necessary to use from 125 to 250 personal computers at the same time.

In some cases, partial network configuration tasks that do not provide comprehensive practical skills are used to solve this problem. In other cases, group training is used when several students work with one set of equipment. This approach to teaching leads to the fact that the task is actually performed by one or two students from the group (Stoitsov & Shotlekov, 2015; Stoitsov, 2017).

Both options do not give the desired effect in acquiring skills, therefore, software that allows emulating a network environment, such as Cisco Packet Tracer and NetKit, is being increasingly used now. Unfortunately, such complexes do not cover all the tasks that arise when organizing networks. For example, Cisco Packet Tracer is designed to study the configuration of Cisco routers and switches, while NetKit is focused on using Linux OS with a fixed set of network services (Cisco Packet Tracer Data Sheet, 2020; Netkit, 2020).

### 3. Research Questions

As a result of the study, the following questions were identified.

How to solve the problem of training students in terms of acquiring practical skills in the deployment and configuration of computer networks?

What methods of practical training for computer networks that do not require large financial costs exist?

What software and hardware are inexpensive, illustrative, easy to use and accessible to every student?

### 4. Purpose of the Study

The aim of the study is:

- To find the optimal trajectory of obtaining practical skills in designing and configuring computer networks.
- To create a virtual network technology class and study the impact of such a solution on the learning problem.
- To provide students with an environment suitable for the practical study of network services at all levels of a computer network.

### 5. Research Methods

To achieve the goal of the study, a line of operating systems was examined for their suitability for solving the tasks.

The first problem is the number of computers provided to the student. As shown, no network technology lab is equipped with enough computers.

The second problem is the availability of network equipment: switches, routers, cables.

Obviously, the only possible option in this situation is the virtualization of personal computers, which are used to build computer networks for educational purposes (Zatsarinnaya & Staroverova, 2015; Tugarool, 2015).

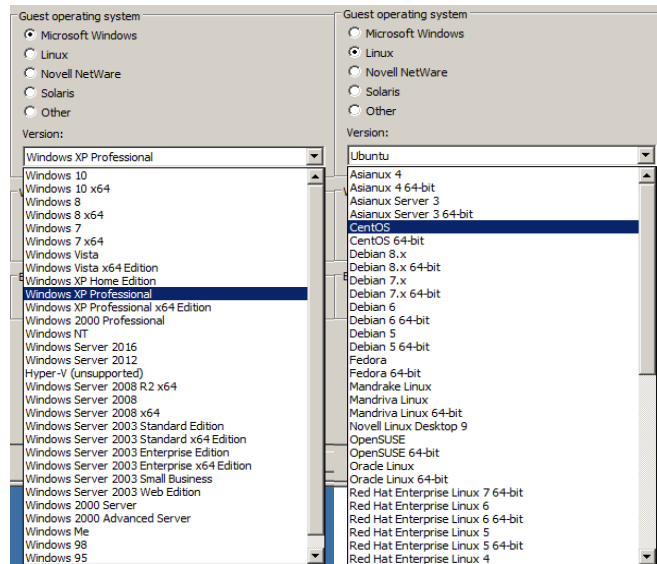
In one form or another, virtualization tools are already present in almost all modern operating systems: in Linux, there is a QEMU KVM virtualization system built into the kernel. Windows already has a built-in Hyper V virtualization environment. In addition, third-party software products that can be used both with operating systems with the Linux kernel and the line of Windows operating systems are widely distributed (Kruchenetsky et al., 2015; Truchly & Humeny, 2010).

Unfortunately, systems based on the Linux kernel, with their free virtualization environment, are hardly ever used in any university today. Therefore, a very good and free option for practical training in computer networks is currently not available, despite the fact that there are a lot of free modern distributions with very extensive capabilities, for example, CentOS, Ubuntu, OpenSUSE, and Fedora.

The most popular for Windows operating systems are software products such as Oracle VirtualBox (Oracle), as well as an extensive VMware product line (Oracle VM VirtualBox, 2020; VMware Workstation 15 Player, 2020).

