Improvement of students' training in parallel and cloud computing

Mejoramiento de la formación de estudiantes en cómputo paralelo y nube informática

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ABSTRACT:
The paper examines the theoretical and practical bases of research on distributed data, namely, the setting up of an educational cluster of high-performance parallel computing, using of cloud solutions, virtualization technologies, the development of its own cloud storage and their introduction into the educational process of the republic's universities. The purpose of the research: is determining the theoretical and methodological foundations for improving the training of students in the aspect of studying courses on parallel and cloud computing, as well as their practical implementation in the learning process. Methods: Examining the foreign scientists' works; make theoretical analysis of research problems; modeling; using questionnaire and conversation in pedagogical experiment; pedagogical observation of the educational process; statistical processing of research results are obtained during the experiment. During the pedagogical experiment was conducted a survey of students compare effectiveness of the formation of the necessary competencies in the course of research work, we conducted a survey of students. At the moment, in the experiment took part bachelors and undergraduates in the number of about 150 people. The analysis and

RESUMEN:
El documento examina las bases teóricas y prácticas de la investigación sobre datos distribuidos, a saber, la creación de un clúster educativo de computación paralela de alto rendimiento, el uso de soluciones en la nube, tecnologías de virtualización, el desarrollo de su propio almacenamiento en la nube y su introducción en el proceso educativo de las universidades de la república. Objetivo de la investigación: es determinar los fundamentos teóricos y metodológicos para mejorar la formación de los estudiantes en el aspecto de estudiar cursos sobre computación en paralelo y en la nube, así como su implementación práctica en el proceso de aprendizaje. Métodos: examinar los trabajos de los científicos extranjeros; hacer un análisis teórico de los problemas de investigación; modelado; utilizando el cuestionario y la conversación en el experimento pedagógico; observación pedagógica del proceso educativo; el procesamiento estadístico de los resultados de la investigación se obtiene durante el experimento. Durante el experimento pedagógico se realizó una encuesta de estudiantes para comparar la efectividad de la formación de las competencias necesarias en el curso del trabajo de investigación, realizamos una
1. Introduction

In the Law "On Education" of the Republic of Kazakhstan, which defines the main principles of the state policy in the field of education, indicates that one of the main objectives of the education system is the introduction and effective using new teaching technologies, including credit, distance, informational and communicational, that can promptly adapt changings of society and the labor market. Realization of the created tasks assumes optimization of the pedagogical process, introduction of modern, new technologies into the educational process and further improvement of the educational and methodical process as a whole.

The task of the experiment is working out an algorithm of educational, methodological and organizational bases, i.e., introduction of special training courses, development of teaching aids, using of digital educational resources, development of cloud storage, adjustment and implementation of the educational cluster of high-performance parallel computing in the educational process and introduce it for of scientific research of undergraduates and PhD students.

The subject of our research is the introduction into the content of the educational process of the issues of distributed data, including parallel and cloud computing. There are opinions that all advanced countries are now paying great attention to parallel computing, considering this to be the most important state task.

The object of our research is the process of improving the training of IT specialists in the universities of the Republic of Kazakhstan.

2. Main part

In the course of our research, sources on the topic were analyzed.

Analysis of scientific literature and Internet resources show that courses on parallel computing and cloud technologies are introduced in higher education in foreign universities, at the same time, Kazakhstan has scientists’ researches and works according to this topic.

The experience of other scientists from different countries was studied, namely the issues of virtualization in studying (Klement, 2017), the modeling of certain studying processes (Liu, Wu, Wong, Lien, & Chao, 2017), the setting up of a parallel computing cluster for the learning process, and cloud computing in education.
2.1. Literature review


In the scientific and pedagogical literature of Kazakhstan (Nurkassymova, Serik., Mubarakov, & Zhanys, 2015) represented in his works problems of introduction of cloud technologies to the educational process, and parallel calculations in the educational process are presented in the works (Akzhalaova 2004; Dyusembiev, 2011; Serik, Bakiev, Zulpyihar & Shyindaliev, 2013; Serik & Bakiev, 2014; Serik, Baklyev & Balgozhina, 2014)

One of the tasks of solving this issue is the introduction of special courses in the educational process. In the educational process, in the preparation of future specialists in informational and communicational technologies, including computer science teachers, special courses on the organization of an educational cluster of high-performance parallel computing, cloud technologies and virtualization technologies were introduced to improve students' training.

2.2. Methods

The methodological basis for solving this problem are:
- a modern requirement of the society to improve the content of vocational education;
- analysis and development of educational standards, model curricula;
- the requirement for professional competence to the specialist of information and communication technologies;
- academic mobility of students for providing an opportunity to get education in the chosen area of training, including semester training in another institution, preferably foreign, providing access to knowledge centers, where the leading scientific schools on the studied problem were formed.

