



Digital Virtualization Technologies in Distance Learning

Irina Anatolyevna Skripak, Svetlana Nikolaevna Aynazarova, Ekaterina Vladimirovna

Ukhanova, Anastasia Evgenievna Tkachenko, Larisa Sergeevna Erina

North Caucasus Federal University, Institute of Humanities, Stavropol, Russia

ABSTRACT

Distance education as a branch of knowledge has appeared based on the introduction of interactive teaching methods into the educational process, inextricably linked to the use of the Internet. Today, knowledge is spread among people, communities, and nations through the extensive use of computer networks and multimedia systems in the educational process. Modern interactive telecommunications technologies, such as video conferences, forums, and chats, make it possible to communicate synchronously and asynchronously, enabling students, tutors, scientists, and researchers to be part of an online community, collaborate on projects, share information, and gain knowledge in a way that is different from the traditional one.

The article presents an analysis of research on the use of digital virtualization technologies in distance learning. Based on an expert survey, the available digital technologies in the field of client virtualization in distance learning for creating virtual desktops have been identified.

Key words: distance education, distance learning, virtualization, digital virtualization technologies, desktop virtualization.

1. INTRODUCTION

Creating computer-oriented environments has become a key point in the evolution of distance learning [1-3]. The emergence of new digital technologies and their availability on the market force one to rethink the entire learning process [4-6]. Investing in lifelong learning in the context of education informatization is vital to remain competitive in the global labor market [7, 8]. The dominant trend in training and professional growth is the use of digital technologies to spread knowledge and create virtual learning environments (VLE) [9, 10]. Due to quick access and new ways of communicating and evaluating students, digital virtualization technologies (DVT) have become an integral part of the learning process in both traditional and distance learning. DTV allows tutors to quickly create their resources without special technical skills. The term "virtualization" is widely used in many fields of

knowledge, in particular, ICT (virtual machines, containers, and environments), philosophy, political science, psychology, sociology (virtualization of society), economics (virtualization of goods and services), education (VLE, classrooms, and communities), and so on.

In the field of ICT, virtualization can be interpreted in a broad sense (creating abstractions for physical computing resources, which underlies the work of any software and operating systems (OS) as a whole) and narrow sense (creating additional abstractions to organize new computing environments based on existing computer systems) [11].

In a broad sense, virtualization involves creating an abstraction for real computing resources that users get at their disposal instead of real resources (RAM, disk drives, etc.) [12]. It is assumed that working with such abstractions is more convenient than interacting with real computing resources since in this case, the user does not necessarily need to know the details of working with these resources and avoids routine work [13]. Such abstractions include, in particular, OS in general, programming languages and environments, system libraries, and several software tools [14, 15].

At the same time, virtualization in the field of digital technologies can be considered in a narrower sense. E. Tanenbaum describes virtualization as a technology that allows a single computer to become the base for several virtual machines, each of which can run different OS [16]. Similarly, virtualization is defined in [17] as a means of organizing multiple virtual computers in a single real one. In [18], virtualization is a technology that allows dividing one physical server into several virtual servers that work, in a sense, independently of each other. A. Bologna and R. Bologna, by the term "virtualization", understand the ability to simultaneously run multiple OS on the same physical computer that is, again, the ability to create multiple virtual computers on the same physical one. However, the authors note that these OS do not necessarily have to be the same [19]. In the study [20], virtualization is associated with the separation of a request for a certain service from the physical provision of this service. In [21], virtualization is a technology for hiding the physical characteristics of computing resources from other systems, programs, or users interacting with these resources and separating the system's

representation from its implementation.

According to V.N. Zakharov [22], virtualization is a concept that combines technologies, tools, methods, etc., which have three main features:

- 1) Separation of resources of one physical computer into several mutually independent virtual environments or, conversely, the combination of resources of several physical computers in one virtual environment;
- 2) Efficiency of transition from one virtual environment to another;
- 3) Hiding real physical resources and replacing them with abstractions.

When it comes to virtualization technologies, the term "virtual machine" is also used in many cases. According to J. Smith and R. Nair, a virtual machine is a computing environment, the set of resources and operating rules of which is generated (using software) in some other computing environment [23]. M. Rosenblum defines a virtual machine as a specific instance of a certain virtual computing environment ("virtual computer") created using a special software tool that the author calls a virtual machine application [24].

