

ASPECTS OF APPLICATION OF VIRTUAL ENVIRONMENTS AT TRAINING OF SPECIALISTS IN THE FIELD OF ICT

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Abstract: *Performance of practical tasks is the main component of training of specialists in the field of ICT. Modern software, namely systems of virtualization, allows solving effectively a problem of the organization of individual access for users to the studied software of different function in the remote mode. In article definition of a virtual practical work, its structure and types of virtual environments, which can be applied in practical works, is given. The architecture of a virtual practical work and the requirements to practical work components is considered. For management of a virtual practical work the minimum set of functions, which is realized by means of the additional management module of virtual environments by which it can be caused directly from LMS, is offered. Influence of virtual practical works on quality of training of specialists in the field of ICT and application of virtual practical works in Lifelong Learning education is discussed.*

Key words: *virtual environment, virtual practical work, distance learning*



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1. Introduction

The traditional system of specialists training in the field of the information and communication technologies (ICT) can't satisfy need for the experts who are perfectly knowing modern software products and information technologies (Azarov & Fomin, 2014). The theoretical orientation of preparation (acquisition by students of formal knowledge), technological "inertness" (impossibility to master the new equipment rooms and software appearing in the market), absence in programs of preparation of a necessary number of hours for practical development of the studied object are the main reasons.

The problem of modernization of engineering education and increase of its efficiency occupied many higher educational institutions and research teams. Many various approaches are developed and is used (Rebrin & Sholina, 2014). So in (Cus & Balic, 2013) formulated requirements to training of engineers in the conditions of Globalization. The group of authors (Rosu et al, 2010) describes architecture of the virtual enterprise for support of creation of the educational sites. Experts from Vigo university (Spain) (Fenollera & Goicoechea, 2011) within competence-based approach suggest to use project-oriented training and a platform of Virtual training.

In the world enormous experience of application of remote technologies of training is saved up, are developed and numerous learning management systems (LMS) (Ferriman, 2013) and the systems supporting mass online courses are used (Jansen & Schuwer, 2015). However these systems allow to gain, as a rule, "formal knowledge" (Fomin & Sidorov, 2013), but don't give the chance to gain necessary experience with the studied object.

In these conditions special importance is gained by the practice-oriented courses which give the chance to students to develop initial abilities during the work with the studied software (Azarov & Fomin, 2014). Such courses can give the greatest effect at application of remote technology of training both when studying theoretical material, and when performing practical tasks. Therefore it is expedient to connect functionally LMS (Ferriman, 2013) with control systems of virtual computers. Such association allows to create the highly effective virtual practical works providing access to real objects at any time and in any place where there is an Internet.

Modern opportunities of personal computers and server platforms, functionality of virtualization systems, capacity of channels of information transfer allows to create systems of support of virtual remote practical works.

Substantial increase of learning efficiency at application of the practice-oriented remote courses it is possible to predict for students of older years of higher education institutions within facultative practical works and at performance of research projects by students (Azarov & Fomin, 2014). Besides, virtual practical works will make an undoubted contribution to professional development of experts and in systems of continuous education.

In work the attention on architecture and functionality of virtual practical works is focused. Are considered:

- types of the virtual environments used in virtual practical works;
- architecture of a virtual practical work;
- functions of the module of management of virtual environments;
- influence of virtual practical works on quality of training of specialists in the field of ICT.

Further, we will call the students working with virtual environments, listeners of remote advanced training courses, the specialists studying disciplines of ICT in system of distance learning “users”.

2. Structure of a virtual practical work

Performance of practical tasks can be supported by the technologies of virtualization realized by numerous control systems of virtual computers (hypervisors) (Fomin & Sidorov, 2013). Emergence of freely extended software products of this class and technical capabilities of modern personal computers allow to create virtual environments for carrying out practical works on programs of professional retraining and professional development in the field of ICT and to organize remote access to this environments.

The Virtual Environment (VE) we will call the individual system exercise machine consisting of one or several virtual computers and allocated to the user for performance of a practical task.

