

# Virtual Laboratory for Distance Learning: Conceptual Design and Technology Choices

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**Abstract:** Questions of designing and a choice of technologies of creation of virtual laboratory for the distance learning system are considered. Distance learning system «Kherson Virtual University» is used as illustration.

**Keywords:** distance learning system, virtual laboratory, Rich Internet Application.

## 1 Introduction

Objects of research are systems distance learning systems and virtual laboratories (VL). Research objective is designing and description of technology choices of virtual laboratory development in distance learning system for expansion of educational possibilities of distance education.

Virtualization from the point of view of education is a process and result of communicative interaction of subjects and objects of education in the virtual educational environment which specificity of the maintenance is defined by concrete subjects and objects during the interaction.

The wide concept of virtuality should be narrowed to area of the concepts describing virtuality from positions of processes modeling in a concrete subject domain. Virtuality is a set of prospective interactions of real objects representations among themselves, and also possible consequences, i.e. conditional interactions of concepts images and objects formally represented as real.

Concept "laboratory" is a place specially organized for execution of laboratory works, experiments and a place for search of decisions in the field of fundamental sciences, or for the tasks solutions in a certain application area of knowledge.

The concept of the virtual laboratory has not the accurate settled definition, therefore often companies interpret it at own discretion, and they adjust it under concrete needs of their products. We will introduce concept of virtual laboratory, being based on the resulted definitions. So, the virtual laboratory is a virtual environment in which the possibility of research of conducts of models of objects, their sets and the derivatives, set with the certain stake of detailing in relation to the real objects, in a certain field of knowledge is organized.

Analysis of the Internet resources shows that the overwhelming majority of projects of virtual laboratories are not conforming to the concept of laboratory. More

frequent it is Internet sites where the texts of laboratory works are present, supported by media maintenance. Frequently only one process without management possibility is displayed in accompaniment. If in the context of such "laboratories" are any objects they are very limited in possibilities, and they are procedural programs, but not objects, without possibility to modify or to complement the motion of going processes.

That is, there is a certain discrepancy of purpose and the name of the majority of the Internet resources – «virtual laboratories». From this follows the research problematic – creation of the project and development of the software of virtual laboratory.

Besides, it is necessary to notice, that modern IT possibilities allow to expand concept of virtual laboratory – to apply it not only for fundamental sciences but also for more wide range of fields of knowledge, for example rendering support at studying of arts, linguistics, the rights, philology, etc.

In department of multimedia and distance learning technologies KSU there are already preconditions to creation of such virtual laboratory. In the asset of department there is an experience of creation of declarative virtual systems of processes modeling, in particular, the demo-project «Electrotechnics» in which the algorithms of creation and an estimation of quality of interaction processes in electric circuit are laid. The distance course "Cytology" is the software product the purpose of which is support of process of execution of virtual educational laboratory works on the course of the discipline with the same name. Besides, there is an experience of creation of virtual educational training simulators, such as, a microscope and the electric motor, allowing studying the details of construction and principles of its work. Also, there is a long-term experience of teaching of discipline «Modeling of physical processes», students create virtual models for calculation and visualization of processes in various sections of course of physics under the guidance of employees of department. Thus, we have concepts of creation of virtual laboratory which can unite in itself support training process of students on the whole spectrum of fundamental and applied disciplines.

As we understand, the virtual laboratory should function inside the system of distance learning. Using the virtual laboratory works is capable to expand qualitatively possibilities of distance learning, and also effectively support execution of practical works.

Interviewing of teachers and students – users of distance learning system «Kherson virtual university» (DLS KVU) has shown, that answers for the question «What tutorials do you prefer?» show the positive growth of requirement and interest to non-standard approaches in education (Fig. 1). There is already a category of people who consider that the possibilities, which are integrated in the standards of distance learning (DL), are not enough today. The wider toolkit for execution of virtual laboratory works is needed for active users of DL.

Progress of DLS has caused the transferring to the virtual environment the basic forms and ways of education - the groups, courses, tests, libraries, virtual rooms of communication, virtual boards with wide exposition facilities of information. The following stage of development DLS is obvious - it is necessity for creation of the universal virtual laboratory, which will have the digital analogues of laboratory offices of university, with all necessary tools. In such laboratory the support of

scientific researches of students and the control at all stages of cognitive process are provided.

