# EDUCATIONAL SEGMENT OF UKRAINIAN GRID INFRASTRUCTURE

***Petrenko A., Velichkevich S., Alenin O.***

*National Technical University of Ukraine "Kiev Polytechnic Institute",*
*37 Peremogu Rd., Kyiv-56, Ukraine, Email: petrenko@cad.kiev.ua*

## *ABSTRACT*

*Grid technologies and the world Grid network take the place of usual Internet with its Web services as means of shared use of computind and data storages resources. Grid does not provide the simple data exchange between the computers , it enables to turn the global network into some kind of enormous virtual computer available in the mode of remote access from any point, independently from the user's dislocation. The project "Development of the National Grid infrastructure for scientific research and education (UGrid)" which is dedicated to building the high-quality national Grid infrastructure with corresponding services for giving possibility to native scientists to collaborate fruitfully in European Research Area (ERA) is described in the paper. The project is executed by the team of 10 different Ukrainian organizations (2 academic, 6 educational and 2 industrial ones).*

## 1 INTRODUCTORY REMARK AND THE HISTORICAL OVERVIEW

The Grid infrastructure is recognized today in Europe and worldwide, together with the highspeed networking, as one of the basic components of the e-Infrastructure of research and education and soon of the entire knowledge-based society. The starting point of such perception of the Grid infrastructure is the paradigm of the grid itself, which offers a flexible organisation of geographically distributed resources (computing, data and information resources as well as, for instance, laboratory and experimental devices and equipment), with a consistent and simple access option and possibility to co-ordinately share them within collaborating virtual teams and organizations.

The project of building the national Grid infrastructure for information society development in Ukraine, its composition and tasks were first voiced by NASU academician M.Z. Zgurovsky on WSIS (World Summit on Information Society) in 2004 [1]. Later this report was re-published in our literature because of its strategic contents [2]. It was concerned about the necessity of creating the educational and research segment of Ukrainian information society with two main directions: wide use of information and communication technologies on all stages of scientific research and education, and also information management of corresponding branches. The main tasks of *first direction* included:

- Grid infrastructure modeling for education and research support.
- Infrastructural development of Ukrainian research and educational URAN network and its integration into European GEANT – 2 network.
- Getting the experience of work with Grid infrastructure and distributed systems exploitation, development of algorithms and methods of solving the applied tasks in distributed computing environment.

*The second direction* took:

- Introduction of efficient information management of education and science.
- Development of the means of storing, processing and open access to scientific and educational information resources (data bases, archives, electronic libraries, etc.).
- Connecting Ukrainian Grid to European Grid being developed under the EGEE project and to the World Data Centers net.

Goals and tasks proposed in [1,2] found their implementation in **State program 'Information and communication technologies in education and science for 2006—2010'**, adopted by Cabinet of Ministers of Ukraine (Decree of Cabinet of Ministers of Ukraine №1153 from December 7, 2005. Institute for Applied System Analysis (IASA) of the National Technical University of Ukraine 'Kiev Polytechnic Institute' won the of projects tender and the project **" Development of the National Grid infrastructure for scientific research and education** (UGrid)**"** was adopted by the Ministry for Education and Science of Ukraine (MESU) under the agreement № IT /506 - 2007 from August 22, 2007.

## 2 THE NATIONAL GRID INFRASTRUCTURE FOR SCIENTIFIC RESEARCH AND EDUCATION (UGRID)

**Ugrid project** (www.grid.ntu-kpi.kiev.ua) is dedicated to building the MESU segment of National Grid infrastructure with corresponding services for giving the possibility to Ukrainian scientists to collaborate efficiently

in European Research Area (ERA) and to favor building the economics of information society, based on knowledge, by introducing scientific Grid concepts along with the most substantial scientific applications, which are used in Grid environment. Grid technologies enable to rise the creative potential of mankind by uniting computational resources for the most important applications and enabling the geographically distributed users to interact and to support the common work.