The didactic bases for solving this issue are:
- development of educational programs on the basis of educational standards and model curricula;
- identification of a didactic expedient path of educational problems on the research topic and ways of their implementation;
- methods and techniques of scientific knowledge for the assimilation of materials;
- mastering students of this or that competence after studying introduced new subjects;
- use of modern solutions of information and communication technologies.

One of the didactic peculiarities of educational activity is the management of the teacher by means of purposeful work on the problem being solved. On the specialties "Computer Science", "Information Systems" and "Computer Science and Software" of the Eurasian National University. L.N. Gumilev and Kazakh University of Economics, Finance and World Trade of Astana, Republic of Kazakhstan, the following types of organizational, educational and methodical works were realized:

1) in the aspect of high-performance parallel computing:
- an educational cluster of high-performance parallel computing has been set up and implemented in the educational process of the specialty on the basis of available personal computers;
- special courses "Parallel computing", "Client-server technology implementation", "Cluster of parallel computing";
- educational manuals "Parallel computing in MatLab", "Parallel computing", "Programming and parallel computing in the RAD Studio environment", as well as educational and methodological complexes for special courses;
- developed and used digital educational resources (https://moodle.enu.kz/).

The cluster is called educational, since the main goal of our work is teaching the students, to be able to organize the hardware and software bases of high-performance parallel computing, to apply them in the educational process and further professional activities.

A cluster is a collection of computational nodes, united by a network. In the 1980s, supercomputers were a large array of interconnected processors. They were unique and therefore had a huge cost in terms of acquisition and support. In the 1990s, cluster systems were widely used, which were used inexpensive, single-type computing nodes as a basis (Voevodin & Voevodin, 1999).

The main advantages of the cluster approach are easy extensibility and availability. For example, if (in our case) the cluster consists of computers with dual-core processors, and each core in MatLab can execute maximum 3 workers, there are opportunities to simultaneously perform several parallel computations, which makes it possible to use the cluster for parallel computing in the training purposes. Therefore, the main ways to improve the performance of modern computing systems are: increasing the number of processors, developing new principles for building communication environments and topologies using different network interfaces, while computers are in the same local network and in the same working group.

To the hardware requirements, in our case we used the dual-core Pentium (R) Dual-Core CPU 2.8 GHz and Pentium (R) Dual-Core CPU 3.5 GHz. With a memory of 2 Gb.

The software requirements include: installing and running Matlab R2011b on each computer and running the Matlab Distributed Computing Server on each computer as well.

Below is an example of setting up a parallel computing cluster for student learning, which consists of two computers (in the learning process, different computers were also combined):

```matlab
clientHost = 'server1';
node = {'server1','server2'});
for k = 1:length(node)
    for z =1:2
        str = ['!startworker -name w_' num2str(z) '_' node{k} ' - jobmanagerhost ' clientHost ' -jobmanager enu -remotehost ' node{k} ' -v'];
eval(str)
    end
end
```

Host = 'server1' is the computer which the task is started. The results of the work in Figures 1 and 2 show examples of the settings in the classroom for students of the parallel computing cluster [21] (Figure 1 - using two dual-core computers, Figure 2 - using an eight-core laptop). In the first case, two workers are used for each core of the microprocessor.

**Figure 1**

Example of configuring a parallel computing cluster using two dual-core computers
In the following case, 1 worker is used for each microprocessor core.

**Figure 2**
Example of using all eight laptop cores for parallel computing
In the content of the special course, along with the issues of parallel computing, the application of NVIDIA CUDA in MATLAB is also considered.

Cloud computing is considered as a special case of parallel computing, and therefore we have introduced special courses on cloud technologies.

2) In the aspect of developing and using cloud solutions:
- application of well-known cloud services in the educational process;
- software definition and installation of web servers for development of cloud storage;
- development of private cloud storage and use it in educational process;
- development of network drive and organization of the synchronization process;
- introduction of special courses "Basics of cloud technologies", "Cloud computing and virtualization technologies".

During the implementation of distributed data on the basis of cloud technologies, training manuals, educational and methodological complexes, electronic textbooks on cloud technologies were developed and introduced into the educational process of the university. The theoretical parts of the manuals contain basic concepts on the topic, key words and examples, and the practical part is accompanied by examples, assignments, methodological instructions and control questions to consolidate the cover material.