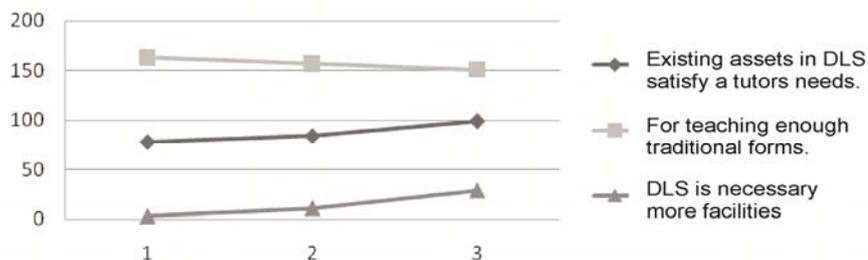


Fig. 1. Results of interviewing of users DLS KVU.

## 2 Analysis of existence of interaction between DLS and virtual laboratories

There is a big variety of DLS. The systems are free-extended, brand and author's systems. All systems are developed according to the international standards of distance learning, which allow providing the compatibility of components and the possibility of their repeated use in other systems, guaranteeing their invariance and unequivocal treatment. In opinion of the authors of DLS KVU any system has viability if it completely conforms to standards, and also it goes on a step ahead, introducing new educational means, it expands possibilities for the users, it introduces innovations which will not contradict the basis – standards, such as IMS and SCORM.

In the standards of DL virtual laboratories are not regulated, there is only a generalized description of objects of education. Requirements to such objects of training are in two key concepts: first of all the property of isolation, as a black box with the entrance and target strict-designated parameters, they are parameters of initialization of object and the parameters describing results of work. The educational resource should correspond to the standard at level of statement of an educational task, provide execution of educational task and should give an estimation of results, for the account in the rating estimation system. Packing of this type of a resource for carrying over to other educational system should be provided. The system resource will not contradict the standard at performance of these conditions [2].

The analysis of experience of introduction of virtual laboratories in DLS shows, that the problem of development the virtual laboratory as a part of DLS was yet not set by developers.

More often, laboratories reflect only one field of knowledge, usually it is sections of classical sciences, such as an electricity, analytical chemistry, optics etc. Also it is necessary to notice, overwhelming number of laboratories are in a format of distributive local software products which are delivered on separate computers, or on a small local area network, school or high school.

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Both these of type of virtual laboratories are frequently used limited, not in distance learning system, but only as additional facultative resources. In them there are not or partially realized modules of support of educational process. Usually the control of knowledge is realized in the form of self-checking questions, or the elementary test, the results of modeling are simply displayed to the user, but are not gotten to group journal of progress automatically.

The virtual educational and engineering laboratories of the industrial enterprises intended for automation of engineering work are the separate class. They are used in highly specialized areas of engineering science. These laboratory cabinets model real industrial problems of the concrete enterprise with high level of detailed elaboration. The main attention is usually given to realization of procedures of mathematical modeling, calculation and optimization of studied objects or processes during their creation [2].

During projecting and development of virtual laboratory the most effective approach will be focused on this class of software products, they have powerful analytical and mathematical appliance, the detailed level of imitation of processes.

The urgency of creation of virtual laboratory is caused not only development of DL. There are a number of disciplines in which laboratory researches mean considerable charges of educational institutions on machine tools, tools, preparations, reactants, etc. Besides as practice shows, students can't execute laboratory work correctly, after theoretical preparation in first time. Often for a successful execute the laboratory work it is necessary to make experiments several times, and then the expenses can essentially increase. Besides, in educational institutions, far not always there are means for purchase and completion of laboratory offices by all necessary. Virtual models are used in cases when the experiment is dangerous, expensive, occurs in inconvenient scale of space and time (too long-term, too short-term, lingered), is impossible, unique, not visual etc. [3]. In these cases the virtual laboratories become the necessity, it gives the chance to spend educational process with smaller expenses, or it will allow saving means, preparing students at first on special training apparatus, for the subsequent transition for real expensive laboratory stands.