On the basis of virtual environments virtual practical works – program complexes can be created. Virtual practical works can include the following components:

- virtualization system;
- the virtual computers which are a part of virtual environments;
- a learning management system (LMS) (Ferriman, 2015), storing training materials;
- the software automating work with virtual environments.

At interaction with a virtual practical work opportunity to create and destroy the virtual environments applied when studying a course, opportunity to send notices of performance of a task to the teacher, and opportunity to receive attributes for connection with the virtual environment has to be given to the user.

3. Virtual environments of practical works

It is possible to define three types of virtual environments:

1) VE based on the shared virtual computer (VC). It is the virtual computer with which some users can work. The user works in his own account irrespective of other users. This VE type can be applied to performance of the practical tasks that aren't connected with modification of system objects of operating systems (for example, development and studying of application software);

2) VE based on individual VM. It is the virtual computer provided in the individual utilization of the user. Application of VE of this type conveniently for

performance of tasks on system programming and system administration, and also during the work with objects which share between users is inexpedient (owing to license policy or technical difficulties);

3) Complex VE. That VE consists of several virtual computers. Part of them may be shared, and another – individual. The user has access to each virtual computer as a part of the virtual environment. VE of this type can be applied to performance of tasks on system administration, network programming, studying of safety of information systems, studying of components of corporate information systems.

Types of virtual environments for remote practical works and the indicative list of practical works, that can be carried out with application of these practical works are given in table 1.

№	Virtual environment	Practical works
1.	The virtual single-user environment – the Windows workstation (XP, 7, 8).	Installation and Windows OS control. Development of Windows. Work with application software, DBMS, programming systems.
2.	The virtual single-user environment – the FreeBSD server.	Installation and FreeBSD OS control. Development of FreeBSD. Work with packages, DBMS, programming systems.
3.	The multiuser environment based on Windows Server.	Work with DBMS in the multiuser mode.
4.	Model of a local network with the allocated UNIX server (Virtual environment "Network Cell") (fig. 1).	Installation and control of system software on the allocated UNIX-server of a local network. The established services: DHCP, Samba. Firewall (ipfw+NAT). Web server Apache. Fileserver.
5.	Multi environment (some virtual computers united in a virtual network of the necessary structure).	1. Installation and control of system software for a local network with the demilitarized zone. Setup of servers of a local network and the demilitarized zone. Setup of firewalls. 2. Data security application of funds: invasion sensors. Protocols and means of protection of information channels. Protocols and means of authentication of users in the distributed systems.
6.	Own virtual environment ("research field").	The user for studying of any hardware-software complexes can create virtual environments of this type.

Tab. 1. Types of virtual environments of remote practical works

The example of the virtual environment is given in fig. 1. The virtual environment (so-called "a network cell"), consists of two virtual computers united in a virtual network. On one virtual computer the UNIX FreeBSD operating system is installed (it is the server of a virtual network), on another (it is the workstation of a virtual network) – Windows XP OS (or Linux Ubuntu) is installed. Such virtual environment can be used for development of installation and setup of the allocated UNIX server of a local network. As system of virtualization, Oracle VirtualBox can be used (Oracle, 2015; KVM, 2015). Access to the virtual environment is possible as in local option (at placement of system of virtualization on the personal computer), and from the Internet (at placement of system of virtualization on the server available from the Internet). Linux Ubuntu can be a basic operating system of the server.

