Distance learning through distributed information systems using a virtual computer lab and knowledge management system

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Abstract. This article discusses issues surrounding the training of specialists in distributed information systems through the use of innovative methods and technologies in a virtual computer lab environment with an integrated knowledge management system. The article clearly shows how complex knowledge, skills, and professional competencies should be taught to IT specialists. It provides a detailed exploration of the architecture of the Virtual Computing Lab (VCL) and describes the successful experience of using the VCL in classes taught by the Department of Systems Analysis and Control at the Dubna State University. The article provides a detailed description of key components and integration technologies, and it also covers details of how it can be applied to distance learning.

Keywords: virtual computer lab, knowledge management, distance education, distributed information systems, training IT specialists.

1. Introduction

When training highly skilled IT professionals, it is an important challenge for the university to teach professional competencies to graduates that they will be able to use to successfully solve a broad range of substantive problems that arise at all stages of the lifecycle of distributed corporate information systems. Such information systems in practice, as a rule, are used for enterprise management, workflow management in technological processes, IT infrastructure management, creating web-solutions for high availability, data collection, and data analysis and storage. It is obvious that in order for students to learn these professional competencies, they need to master a large amount of theoretical material and to carry out practical exercises and research on the development of modern information systems, their deployment and support, the effective implementation of solutions for problem-oriented tasks, etc. [1, 3, 20].

2. Background

The organization of an effective process for the goal-directed training of IT experts has demanded a speedy solution to the following problems: an often insufficient number of classroom hours for students to cover a necessary and sufficient set of practical exercises that help students learn complex information systems; on a typical personal computer with average capabilities it is impossible to get real practical experience working with multi-component information systems because the hardware requirements for such systems often go beyond what is offered on typical home, office and laptop computers; sometimes there are difficulties installing and supporting some information systems, and these problems cannot be solved without gaining experience about how to use such systems; the single-user license cost is too high, and in most cases, such a license is required only for the duration of the learning process.

The main way to solve these problems has been to create a virtual computer lab that is able to solve the problem of insufficient computing and software resources and to provide an adequate level of technological and methodological support; to teach how to use modern technologies to work with distributed information systems; to organize group work with educational materials by involving users in the process of improving these materials and allowing them to communicate freely with each other on the basis of self-organizational principles [4-6, 13-15].

3. Brief concept of using virtual computer lab

The virtual computer lab provides a set of software and hardware-based virtualization tools that enable the flexible and on-demand provision and use of computing resources in the form of "cloud" Internet services for carrying out research projects, resource-intensive computational calculations and tasks related to the development of complex corporate and other distributed information systems. The service also provides dedicated virtual servers for innovative projects that are carried out by students and staff at the Institute of System Analysis and Control.

One main distinguishing trait of the virtual computer lab is its self-organizing principles, which make it possible to transition students from a rigid system of group security policies to a new system where each student can develop a sense of personal responsibility, respect for colleagues, and tolerance, which should provide a solid foundation for strengthening and developing basic European values in the education environment. It is clear that education is apolitical. Thus, today the need has arisen to incorporate technologies into the educational process that will contribute to general European integration in the foreseeable future.

It is not arbitrary that education that is conducted through high-availability distributed information systems is a priority, because these types of software solutions have become an integral part of modern business. That's why the task of designing and deploying failover clusters forms the topic of several special courses, which are designed to satisfy the demand for these skills by modern companies. When designing corporate information systems and ensuring the availability of critical applications that are independent of a particular hardware and software environment, it is critically important to ensure the

successful implementation of many key business processes. Downtime, including for scheduled maintenance, leads to additional costs and the loss of customers, and the long outages are simply unacceptable for modern high-tech enterprises [7-16, 21, 22].

In learning such practical skills, students must independently master the requirements for creating a failover cluster; determine the critical components that require redundancy; configure virtual machines; become familiar with advanced data storage tools and technologies, the principles for creating distributed systems, different types of server operating systems (Windows and Unix), and ways for ensuring their interoperability; learn about communication protocols on the basis of iSCSI; set up computer networks; draft security policies; and solve the problem of integrating system components.

The task of deploying failover clusters demonstrates the capabilities of the virtual computer lab. It also illustrates how it can be used as part of practical lessons and extracurricular work, making it possible to train IT professionals in accordance with the requirements of the most advanced educational and professional standards.

4. Structural components of virtual computer lab

Blade servers are the hardware components that support virtual computer labs. They are compact and allow the space in the server room to be used more efficiently.

The software platform of the virtual computer lab is implemented based on the VMware vSphere Software, which consists of vSphere ESXi hypervisors that handle all of the computing work of the virtual machines as well as vCenter Server central management servers.