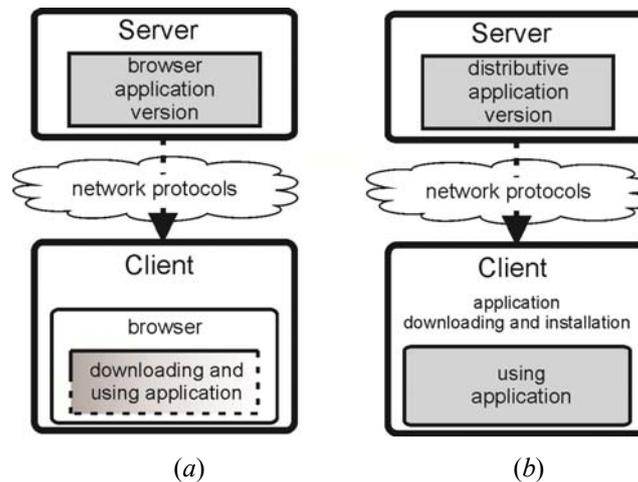
In our opinion, the virtual laboratory is capable to expand a spectrum of given educational services considerably. Its use will allow expanding possibilities of interaction of all participants of educational process. The authors put the objective – to create virtual laboratory as an educational resource in DLS «Kherson virtual university».

### 3 System architecture

#### 3.1 General approaches of realization and place of virtual laboratory in DLS

Modern possibilities of network technologies, universal prevalence of high bandwidth telecommunication channels, and also the width of possibilities of means of programming, in which it is comfortably to develop the web-oriented software products, allow saying that virtual educational means are expedient to create in the form of web-services.

Considering that fact that DLS KVV is the Internet application, the designing and development of VL should be executed as a web-oriented application. Though, it is not necessary to reject the possibility of creation of the software adapted under a local network with possibility at work to contact a server for data exchange.



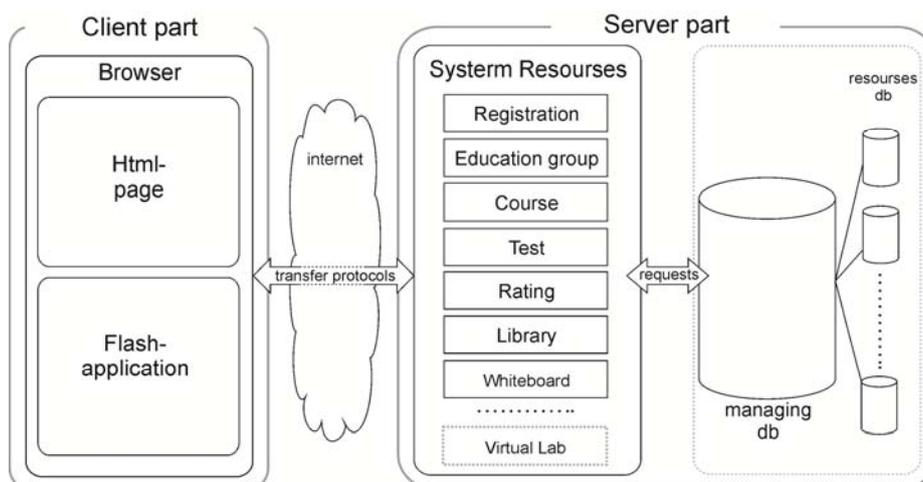
**Fig. 2.** Architecture web-oriented and locally network applications.

In fig. 2 the basic approaches of work of client-server applications are presented. In fig. 2 (a) the model of the web-oriented applications in which the client receives and uses the freshest versions of the software is presented. In fig. 2 (b) the model of locally network applications in which the software is installed on the computer of the user is presented. The user should contact the developer and receive corresponding modules of updating for reception of updating of the software.

The virtual laboratory has considerable volume of the information which at the first approach can demand much disk space and operative memory that will occupy definitely superfluous resources at each application launch. Frequently all laboratory modules are not necessary for user at once, in this case an optimum variant is to make possibility for loading only the basic environment of the certain working module and

necessary section of library of objects. Then the user will save the traffic of resources and can increase the effectiveness of work.

It is necessary to notice, that in both cases there are advantages and lacks, therefore the realization of both ways of installation of applications will be the best variant then the concrete user can choose the way of installation more suitable for him, considering its personal needs.



**Fig. 3.** Virtual laboratory as a resource in DLS «Kherson virtual university».

In fig. 3 the place of virtual laboratory in DLS «Kherson virtual university» is shown. The laboratory is considered by developers as one of the important resources of system. Educational and the control facilities are an integral part of educational process in the distance form.