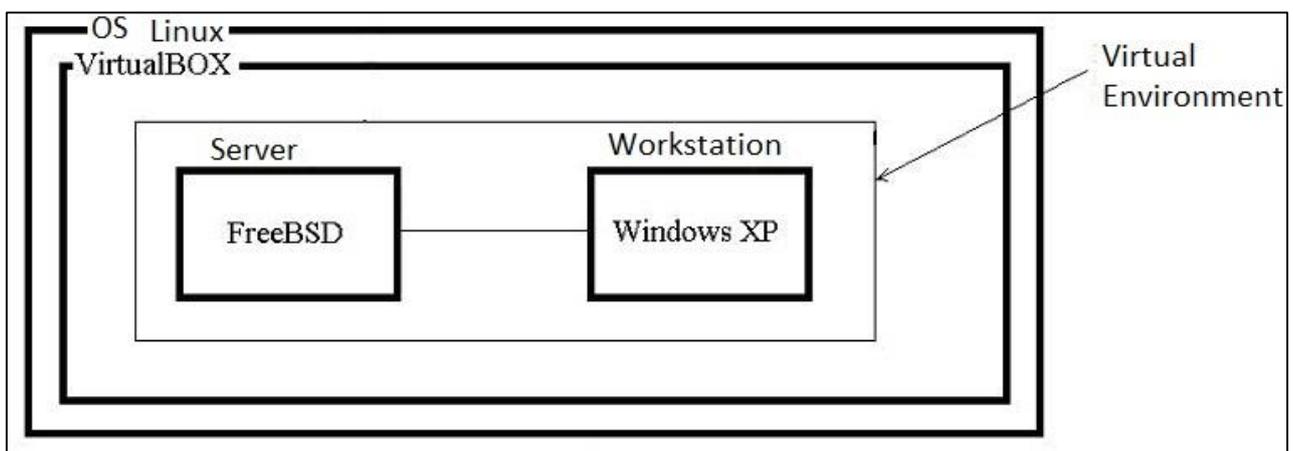


Fig. 1. Virtual environment "Network Cell"

4. Architecture of a virtual practical work

Server realization of a control system of virtual practical works can function under control of the Linux Ubuntu operating system and includes a learning management system and a control system of virtual computers (hypervisor) (fig. 2). As LMS in a virtual practical work, the Moodle package is used.

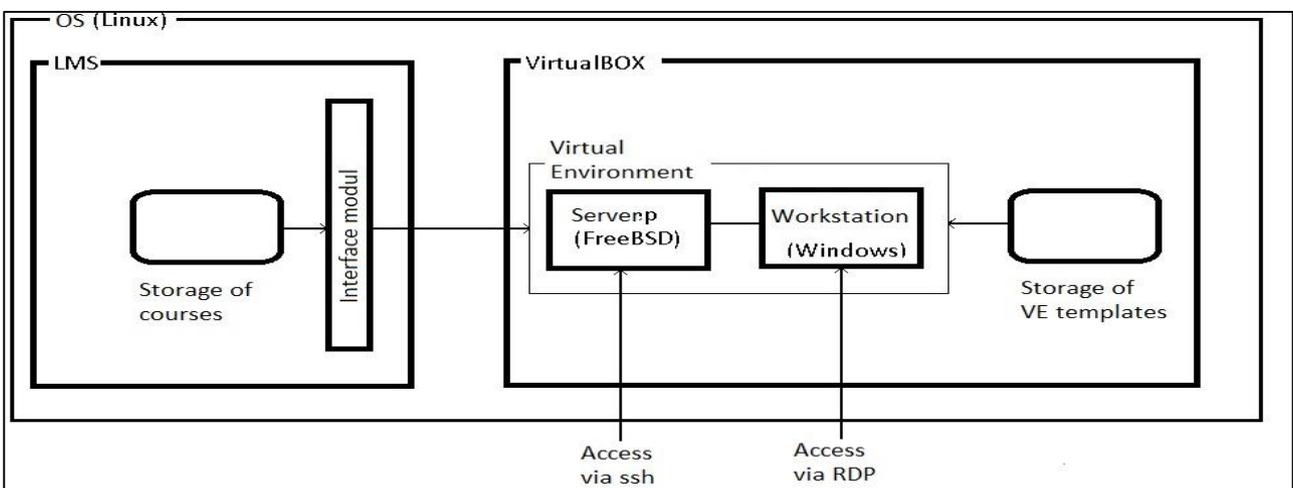


Fig. 2. Architecture of a virtual practical work

For management of the virtual environment of the user specially developed module of management of virtual environments that is caused by means of the interface page from the section «Virtual Practical Work» of the training materials placed in LMS Moodle is used.