Understanding the basics of DVT and the differences between their varieties is significantly complicated by the considerable diversity of these technologies and, as a result, the lack of a unified approach to their systematization in the developed sources.

Based on the analysis of works [25-27], it is possible to identify various areas of application of virtualization technologies:

- system administration (server virtualization, desktop virtualization);
- working with applications (desktop OS virtualization, application virtualization);
- development and testing of multi-platform software products (desktop OS virtualization, software application virtualization);
- web design (desktop OS virtualization, application virtualization);
- foundation for cloud technologies (server virtualization, application virtualization, desktop virtualization);
- training, including self-training (desktop OS virtualization, application virtualization).

The last two areas of application – training (directly) and the basis for cloud technologies (indirectly as a learning tool) are of particular interest for this study.

In turn, the pedagogical and technological point of view transfers the concept of virtualization to the plane of theory and practice in the field of education, using such concepts as virtual pedagogy, virtual education, virtual reality, virtual classroom, virtual laboratory, virtual network community, etc. In the framework of the pedagogical and technological point of view on the concept of virtualization, this refers to, in particular (but not exclusively), virtual machines, virtualized software and other digital technologies, which can also be

summarized by the term "virtualization in the narrow sense" [28].

Considering virtualization as a learning tool may not involve the direct use of virtualization in a narrow sense (as in the case of virtual classrooms, virtual laboratories, virtual network communities, etc.), but it may also involve (virtual machines, etc.) [29]. In all these cases, a kind of virtual reality is created – a virtual (imaginary) laboratory, a virtual (imaginary) class, a virtual (imaginary) computer inside a physical computer – and therefore, the corresponding tools can be associated with the category of tools and technologies of virtual reality systems [30].

In the case where DVT is used for educational purposes, such funds can also be considered as ICT for educational purposes. In other words, the tools, methods, and technologies that are the best practices of e-pedagogy (including DVT as a learning tool) can be used to implement the tasks of distance education, in particular, becoming an integral part of VLE.

VLE are learning process management systems that are designed for students' learning activities and provide the necessary content and resources for spreading knowledge and successful learning [31]. These systems allow teachers to interact with students in person and remotely, spreading and generating knowledge from the comfort of their homes.

The number of universities that use VLE has increased significantly. The VLE, or learning platform in a higher education institution, is an online system that allows teachers to share materials with their students over the Internet. The use of VLE is useful both in traditional and distance education.

Thus, DVT can play the role of a computer-based learning tool within the distance education system.

The purpose of the article is to analyze the problems and prospects of using DVT in distance education.

The hypothesis of the study: DVT in distance learning lead to the creation of a VLE that is accessible to students and tutors on any computer connected to the Internet via a browser and contains a wide range of training tools for tutors (through collaboration, communication, and evaluation).

Based on the results of the study, it can be concluded that the goal set in the study was achieved.

2. METHODS

The study used the following research methods to implement the research goal:

analysis and generalization of theoretical positions to determine the use of DVT in distance learning;
expert survey method for determining available digital technologies in the field of client virtualization for distance learning.

Employees of Russian universities were involved in the online survey as experts: teachers of distance courses – 18 people with more than 15 years of experience, as well as system

administrators – 18 people.

3. RESULTS

According to the experts, desktop virtualization is the most important for distance education among various virtualization technologies – an approach in which the user's work environment (OS, programs, data) is separated from the physical device that the user is used to working with (personal computer, laptop). According to one expert, a virtual desktop is "actually a full-fledged workplace running somewhere on a remote server, with access to it".

According to the experts, desktop virtualization is the virtualization of the desktop environment, including the user's applications. It can provide for remote interaction with computing power, in which user processes are performed on the device (PC, laptop, thin client, tablet, smartphone, etc.) and the server, as well as the local launch of user programs and local data storage. Both types of interactions are often combined.

This approach is based on the joint use of various technologies in the field of client virtualization, the most popular of which, according to the experts, are the following (Table 1).

