Improvement of Quality of Preparation of Engineers in Robotics by using of Grid-technologies

Alexander Bolshakov, Alexey Bolshakov, Olga Dolinina, Alexander Lavrov
Russia, Saratov State Technical University, 410054, Polytechnicheskay str., 77
Bolshakov@overta.ru, BolshakovAlAl@mail.ru, Olga@sstu.ru, AlexLav05@bk.ru

***Abstract* - There is described methodology of using of grid-calculations for the improvement of the quality of preparation of engineers in Robotics. The idea was realized with technical and financial support of HP Labs. It's necessary to take into consideration that including grid-calculations into educational process demands organizational, technical and methodical support. Organizational aspects demand formation of project's teams consisting of students of similar fields of studies for solving of tasks in simulation of robotics systems, automatised projecting in robotics, mechatronics. Technical aspects are connecting of with integration of Intranet-network of the university into grid-structure under software OurGrid. Methodical support includes teacher's guides and students' handbook for using grid-calculations in solving tasks in Robotics. For the unification of management of educational process MS Class Server is used. As a result of implementation this technology students get effective practical experience in using grid-calculations, skills of working in teams.**

Index Terms – Grid-systems, Robotics, Learning system, Parallel calculations.

INTRODUCTION

The distributed calculations and, in particular, grid-systems, is one of most dynamically developing and claimed area that supports scientific researches. It is tied with the general growth of information technologies level [1]: reduction of processors cost, raise of communication means speed, globalization of business and scientific processes. Using of the distributed calculations allows solving complicated computing problems in acceptable time limits. The systems, distributed on a global scale based on the Internet (grid-systems), besides increase of the general productivity, essentially reduce cost of the problem decision. For this purpose, e.g., scientific laboratories give idle computing resources for free-of-charge mutual using to other laboratories. The results of similar cooperation on the basis of network OurGrid are considered below as applied to the educational process in University.

Further we shall mean grid as the hardware-software infrastructure giving access to heterogeneous computing resources as to the united executive environment. The most exhaustive definition to the grid was given by J. Foster. He formulated 3 criteria: coordination of resources usage at absence of their centralized management; application of standard, open, universal protocols and interfaces; maintenance with not trivial way of high-quality service.

Distinctive feature of grid, besides practically unlimited scalability, is essential simplification of access to its resources. The user should less know about technical details realization of resources network infrastructure and concentrate more on decision of a problem from the concrete subject domain. For realization of transparent access to grid resources the specialized software, named intermediate or middleware, is used. It hides from the end user such features as geographical distribution of resources, their heterogeneity and dynamics. The latter means, that the probability of resource refusal is very high. In this case intermediate software should find a new resource and continue calculations imperceptibly for the user. The only things that the user should know are interfaces to start applications that solve his scientific problems.

Intermediate software in the development has passed stages from simple software packages (Globus Toolkit, Virtual Data Toolkit) whose components can have crossings in functionality, complexities in interface, up to full-function platforms with uniform system architecture (DataGrid, Unicore, LiveCluster, DCGrid), that can be described as concerning simple installation, adjustment, convenience of use, the increased fault tolerance and etc.

Similar qualities make grids accessible to general use not only for IT-professional users. One of the major applications of grid-systems is educational process in Universities. Besides acquaintance with modern information technologies students receive practical skills of solution complicated from the computing point of view problems about of its solution opportunity they earlier knew only theoretically. Multi-disciplinary is other aspect of grid-technologies usage. Problem solution, as a rule, needs a team of students from various branches of knowledge. It makes grid a point of appendix of general interest, and does education more attractive. Students receive skills of practical work in a team which will facilitate them transition from participation in educational projects to the solution of real problems when they will be employed. For teachers using of grid enables to receive new experience of teaching that, undoubtedly, is much more important in comparison with traditional simple representation to students of the next new information technology.

PROBLEMS TO SOLVE

The learning system for the course of manipulators management in robotics is created using grid at Saratov state technical university (SSTU) for increase of efficiency of educational process. The given system carries out typical control-learning functions: gives students a theoretical

material, an opportunity to perform virtual laboratory works, checks received knowledge, forms statistics of education.

Problems of three types are used as laboratory works [2]:

- The solution of direct kinematics problem (DKP). Consists in definition of position and orientation of manipulator's mechanical hand in the generalized coordinates (turn angles of joints), and, as consequence, finding the whole trajectory of object movement at the preset laws of generalized coordinates changes.
- The solution of a reverse kinematics problem (RKP). It is necessary to find laws of changes of generalized coordinates to guide manipulator through the set of space points, e.g., start, leaving, approach and finish points. RKP solution is generally ambiguously and also demands to check the whole set of solution variants with a choice optimum by some criterion. The problem possesses property of natural parallelism [3], i.e. its full solution can be separated into set of practically independent subtasks, having common processing module and differing with initial data. For acceleration of result obtaining here it is expedient to perform solution process in parallel mode. Grid is used on this stage
- Determination of approximating polynoms for a trajectory of manipulator's mechanical hand movement. Need to select factors of approximating polynoms so that to receive an optimum trajectory of manipulator movement in all points of a way.