The module of management of virtual environments is realized in the form of system of scripts with which help administration of virtual environments is carried out. These scripts contain commands for control virtual computers. Other decision is development of the program (for example, in C, C++ or Python languages) with use of the corresponding API.

4.1. Technology of work with virtual environments

For execution of a practical task the user, passes in the section of a course which is placed in LMS, according to the link "Virtual Practical Work" to the interface page. Further by means of the button on the interface page the user creates the new individual virtual environment. This virtual environment will be used for execution of a practical task.

Attributes of access to components of the virtual environment are sent to the user (in fig. 2 – to the server and the workstation). The user can establish two connections with the main server: under the HTTP protocol and under the protocol provided for access to VE. On the first connection, he gets access to a learning management system and the Web interface, which is built, in it for management of the VE, and on the second – access to VE for performance of a practical task. For the version of the virtual environment given on fig. 2 with the FreeBSD server it is possible to establish connection under the ssh protocol, and with the workstation (Windows OS) – under the protocol of access to a remote desktop (RDP).

The user for execution of problems of a practical work interacts with operating systems of virtual computers, which are a part of the virtual environment. Having finished work, the user by means of the interface module of a learning management system notifies the network teacher on completion of work. Access to the virtual environment for the user is closed. The network teacher establishes connection with the virtual environment, estimates work of the user and, having returned in LMS, puts down a mark for the performed work.

4.2. Interface of the management module of virtual environments for the user

Elements of management of the virtual environment have to provide logic of work with virtual environments and should not be attached functionally to a concrete control system of virtual computers. It will allow transferring virtual practical works to other control system of virtual computers in case of need. When executing a virtual practical work it is necessary to consider that qualification of users can be various, and that the user isn't obliged to know feature of work of a concrete control system of virtual computers. Two versions of the interface page are necessary: for the user and for the network teacher.

On the interface page for the user, necessary elements of management of the virtual environment can be placed. For the elementary virtual environment, it is possible to specify the following elements of management:

- “To create the virtual environment”. In this case take place a cloning of a template of the virtual environment, (the individual version of the virtual environment with which the user will work is created). The user can create only one copy of the virtual environment. After creation of the virtual environment in information window parameters necessary for connection with it will be output.
- “To remove the virtual environment”. The individual version of the virtual environment with which the user worked is removed. Destruction of VE can be necessary when the user damages it during attempt to perform a task.
- “To send for check”. The user finished performance of a task in the virtual environment. Access to the virtual environment for the user is closed, to the Network teacher the notice that the user finished work goes. The network teacher can enter the virtual environment of the user and check completeness of performance of a task.
- “Connection parameters”. Allows displaying parameters of connection with VE.

Except elements of management of the virtual environment on the interface page, the indicators allowing the user to control a condition of the virtual environment can be placed, for example, "VE is turn on/is switched off".

4.3. Interface of the management module of virtual environments for the network teacher

The network teacher gets access to the interface of the module of management of virtual environments as well as the user; however, his interface has some additional elements. The following elements are in addition displayed: the table of all users who sent the notice of need of check of the result received in this task and the table VE, existing at users in this task.

At a choice in the table of users of the specific user, in information window, information on this user is output and the “Send Back for Revision” and “Estimate” buttons become active:

- "Send Back for Revision" - the network teacher can create remarks for the user;
- "Estimate" - the network teacher goes to the page of evaluation of the work of this user provided by LMS Moodle.

After work of the user is estimated, the network teacher can download result of its work and remove the user's VE.

5. Unified management of virtual environments

Exist a set both the proprietary and free control systems of virtualization. Control interfaces of such systems differ both on functionality, and on complexity of work with them at all levels. One property unites these systems – they weren't created for application only in distance learning systems, therefore possess excess functionality, and demand automation of the operating actions for work of the user.

Management of virtual environments of the administrator is reduced to work with functional subsystems of control systems of virtualization and for this purpose, it is necessary to be super user.