The vCenter Server consists of the following key components:

vCenter Single Sign-On. This component is critical to the whole environment, since it provides secure authentication services for many vSphere components. Single Sign-On creates an internal secure domain in which the various components and solutions that are included in the vSphere ecosystem are registered during the installation or upgrade process, and subsequently they will be assigned basic infrastructural resources. Within the VCL architecture this component is responsible not only for internal authentication services, but it is also used to authenticate users from the university's internal domain who have Microsoft Active Directory accounts at the university.

vCenter Server. The vCenter Server component is a central component that is used to manage the vSphere environment. This module provides management and monitoring interfaces for a number of vSphere nodes, and it also enables the use of such technologies as VMware vSphere vMotion and VMware vSphere High Availability.

vCenter Inventory Service. Approximately ninety percent of vSphere Web Client requests to the server are just requests to read the current configuration of the system and its state. The Inventory Service is a component that caches most of the information about the current state of the environment in order to respond to vSphere Web Client requests so as to reduce the load on vCenter basic processes.

vSphere Server for Web Client (vSphere Web Client). vSphere Web Client is the main interface that is used to centrally manage the environment. It can be divided into two parts: the first server part, which serves requests from the second part, which is the end user's Adobe Flex compatible browser with support for NPAPI-plugins. It is worth noting

that the VCL may also be managed using the vCenter Server Desktop Client that is installed on the end user's computer.

vCenter Server Database. The database is one of the key modules in the vCenter Server stack architecture. Almost every request sent to the vCenter Server entails communicating with the database. This database is the main storage location for vCenter Server parameters, and it is also a repository of statistical data. Saved statistical data make it possible to optimize system performance during subsequent analysis [23-25].

The NVidia Kepler graphics card is used for 3D virtualization, and VMware Horizon Suite is used for remote VDI connections as well as for creating images of virtual servers and workstations that are separated into layers using VMware ThinApp and for managing these images [18].

A centralized management portal as well as a knowledge management system were created in order to manage the virtual computer laboratory. The need to create such a system was conditioned by the fact that students are able to learn about distributed information systems remotely, so it is important to create a social network between all participants as well as to create an environment that allows pupils the opportunity to independently engage in such processes as the identification, acquisition, presentation, and use (distribution) of knowledge without the direct involvement of the instructor.

Methods of use (propagation) are directly related to storage methods and, consequently, the technological tools that may be used for the transmission of formal knowledge include knowledge bases with various search functionality; blogs, wikis, and social networks; "Wiki Textbooks" that allow all participants to collaboratively create and update educational content and exchange practical problems (including from real companies); as well as user blogs, forums, and group chat systems. [2, 7].

5. Approach to integration of the components

One of the major components is an expert system that can automatically determine the number of virtual machines on the basis of a series of questions and answers and generate the needed configuration for a particular distributed system. This approach makes it possible to significantly expand the functionality of the Distance Learning System at Dubna University. In order to implement the approach, it was integrated with the VMware vSphere technology platform that was discussed above. In order to simplify understanding, the model uses a 3 server configuration, where the Alpha and Beta servers are the hypervisors, and the Gamma server is a management and authorization server that is connected to the central LDAP directory of Dubna University student accounts.

Fig. 1. Conceptual Integration Model of VCL's knowledge management and expert systems with VMware technology platform

The AP BL (Applied Problem (AP) business logic) Service and GIM DB components carry out the same functions as in the architecture example that is described above, which is designed to handle a business logic and database service. The main difference is that in this implementation, the communication between the business logic service and the VCL software platform occurs through the use of the web service provided by the VMware vCenter Server.

Messaging is conducted using SOAP and HTTPS. SOAP (Simple Object Access Protocol) is a protocol for the exchange of structured messages in a distributed computing environment. Originally SOAP was intended mainly for the implementation of the remote procedure call (RPC). Now the protocol is used to exchange arbitrary messages in the XML format and not just for procedure calls. SOAP can be used with any application layer protocol, including SMTP, FTP, HTTP, HTTPS, etc.

The VMware vSphere Web Client is the main tool for managing the VMware stack architecture. Architecturally speaking, it can be divided into two layers: the user interface layer and the service layer.

The interface layer consists of the Adobe Flex application that appears in the user's web browser. This application contains all the user interface elements.

The service layer consists of a collection of Java services that can be launched in the vSphere Web Client application server framework, which is based on the Virgo server. Java services interact with the vCenter Server and other parts of the vSphere environment. The vSphere Web Client application server includes the Spring Framework, which is

responsible for managing communications between the interface layer and the services layer [19].

The vSphere Web Client architecture is expandable due to the ability to install plug-ins that utilize the Adobe Flex, HTML, and JavaScript technologies. This extension is designated as the Web Client Extension in the information system architecture diagram. It is this extension in particular in the implemented architecture that provides the end user with an interface that makes it possible to successfully implement applications. In conjunction with the service business logic, it also makes it possible to fully deploy an expert system to automatically generate virtual machine configurations on the basis of user answers to key questions. If desired, the functionality of the business logic service can be transferred to the inner Java service in the Virgo server component. In this case, it is no longer necessary to have a separate business logic server, but, in the opinion of the authors, foregoing this server may somewhat complicate support, maintenance, and the migration of system components to new hardware.

A fully conceptual model of the virtual computer lab is shown in Fig.2. The implementation of a virtual computer lab makes it possible to implement innovations, and it represents a significant leap forward over traditional educational approaches [8, 17].

Fig. 2. Architecture of Virtual Computer Lab with schematic instances of user's failover clusters

6. Conclusion

It should also be emphasized that the virtual computer lab has helped us provide an optimal and sustainable technological, educational-organizational, scientific-methodological, and regulatory-administrative environment for supporting innovative approaches to computer education. It promotes the integration of the scientific and educational potential of Dubna State University and the formation of industry and academic research partnerships with leading companies that are potential employers of graduates of the Institute of System Analysis and Control.

The results that the Institute of System Analysis and Control has achieved in improving the educational process represent strategic foundations for overcoming perhaps one of the most acute problems in modern education: the fact that it tends to respond to changes in the external environment weakly and slowly.

7. References

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