OURGRID CONCEPTS

Grid can be used in two ways: creation of new own or connection to the existing grid. Creation of new grid-infrastructure demands great expenses and should be made only at real or perspective necessity, therefore the second way is chosen. SSTU as grid-unit on the basis of server Itanium II received under the grant from company Hewlett-Packard (HP) was connected to the existing scientific grid OurGrid (www.ourgrid.org). It is open, with free-of-charge connection grid in which laboratories give its free resources in exchange for use of resources of other laboratories if necessary [4]. OurGrid is created on the basis of Brazilian university Universidade Federal de Campina Grande (UFCG) in December, 2004 and actively develops with support of HP and the governmental funds of Brazil. Employees of university develope own intermediate software - platform OurGrid that satisfies modern requirements.

From the very beginning OurGrid sofware developes as free-of-charge, easy in use means for putting tasks to the distributed computing environment. Today it continues to develop but already now this software makes a serious competition to existing commercial platforms. OurGrid is intended for problems of class BoT (Bag of Tasks) [4] which solution can be executed independently from each other. It consists of three parts:

- Grid-machines that carry out the solution of separate parts of task - Grid User Machine (GUM). Software that implements GUM interface, e.g., UserAgent, is established on this machines;
- Peer machines - the dispatchers of resources which register lists of accessible GUM and give out them on demand for calculations, form statistics on mutual use of resources with other Peers. They serve also for connection with other grid-network in the world. Installed software is also called Peer;
- Workplaces of users from which tasks for the distributed calculation starts. Installed software - MyGrid. MyGrid broker performs a lay-out of task starting, monitoring of the started tasks, restarting tasks on others GUM if previous has given up.

The serious attention in OurGrid is given to safety issues. For its maintenance above a layer of means closing to resources of operational system is built the layer, named SWAN that implements the concept of so-called work in a sandbox. In the elementary case SWAN carries out tasks by the virtual machine Xen established on GUM. At that the programs executing tasks have no physical access to a computer of the user, and, hence, cannot damage its data. At full use of SWAN protection applications receive one of two performance levels: the first one is confidential in which software OurGrid functions itself and the second one is without the trust, used by the modules which are carrying out the user tasks. In addition to this after task finishing it is performed checking of GUM configuration integrity, e.g., for prevention of distribution of harmful programs.

In OurGrid there is a very flexible system of tasks statement for performance. There are two interfaces: scripts for usual humanitarian users and Java API for IT-professionals. Using scripts all work is broken into 3 subtasks: init (initial) on which files (programs and data) which are necessary for sending on GUM are listed; grid (actually computing stage) on which programs, input and output variable (files) for start on GUM are described; final (final) - defines output files which need to be taken away from GUM. It is possible in addition to describe requirements to machines on which the solution of problems should be carried out, e.g., to define type of operational system and minimal requirements to operative memory. Java API represents a set of the Java-classes, allowing to automate tasks putting in grid.

There are advantages of OurGrid which are necessary for taking into account:

- Nonalienability of resources of local users, i.e. the local user has the best priority and any local task finishes execution external task in GUM;
- The advanced layer of software coordination in which some schedulers of tasks (WQR, Storage Affinity) are implemented; It allows to balance loading between resources and to increase grid's productivity;
- Independent (i.e. doesn't require uniform resource server such as, e.g., GIIS in software Globus) system for statistics account of mutual resource granting is based not only on time parameters, but also on productivity of machines - suppliers of resources. The given system allows to exclude very quickly from interaction free riders which only consume resources of grid, not giving anything in exchange;
- Return results of execution is supervised by broker MyGrid who returns results to the user only after all

work has been completed, i.e. fault tolerance of system is implemented on program level since broker MyGrid independently restart the failed task on the other resource;

- Interoperability with existing systems, in particular, tasks can be placed on computers with established middleware GlobusToolkit;
- For grid infrastructure creation can be used personal computers and clusters on the basis of batch operation systems such as Maui, OpenPBS, LSF.

Thus, chosen grid and its middleware practically completely meet modern requirements to similar systems [1, 3] and allow solving the problems put by development of learning system.

LEARNING SYSTEM STRUCTURE

In a basis of learning system (fig. 1) is software MS ClassServer 4.0, providing an educational portal with an opportunity of teaching materials (the theoretical information, tasks) publication. It also supports a database of users (schoolboys, students and teachers). MS ClassServer functionally provides authorization of users, automatic formation of their work statistics (by results of tasks performance), reception of reports on progress, and also unification of teaching materials formats. On fig. 1 is shown the structure of one of supported formats - LRM (Learning Resource Material) which consists of set of pages (catalogues) containing a Web-content, and a manifest file Index.xml.