The user, unlike the administrator, does not need exhaustive data on functionality of a control system of virtualization and on the contrary, functions, which don't contain in functionality of control systems of virtualization, for example, creation of the virtual environment, are necessary.

Having considered various virtual environments (Fomin & Sidorov, 2013) which can be applied when studying disciplines of ICT (tab. 1), it is possible to formulate some initial requirements to the interface of virtual practical works. The interface has to provide:

- The operations necessary for the user for the mediated management of virtual environments sufficient for execution of a practical task with application of virtual environments ("To create the virtual environment", "To remove the virtual environment", "To send for check", "The Status of VE", "Connection parameters").
- The operations necessary for the network teacher for the mediated management of virtual environments sufficient for control over work of the user and check of results of performance of a practical task with application of virtual environments ("To send back for revision", "To Estimate"). Operations of obtaining data on users and their virtual environments, and receiving attributes of an entrance to the virtual environment of the user for check of results of performance of a practical task. Besides, have to be available to the network teacher: the table of all users who sent the notice of need of check of the result received in this task and the table VE, existing at users in this task.
- Independence of system of virtualization. Operations of management of virtual environments should not be functionally focused on any control system of virtualization and should not demand knowledge and abilities of work with it.
- Communication with a learning management system. Virtual practical works have to be available from a learning management system in which materials of courses are placed.

6. Quality of specialists training

Development and deployment in educational process of system of maintenance of the practical tasks performed in virtual environments allows increasing considerably efficiency of process of training on the courses focused on practice of ICT. Increase of efficiency can be reached at the expense of the following factors:

- disclosure of the potential put in self-supporting work of students due to methodical, information support from LMS and ensuring access to the studied objects in the remote mode round the clock;
- improvement of the current control over work of the student by means of LMS;
- consultations from the network teacher when performing tasks in the remote mode;

- possibility of student's work with the studied objects in addition to classroom lessons (it allows to develop with guarantee the corresponding skills);
- possibility of student's work with the studied objects at individual speed.

7. Practical works in lifelong learning

Professional development and professional retraining of specialists, i.e. lifelong learning (Jurina, 2014) in the field of ICT, when using system of virtual practical works becomes effective and purposeful, giving the chance to users to master modern software and technologies directly on a workplace, at individual speed and volume. The mode of "research field" (the own virtual environment) will allow users to create and investigate perspective hardware-software complexes in various modes of their work, to hold preliminary testing of program systems during their development.

8. Conclusion

In work, the architecture is offered and functionality of virtual practical works for training of specialists in the field of ICT is considered.

The proposed solution assumes association of opportunities of LMS and control systems of virtual computers. Merger of these two systems is carried out by means of the additional module of the management of virtual environments connected to LMS Moodle. In work it is given functions of this module, invariant to the applied control systems of virtual computers. The list of types of the virtual environments applied in virtual practical works to training of specialists in the field of ICT is given above. Depending on the solved task various virtual environments can be used. The prepared users can use possibility of creation of own virtual environment which allows to deploy necessary hardware-software complexes.

Virtual practical works can be applied in the courses allowing use of various virtual environments and different types of connection with them.

Use of virtual practical works for carrying out a practical training has the following advantages:

- the user, receiving the ready virtual environment (VE), at once can get to work in it, without preliminary installation and setting up the software, necessary for occupations. It needs only the web browser and the client program for connections with individual VS or an account in the divided VS;
- if individual VS is damaged by the user during performance of a task, it can be automatically destroyed, and instead of it new VS is created;
- VS of users are created dynamically by their inquiries. It provides Consumption exactly such quantity of resources of the server which is necessary for works of concrete number of users at present;
- VS of the user is available to the network teacher to the check executed works.

The listed above possibilities of virtualization and the offered system of maintenance of the practical tasks performed in virtual environments are the basis for

the computer engineering of MIEM NIU HSE of an automated control system for training process developed in department.

The working prototype of this system based on the free software is created. As a system of virtualization, VMWare Server 2.0 is applied (VMWare_server, 2015).

Now works on creation of a private cloud on the basis of OpenStack system with similar architecture are conducted.

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