The necessary hardware and software for the work are: computer, Internet access, web browser (Google Chrome, Internet Explorer or Mozilla Firefox), user accounts; But for develop your own cloud are needed : a web server, cloud configuration software and services.

Our developed academic cloud is a systematically organized set of information, technical, educational and methodological support, inextricably linked with the learner as the subject of the educational process. The "content of the cloud" includes the necessary training and methodological support. Figure 3 shows the initial page of the developed cloud on the site bult.kz.
The content of the special course also covers issues of introduction of cloud technologies in the Republic of Kazakhstan, cloud technologies of the mobile operator, antivirus protection, organization of centralized access to local domain data, etc. Further study of the above courses continues in the content of the doctoral education of these specialties.

Formation of practical skills for students is also realized through the 15 digital educational resources developed by us on parallel computing that are intended as new opportunities for increasing the efficiency of the specialty educational process. Contribute to the use of modern interactive forms of learning, provide high interactivity, multimedia, as well as the opportunities for tier differentiation and individualization of training.

It is known that the effective assimilation of the acquired knowledge occurs in the process of cognitive activity of trainees, which is organized through laboratory exercises.

To implement the research tasks, the digital educational resources developed by us encompass not only theoretical materials, methodological instructions for laboratory studies, assignments for independent work, a course test, but also aimed at significantly improving the quality of education, the formation of new organizational forms and educational services.

Intensive using of electronic educational and methodological information in the form of digital educational resources makes it possible to increase the effectiveness of training in credit technology, automation and self-control of the acquired knowledge.

Next, consider the structural and logical scheme for validating, on the basis of mathematical data, the optimal variant of compiling the content of education on the topic under study.

### 3. Description of the study

Studies in the field of the consideration of the structural-logical scheme in the educational process occur in several studies (Moskalenko, 1991; Nurkassymova, Serik., Mubarakov, & Zhanys, 2015).

On the basis of the model of the design of the content of education, the vector of obligatory disciplines with components

\[ S_j \ (j = 1, ..., m) \quad (1) \]

And a vector of special courses with components

\[ S_i \ (i = 1, ..., n) \quad (2) \]
Let's create a matrix

\[ A_{ij}, i = 1, ..., n; j = 1, ..., m, \]  

The column names, which are the components of the required disciplines vector, and the row names are the components of the vector of developed and implemented special courses.

At the intersection of the columns \( i \) row and the \( j \) column of the above matrix is 1 if there is a link between the \( S_i \) and \( S_j \) components of the corresponding vectors, and there will be 0 if there is no such connection, where \( i = 1, ..., n; j = 1, ..., m. \)

The total number of \( k \) units is equal to the number of units in the coupling matrix. For example, we took the contents of the curriculum of the above specialty.

The degree of connectedness of the vertices of a graph is defined as:

\[ \text{Degree} = \frac{\text{sum of connections}}{n \times m} \]

Where \( n \times m \) is the maximum number of connections in the graph. Observance within subject connections allowed to make up the logical structure of the content of specialty education, to establish a sequence of disciplines, the relationship with other disciplines, the optimality of introduced new special courses.

To increase the maximum number of connections of the graph \( z \), the issues of introducing modern courses into the content of education were considered, i.e. Improving the content of education in the aspect of studying courses on distributed data. In our case it turned out that \( z = 0.7 \) (close to 1, i.e., it is the optimal indicator).

### 4. Results

To conduct comparative effectiveness of the formation of the necessary knowledge, skills and skills during the research work, we conducted a pedagogical experiment. At this point, the experiment involved about 150 students and undergraduates.

The staging sections of the pedagogical experiment were carried out at the beginning of the study. The purpose of the ascertaining experiment was the diagnosis of the initial level of information preparation on distributed data. As tasks of the experiment, we made a diagnostic determination of the level of theoretical knowledge, the formation of practical skills and competence, the selection of the necessary research assignments.

### 5. Conclusion and Recommendation

Analysis of the results of this study stage made it possible to conclude that the preparation of distributed data technologies does not meet the modern requirements for the future specialist in the field of information and communication technologies.

The next stage of research work is the conduct of a formative experiment. The purpose of the forming experiment is to substantiate the effectiveness and purposefulness of improving the training of students in the aspect of distributed data technologies.

As a result of the experiment, it can be stated that at the present time the level of theoretical knowledge in the field of distributed data has noticeably increased, there has appeared a motivation and need for the use of parallel and cloud computing technologies, knowledge on the organization, significance and purpose of digital educational resources has become more specific.

The introduction of such modern educational technologies is actual and is the answer to the task in the Message of the President of the Republic of Kazakhstan "Raising the well-being of citizens of Kazakhstan is the main goal of state policy".

### References


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