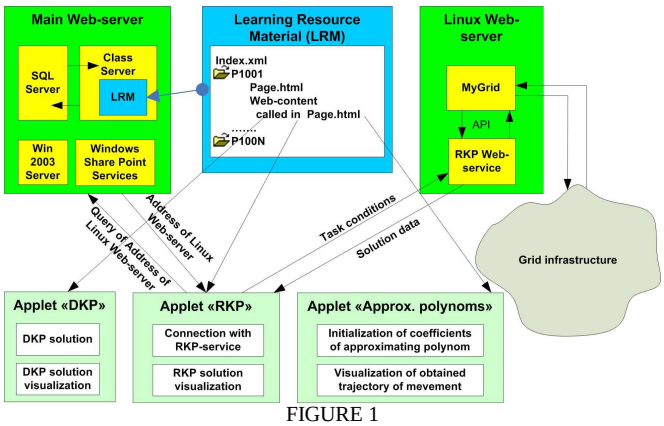

FIGURE 1
LEARNING SYSTEM STRUCTURE

Owing to complexity of organization of above-enumerated problems solution a Java-applet is included into the structure of a LRM-material for corresponding theme. With its help the difficult user interface and an opportunity of dynamic visualization of solution results are realized. Applets "DKP" and «Approximating polynoms» completely solve the problems on client side and carry out visualization of results using library Java3D. Applet "RKP" enables software MyGrid on server through Java API.

Software OurGrid (Peer, MyGrid, UserAgent) functions only on a Linux platform that is consequence of initial statement on creation OurGrid as an open source product. Therefore in structure of learning system is included the Web-server (Apache TomCat) on the basis of OS Linux on which software MyGrid is installed. For connection of applet "RKP" with MyGrid on a Linux Web-server the specially developed Web-service is installed. It carries out statement OKP in grid for solution with parameters, transferred from applet. The given service accepts conditions of a task from the RKP-applet, separates them into independent subtasks and distributes for execution to the list of GUM-resources received from Peer. Decision of RKP is ambiguous, therefore, the more variants is investigated the decision is more exact. In this case a subtask which is carried out on a separate resource, just solve and scan beforehand certain amount of variants and chooses the best. To perform this subtask the executed file written in language C ++ is sent to the GUM. Results of its work as output files come back in RKP-service where the optimum variant finally gets out and is sent the DKP-applet in which visualization of the solution is performed.

After completion of laboratory tasks results are saved in database of MS Class Server using access through API to the standard Class Server service named CSDataService.

RESULTS ESTIMATION

For tasks, in which active participation of students is required (solution DKP, finding of an approximating polynom), the estimation is performed by the analysis of comparison of student answer with the result calculated by the program (two graduations of scale: true, false). At DKP solution the student performs minimum of actions, the probability of mistake since the major work is carried out with the program therefore is minimal. Thus the student should understand process of program functioning while solving all three problems. For this purpose besides theoretical filling data on a robotics, the teaching material contains the information on the scheme of learning system functioning, on methods and means of solution.

Therefore in a final part of a learning material on each theme the usual test for the stated theory understanding is included. Test result will influence on the final estimation of made laboratory work.

CONCLUSIONS

Visualization using applets of solution of DKP, RKP and problems of approximating polynom finding allows to present in more evident form to the student a complicated material and to show modern opportunities under the solution of stated problems.

Creation of learning system is performed by employees, post-graduate students and students of faculties «System of an artificial intellect» and «Applied information technologies» of SSTU. Teamwork has led to mutual expansion of a scientific outlook of executors, and as a whole - to increase of student's knowledge level due to use of active means of education. Thus one of advantages of chosen software for grid-infrastructure is that the University at appliance of new IT-technologies minimizes financial expenses.

ACKNOWLEDGMENT

Authors are grateful to company Hewlett-Packard for the given opportunity to participate in interesting work with application of the newest IT-technologies and for its attention given to education.

REFERENCES

[1] Kovalenko V.N., Koryagin D.A. "Distributed computing and grid" http://www.gridclub.ru/library/publication.2006-07-17.5298811749/view.

[2] Bolshakov A.A., Glazkov V.P., Egorov I.V., Musatov V.Yu., Ptchelintceva S.V. "Application of Grid-technologies in educational and scientific processes of SSTU", Materials of conference «Internet technologies - on service to a society », Saratov, 2006,.pp. 113-119.

[3] Kovalenko V.N., Koryagin D.A. "Grid resource organization", http://www.gridclub.ru/library/publication.2004-11-29.9287628406/view.

[4] Cirne W., Brasileiro F., Andrade N., Santos R., Andrade A. "Labs of the World, Unite!", http://www.ourgrid.org/twiki-public/pub/OG/OurPublications/LabsoftheWorldUnitev19.pdf.