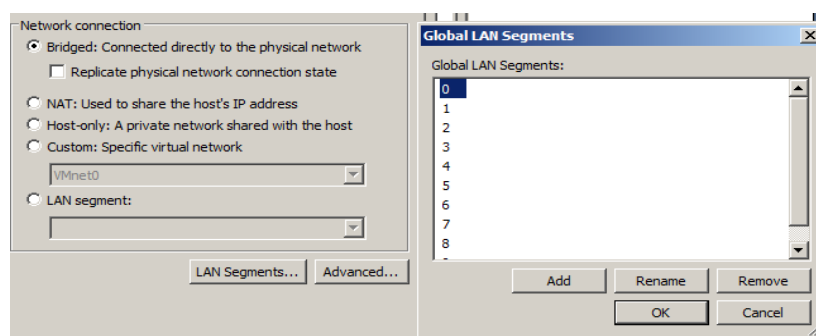
For obvious reasons, for universities, free or shareware products, such as Oracle VirtualBox and VMware Player, are most suitable. In terms of functionality, they are approximately the same, but VMware Player is more convenient when moving virtual machines between home and university, since the entire virtual machine is completely stored in one directory (Govorov et al., 2014; Vorobiev & Dang, 2018).

VMware Player supports many operating systems, as shown in Figure 01. This, in turn, enables students to gain the skills to configure all the network services present in modern operating systems.



**Figure 01.** Supported Operating Systems

VMware Player has built-in support for a variety of network infrastructures and topologies. It supports an unlimited number of LAN segments (virtual hubs), and provides opportunities for building various network topologies, as shown in Figure 02.



**Figure 02.** Network adapter settings

It has built-in tools for accessing the real network, both directly and through NAT, which makes it possible to connect training networks to the Internet in access-controlled networks (for example, port security), as well as organize a variety of virtual network interactions with various services real networks of organizations.

The ability to build heterogeneous networks provides the opportunity to include in the process of practical study all the services of the application and transport layers, as well as the main features of the network and data link layers that are present in all modern operating systems.

## **6. Findings**

This article describes the problem associated with providing each student with a separate computer network for practice in deploying and configuring the network. The article shows that network virtualization is the solution for this problem.

A comparative analysis showed that the best option is to use VMware products, in particular the shareware VMware Player.

Many years of experience confirm the effectiveness of this approach: in the process of studying, students gain practical skills in network setup in both Windows and Linux, starting from the lowest levels - routing, and ending with the highest - applied network level.

At the end of the course, students have practical skills in deploying and configuring networks with static and dynamic routing (RIP v1, v2; OSPF), dynamic host configuration (DHCP), local and domain name services (WINS, DNS), various file services (SMB, FTP). Students are able to deploy a WEB server with virtual hosts, and so on, and all this in both Windows and Linux-based Operating Systems.

After introducing the described technology into the educational process, the material becomes much more understandable and accessible for students. Many years of experience in the application of the proposed methodology shows its effectiveness, since most graduates in the thesis project choose topics related to the design of computer networks and distributed systems as a well-known and learned area of knowledge and skills.

It has been shown that the introduction of virtual machines in the educational process is also effective in the study of other curriculum disciplines (Titovskaia, et al., 2019).

## **7. Conclusion**

This article shows that modern information technologies can successfully solve the long-overdue problem of obtaining practical skills in configuring computer networks.

Such technology is the creation of virtual machine networks running VMware Player, which allows students to use almost all modern operating systems. This approach provides the acquisition of extensive knowledge and skills of deployment and configuration of the widest range of network services running a variety of operating systems.

The developed mechanism for organizing the connections of virtual machines with each other and with real networks allows students to gain skills in working with various, and, if necessary, quite complex network topologies and configurations.

The above features and capabilities of VMware Player indicate that it is an excellent testing ground for the practical study of computer networks using the capabilities of modern operating systems.

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