Developers put the task to create such mechanisms:

1. Possibility of creation of the working model or construction
2. Possibility of carrying out of various transformations and change of statuses (editing) of model or construction
3. Possibility to carry out necessary calculations and measurements of parameters of model or construction virtual measuring devices

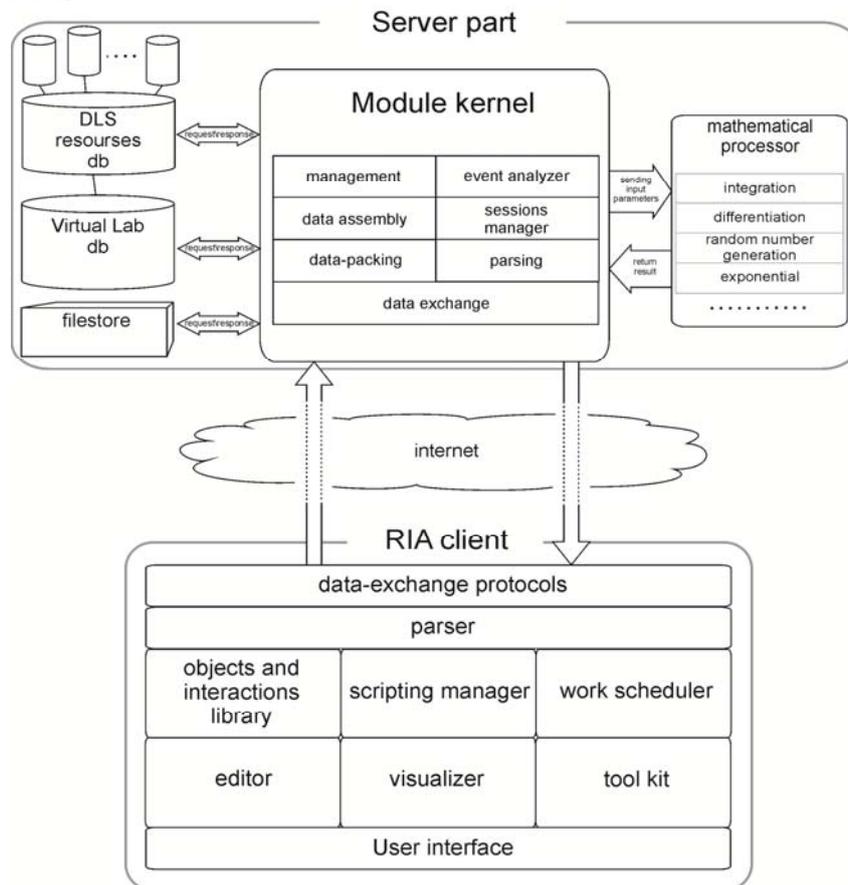
Let's consider the method of creation of the module of virtual laboratory in the form of the client-server application in format Rich Internet Application (RIA) [4]. The choice of this model is connected with advantages which are given by this format to developers and users. First of all it is necessary to note the possibility of the user to work on any computer with Internet connection in any browser with installed module Flash Player. The interface and level of interaction of the user with RIA application can be similar with functionality of traditional desktop applications. Developers and designers receive freedom in realization of ideas, considering specificity of concrete area of knowledge.

Today level of use of module Flash Player of users is 96 % [5]. Universal prevalence of Flash-technologies allows speaking about availability to users of such approach in realization of the module of virtual laboratory.

There is a wide variety of developing tools for creating RIA applications. These are such technologies as Adobe Flash\Flex, Backbase, Google's GWT framework, java applications, Microsoft ActiveX controls, Microsoft Silverlight, etc. [4] Our choice of technology for developing client application is Adobe Flex, firstly of all because it installed on the wide prevalence on computers of users, and also it has full multimedia possibilities of Flash that allows to open the essence of modeling of processes VL widely.

### 3.2 Scheme of components of the module «Virtual laboratory»

In fig.4 the scheme represents the architecture of the program module «Virtual laboratory» is presented. In the server part of the application there are three basic components – the module kernel, the connected databases and the mathematical processor.