Table 1: Technologies in the field of client virtualization

No.	Technologies	Characteristics	%*
1	Virtual desktop infrastructure	a system that allows running the user's OS on a virtual machine on a server in a data center and work with it remotely from any device	86 %
2	Remote desktop services	classic terminal access, through which the server OS is provided to several users in a competitive mode. Each of the remote users works in their session	80 %
3	Remote physical workstation	a workstation (often with a graphics adapter installed) in the server form factor is located in the data center, through which remote users can access computing resources	74 %
4	Application virtualization	a virtual environment is created for each instance of the program. This allows the application to run in environments that do not initially support this application. This makes the migration of applications much easier (for example, portable versions of	71 %

		programs) and requires fewer resources than virtualizing the entire OS	
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Note: compiled based on the expert survey; * – percentage of expert mentions

4. DISCUSSION

It may be necessary to use certain software tools for the training of students of distance learning courses. In this regard, the experts suggested using a freely distributed open-source software product from Ulteo – Open Virtual Desktop (OVD) to provide virtual desktops, which is quite powerful for administrators and can be fully considered as an alternative to virtual desktop infrastructure (VDI).

From a technological point of view, through OVD, a graphical terminal is displayed, which is controlled through desktop sessions, and delivered to various end-users of the network.

Thus, through OVD, any registered user can get access to the desktops – along with the data stored there – anywhere, or use special native applications in the browser. This approach to collaboration allows multiple users to access a single desktop and Ulteo's approach avoids many of the disadvantages of conventional desktop data exchanges.

The full use of mobile platforms, such as Android, which can also be used as clients, is added in OVD of later versions after 4.0.

Another feature that appeared in version 3.0 is the ability to publish Linux and Windows applications like remote desktop services (RDS). In addition, it is possible to configure a combination of local drives and printers.

Using OVD, it is possible to provide desktops and desktop applications using one or more application servers; they are used to host applications and provide the remote display. The server or application servers may function on computers running Linux or Windows OS, depending on the program to be hosted.

Also, using the client, which is available by default, does not require a central file server, which stores data from all desktop sessions in collaboration. The file server provides a network file system through which it is possible to get access to the desktop session using the application server.

The entire interface is designed in several languages, including Russian. The client part can be used in several modes – as a familiar desktop (including full-screen) or as a so-called portal for launching individual applications. In the latter case, application windows will be integrated into the OS where the client is running.

The speed of the web client is more than sufficient for comfortable work. The client also provides transparent access to files and folders on the device where it is running. The experts noted that this is a fairly successful, free solution, especially a fairly simple setup.

The experts presented an example of setting up a system of

virtualization tools to support learning distance courses based on the Ulteo virtual desktop system.

The distribution can be downloaded from the project's official website at www.ulteo.com. Approximate size – 1.5 GB. Installation is possible either on a physical server or on a virtual machine. It is possible to start the installation from a physical media or mounted image. Starting the installation process:

1. The installation process is standard and does not differ from the usual installation of a Linux system (a distribution based on Ubuntu).
2. Install the necessary sections of memory where the v will be installed and determine their volume.
3. After the installation and reboot, the process is complete and the console for the administrative part of the OS will load. The default username and password are `ulteo/ulteo`.
4. After entering the login and password, a transition to the window occurs, in which it is possible to select one of the options for further work from the list:
 - a. Configure settings automatically – DHCP (if the corresponding service is configured in the network);
 - b. Configure network settings in manual mode;
 - c. Configure settings for input devices;
4. Check for updates (possibly with an Internet connection);
5. Restart the OS;
6. Open the admin console.

After configuring the network in automatic or manual mode, the administrator console is accessible via a web interface with a specific IP address, which must be specified in the browser's address bar.

Through this page, it is possible to get access to the user login page and the administrative part of the system (administration console), download the add-on for the server running the Windows OS, read the documentation, and go to the official website of the Ulteo project.

Joining the application server Windows server farm is as follows:

1. It is necessary to configure the terminal server services and the application server service on the Windows server. If necessary, it is possible to configure additional services, such as a file server service, and the server must be in the same workgroup or domain as the server where the session manager is installed, but without the domain controller role enabled.
2. It is necessary to download the application for Windows servers from the official site of the project and install the downloaded file. It is necessary to specify the path during the installation process where the tool will be installed, as well as the address of the session manager.