At project realization, the following tasks are solved, according to approved technical tasks:

## 2.1 First stage of work (06.2007-09.2007):

- Analysis of concept, architecture and resources of modern Grids was made, information on methods of building the distributed systems architectures with the use of Grid technologies were systematized;
- Grid infrastructure with 6 resource-operational centers (in Kiev, Kharkiv, Donetsk, Dnipropetrovsk, Zaporoje and Lviv) was built; remote servising the future users-scientists from universities and scientific establishments of Ukraine was begun. Certainly, this initial Grid infrastructure will be expanded, and the number of its centers and developers from DESU organizations and NASU academic institutes will be increasing. The Grid infrastructure fractality, i.e. such its property when the system resembles itself on every, different in scale, section, favors it.
- In **June, 2007**, Agreement with European DANTE organization about connecting the National scientific educational URAN net (www.uran.net.ua) to European GEANT-2 network was signed. URAN (Ukrainian Research and Academic Network) net was created by the jiont efforts of Ministry of Science and Education of Ukraine (MESU) and National Academy of Sciences of Ukraine (NASU) for providing establishments, organizations and individuals in the spheres of education, science and culture of Ukraine with information service on the basis of Internet technologies for professional needs realization and development of these branches. The main network management center is situated in Kiev, and regional centers are in the largest scientific-educational centers of Ukraine: Kharkiv, Dnipropetrovsk, Donetsk, Odessa, Lviv, Simferopol, and Khmelnitsk.

## 2.2 Second stage of work (09.2007-12.2007):

- comparative analysis of the components of Grid middleware packages was made, on the basis of which the proposition of using the gLite software in the National Grid environment was made. Middleware gLite has the wide set of services, it supports the service-oriented architecture, it is widely used in European projects, it has enough possibilities on modernization and creating additional functionality. The main approaches to solving of middleware software interoperability tasks are considered. The three-language project Web- site ( www.grid.ntu-kpi.kiev.ua), information resource of which is now more than 80 MB, was created and works now.(fig.1)


**Fig.1**. UGrid project sit

- agreement with European EUGridPMA organization concerning the creation of Certificate Authority in Ukraine, responsible for registration of Grid resources, virtual organizations (VOs), and users, was adopted;
- agreement with NASU was achieved, and it was begun uniting the existing elements of scientific and educational computing and communication infrastructure NASU and MESU into the single **Ukrainian National Grid Initiative (UNGI),** which was integrated into European Grid infrastructures *EGEE* ( Enabling Grids for E-sciencE) and EGI (European Grid Initiatives).

## 2.3 Third stage of work (05.2008-09.2008):

- interonnecting clusters of ITF NASU and NTUU 'KPI' was provided on the basis of NorduGrid middleware software for computing resources of Ukraine virtualization with simultaneous connection of 5 resource-operational centers to NTUU 'KPI' cluster. Common educational program of training on Grid technologies with Korean universities via KOICA organization in Ukrainian-Korean IT Center was approved; its implementation is already begun.
- in January, 2008 activity of Certificate Authority of Open Keys was begun with the goal to provide Ukrainian users with access to European resources and data stores. (www.ca.ugrid.org). This Authority now services the users of both Ukrainian Grid infrastructure segments, being developed by MESU and NASU.
- the portal of **SDGrid** (www.sdgrid.org.ua) access to Grid infrastructure was developed as the single point of users' access to multiple information resources and applications, which will be set in operation in resource-operational centers for users' service and training. This portal is a hardware-software complex with the main functions of tasks definition for calculating in Grid infrastructure, the state of computing and data storages resources monitoring, Grid infrastructure resources and safety policy management, user training, providing access to the other Grid systems, virtual organizations creating and supporting , etc. SDGrid portal was built on Gridsphere 3 with applications for gLite, Globus 2 i Globus 4 software supporting, and Gridsphere provides the developers with highly effective mechanism in developing new applications which use the portlet system (fig.2)

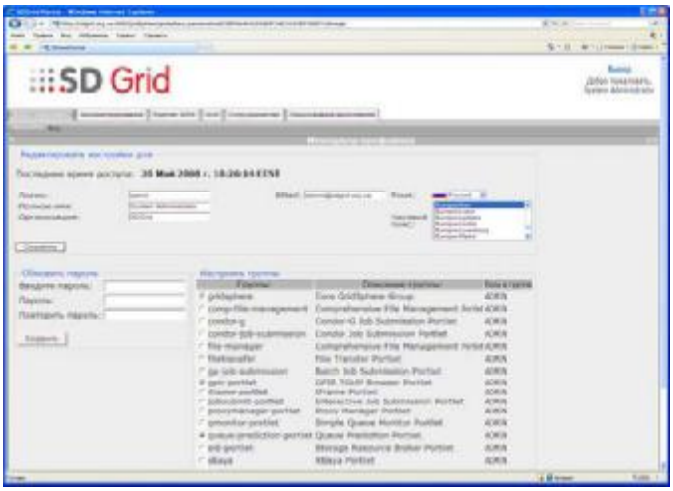


**Fig.2**. Main portal window

## 2.4 Fourth stage of work (10.2008-12.2008):

- methodology of Grid technologies use in universities was explored; experimental educational program on Grid course was created; Master training in the direction '**Grid technologies in science and education'** was begun.