**Fig. 4.** The scheme of model of virtual laboratory.

The set of the basic classes of management are In the module kernel:

1. "Management" is responsible for the rights of accounts of users, provides synchronization of resources of users, and connects options of the components used by the concrete user.
2. «Event analyzer» writes down, orders and stores all actions of users for the subsequent reproduction.
3. «Data assembly» provides creation of packages of data and files of resources for library of the user with the subsequent sending in repository on a server at the start of the work.
4. «Sessions manager» creates virtual rooms, connects to them users, and provides authorization and administration of rooms. It is responsible for reception and data transmission between users and a server.
5. The module «Data-packing» creates packages from resources which will be sent to the client, and also for maintenance of integrity of data and creates metadata of these packages of resources.
6. Module "Parsing" provides transformation of arriving inquiries and messages from the client application and transfer of given data to operating modules.
7. "Data exchange" is the interface of web services of interaction with client applications.

In module VL databases of DLS «Kherson virtual university» are used. First of all, it is base of authorization, statistics, also sending of data about progress of users in base estimation is realized, etc. Except used DLS bases, the module has own database, where records about job of all components of the module, the information about objects, records of events, and also links with storehouses of resources of libraries are stored.

The mathematical processor serves for maintenance of difficult mathematical calculations which cannot be carried out by client computers. These are calculations of the solution of the equations of the higher orders, the calculations demanding use of mathematical methods of correlation, specification, iterations, and calculations of errors, an analysis, and others.

The client part of the software of VL has components for creation and work with virtual models:

1. «Objects and interactions library» contains sets of objects of a certain subject domain, and also the ways of the interaction defined by the current field of knowledge.
2. «Scripting manager» allows adjusting interactions between objects, setting their parameters, imposing conditions. Also it is intended for the description of properties and interactions of the new objects created in the editor.
3. «Work scheduler» has two operating modes. In elapsing mode of laboratory research the user should according to offered course of work make all necessary operations for result reception. In the mode of creation of new work this component writes down history of events, allows to correct them, and to form the scenario of performance of work.
4. In "editor" VL the designing of the new objects is made. Users can on the basis of existing VL of library, preparing them, create other objects. Using in parallel the component of scripting, users can specify and finish new parameters and methods of interaction with other objects, finish new ways of behavior.

5. "Visualizer" is the component in which there is laboratory research, provides display of all designs of objects. In this module the current statistical data, such as values of parameters of system are also displayed, resultants of a direction of movements are specified. Directly here there is a process of modeling and management of a work scenario.
6. "Tool kit" is control facilities of user and changes of the objects which are in components the Visualizer and the Editor.
7. «User interface» – is set of methods of display and interaction of the user and system.

### **3.3 Description of job of users with the interface of the program module «Virtual laboratory» in DLS KVV**

In DLS KVV there are two basic roles of users which work in virtual laboratory - tutor and student. Working with module VL is carried out in two modes: work of the tutor in editor VL in a mode of creation of virtual laboratory work and work of the student in the training mode in VL. The tutor has the rights to create new models in the editor and to look through them, and the student can use ready model during work in VL.

Process of work of the tutor with VL begins with creation of new model of virtual lab work (VLW) in a window of the editor. First of all, the tutor always bases the educational activity on the working program of discipline. In the working program training basic elements, such as lectures, practical and laboratory works are reflected. The first step of creation of virtual laboratory work is creation of scenario. At this stage the tutor creates scenario VLW in the form of algorithm which realizes during laboratory work.

Then, the tutor consistently fills the model of VLW with objects from library VL, realizing the scenario of its performance. The tutor sets to objects parameters, methods of interactions, designs from them blocks, and thus forms definitive scenario VLW.

When the new laboratory work is completely designed, it is passed to the server which processes it and compiles ready model of laboratory work.

The student at performance of VLW has the necessary set of resources of training: tools, objects for work according to the scenario. In conformity with the requirement of isolation of module VLW, it should provide an estimation of quality of performance VLW. Therefore, after performance of laboratory work by the student, the module of performance VLW passes results of work in the form of estimation to a server.

Thus, the process of work in module VL allows to model educational process in real research laboratory, to create, to train and make control of the work.

## **4 Conclusions**

In the article the project of model is developed and technologies of designing the program module «Virtual laboratory» for distance learning system «Kherson virtual

university» are described. The technology of designing of program module VL is based on the client-server application in format Rich Internet Application.

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