To configure the servers in the farm, it is necessary to:

1. Open the admin console via the web interface. Username and password for the default login `admin/admin`;
2. First, at the request of the settings wizard, it is needed to configure a database where user data and other system

information will be stored;

3. The administrator page displays bookmark icons at the top of the page that allows accessing the main sections of the system settings.

The index page displays the current state of the system, the number, and status of servers, links for quickly navigating to frequently used settings items (at the beginning of work, the system is in maintenance mode; to turn the system into the mode, it is necessary to press the button to switch the system to production mode). It is advisable to make changes to the settings in maintenance mode.

On the page with available servers in the demo example, a server running the Linux OS is already registered in the system and Windows servers are located on the unregistered servers tab. The list of available servers contains the following information about servers: address; OS type; OS version; roles that are available on this server. Click the "Register" button to register this server. A list of all servers and their characteristics and operating mode will be available after registration in the system during the transition to the menu item "Servers".

The server settings page also contains menu items for grouping servers (by OS, physical location, etc.), a page for configuring shared folders, and a page with user profiles stored on servers.

The user's page is intended for registering users in manual mode, combining them into groups, and assigning software tools that are available to a user or a group of users.

The applications page displays all applications that are available on all registered servers. Software tools are added to this list automatically if they were installed on the OS. Software that does not require pre-installation does not appear in the list automatically. To add a software tool to the list, it is needed to add it to the registry of the OS. To do this, just add the desired key to the registry entry, where it is needed to specify the name of the software and the path where the executable file is located.

To provide users with access to software tools, it is necessary to specify them as accessible to the user on the user's page or group of users using the "Publishing Wizard". Using the publishing wizard, it is possible to grant access to the use of software tools or groups of them to a single user or group of users.

If all settings are made correctly and the servers are enabled, it is possible to connect to the servers using a browser that supports Java or HTML5. To do this, on the server page, click the link "User login page" – the login page for registered users. It is possible to select a user name and enter the appropriate password in the drop-down list. In this window, one can change the language and select the mode of providing the desktop environment and the keyboard layout. Instead of the list, it is possible to select the user name input mode manually in the server settings.

Today, there are two modes of providing a working

environment: the first is a normal desktop in a browser window, the second is a portal mode in which selected programs open in a seamless window. After clicking the "Connect" button, the desktop of the OS is loaded, which is located on the least loaded server. Software tools that were published for the selected user are installed in the session. The virtual desktop can be downloaded on any device with a browser that supports Java.

In general, the experts pointed out that the use of Ulteo OVD virtualization technology has the following advantages: it allows configuring the working learning environment of participants in the educational process, quickly making changes to all components of the system. For example, to update a software tool, it is not necessary to install it on all workstations, but rather make changes on the server, after which all users can use the updated version; there is a restriction on access to software products that do not relate to the subject of the work that the student performs, so it is easier to focus only on the necessary data; using file servers, it is possible to store data only in one place, so it is not necessary to copy files to each computer and there is a possibility to reduce the amount of memory used; it is possible to run applications on remote services that do not require installation, thereby expanding the range of software products used.

5. CONCLUSION

The introduction of DVT in the distance learning process helps students to focus on self-development, ensuring self-improvement and increasing their independent research and educational activities. The effectiveness of conducting and organizing independent work of students and monitoring its implementation increases under the conditions of using distance learning.

The use of DVT requires fundamental changes, especially concerning the role of the technical staff of the educational institution. The teacher must acquire new knowledge and skills necessary to become a course developer, tutor, and facilitator. In addition, they should be a good organizer, taking into account the significant changes in the concept of space and time introduced by new information technologies. Using the DVT, the teacher-tutor should apply a transdisciplinary approach – involving many specialists from different disciplines – from domain specialists to course developers and system administrators.

In general, the results of the study confirmed the hypothesis that DVT in distance learning lead to the creation of a VLE that is accessible to students and tutors on any computer connected to the Internet via a browser and contain a wide range of training tools for tutors (through collaboration, communication, and evaluation).

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