- Tutorial **'Introduction into Grid technologies in science and education'** (author is Prof. A.I. Petrenko) was prepared and published, preparing of the text-book by common author team of MESU and NASU specialists was begun (fig.3)

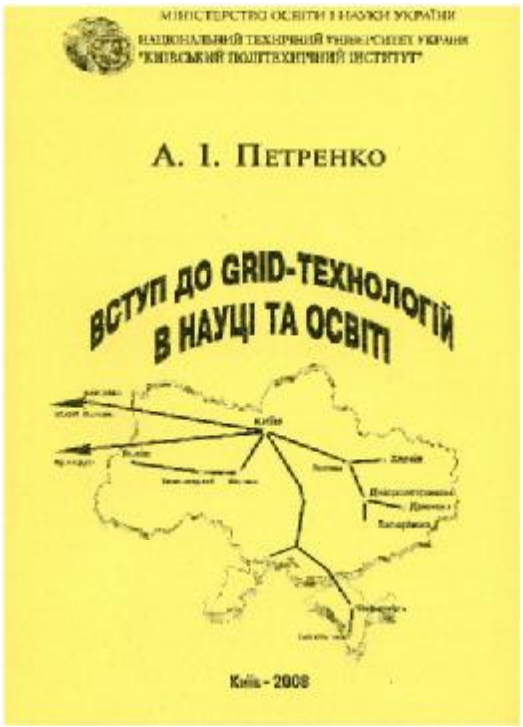


**Fig.3**. First tutorial on Grid technologies in Ukraine

- on the basis of SDGrid portal, the virtual laboratory for demonstration of Grid technologies possibilities was created, shown on fig. 4. It includes five geographically distributed servers: Web server, MyProxy server, CA (Certificate Authority) server, computing resource HPC server, monitoring and reserve copying server, intended for collecting statistics on the state of learning Grid system servers. By the help of this virtual laboratory, the first experience of work in Grid environment can be obtained.

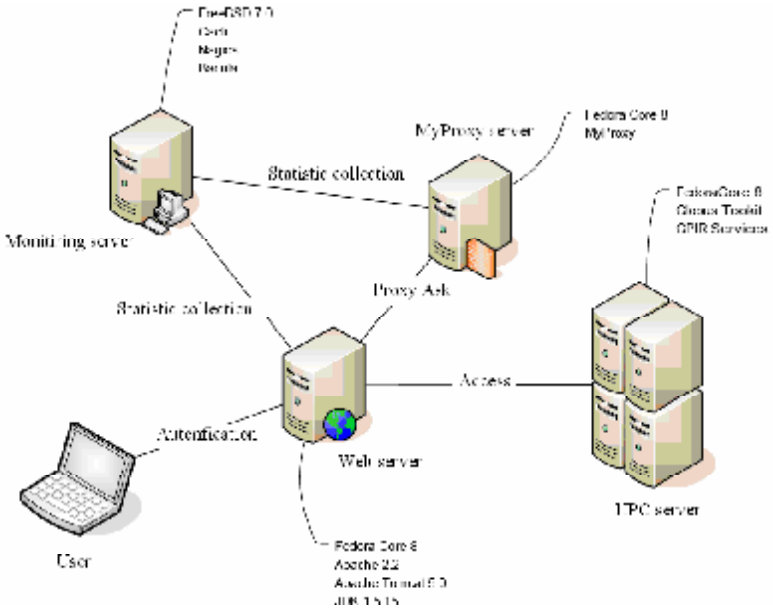


**Fig.4**. User's getting access via SDGrid Web portal

This experience includes registration and receiving the MyProxy certificate, reviewing files in catalogue, navigation within catalogue, forming and running task, tracking the state of its performing, etc.

MESU Grid segment, in distinction from NASU Grid segment, which is the **Computing Grid,** can be attributed to **Data Grid,** because the Ugrid project is mainly connected with providing the service of World Data Center Ukrainian Branch (WDC UB) by providing its clients remote access to world scientific data stores, possibility of efficient shared use of computers, experimental sets and devices (www.wdc.org.ua). WDC UB is the component of World data Centers system, which was created and which is supported by International Council on Science (fig.5). It collects, stores and exchanges data with the other centers on following directions:

- Solid Earth physics (seismology, gravimetry, geomagnetism, sea geology, etc.);
- Solar-terrestrial physics (solar activity, cosmic rays, ionosphere effects, etc.);
- Hydrology, hydrometry;
- Sustainable development;
- Energy safety;
- Information society technologies.

## 3 UGRID PROJECT PARTNERS

Ugrid project is being performed by the team of 10 different Ukrainian organizations (2 academic, 6 educational, and 2 industrial), headed by Institute for Applied System Analysis (IASA) of National Technical University of Ukraine 'Kiev Polytechnic Institute'. Project research manager is Mikhailo Zakharovych Zgurovsky, NASU academician, one of initiators of Grid technologies introduction in Ukraine.

Among the project executors, besides NTUU 'KPI', are: G.E. Puhov Institute of Simulation Problems in Energetics of NASU (ISPE), Kharkiv National University of Radio Electronics (KNURE), Lviv National Technical University 'Lviv (NULP), Zaporoje National Technical University (ZNTU), Donetsk National Polytechnic Institute (DonNPI), Dnipropetrovsk National Mining University (DNMU), government enterprise 'Lviv Research Institute of Radio Engineering' (LRIRE) and USTAR enterprise.

**Fig.5**. Dislocation of World Data Centers


**Fig.6.** Logotypes of partner organizations

Though official financing of UGrid project was begun only in the second half of 2007, works on its execution were begun just after the State program approval.
In October 2006, in the presence of President of Ukraine V.A. Yuschenko, inauguration of HPC Center and WDC UB was held. Earlier, in April 2006, partnership with the executors of European BalticGrid project was established. Current computational resources of the project are shown in table1.

**Table 1**. Native computational resources of UGrid project

| | Cluster | Proces-sors | NODs/ CPU | RAM/ NOD (GB) | HD (GB) | STO-RAGE (TB) |
|---|---|---|---|---|---|---|
| 1. | **KPI** Cluster, National Technical University of Ukraine 'Kiev Polytechnic Institute' | 336 | 84/4 | 2 | | 36 |
| 2. | **KNURE**, Kharkiv National University of Radio Electronics | 10 | 10/1 | 1 | 20 | 0,2 |
| 3. | **ZNTU**, Zaporoje National Technical University | 25 | 2/10 | 1 | 200 | |
| 4. | **NTU 'Lviv Polytechnics'** | 8 | 2/4 | 3 | 200 | |
| 5. | **DonNTU,** Donetsk National Technical University | 12 | 1/12 | 1 | | 2 |
| 6. | **ISPE,** Institute of Simulation Problems in Energetics of NASU | 24 | 3/8 | 8 | 500 | |
| | Total | 415 | 102 | | | 38 |

Meanwhile, modernization of NTUU 'KPI' cluster is being held, and in December, 2008 it will contain 688 processors with productivities after LOPACK higher than 6 TFLOPS. Among the active users of the cluster are specialists from NTUU 'KPI', ZNTU, Institute of Condensed Systems Physics (Lviv), Institute of Molecular Biology and Genetics (Kiev), etc. The majority of higher educational establishments, academic institutes and industrial enterprises don't have supercomputers for now, and so the project provides for research of means of virtualization the resources of common personal computers by the help of Grid technologies.

## 4 PARTNERS' RESEARCH ACTIVITIES

To give researchers the possibility to use the Grid computing resources in habitual working environments the NetSolve **MATLAB** software was installed on NTUU 'KPI' cluster. Now an user doesn't care where he is situated, how he detects and calls for the needed Grid resource; he only points the criteria necessary to choose this resource, and further interacts with this resource in the same way as with the local resources (procedures, classes, programs) of his working environment.

All the organizations – project participants (except duties on resource-operational centers organization, providing their functioning, user training and support) run scientific research in the field of interoperability of different Grid infrastructures middleware, providing end-to-end information safety during uniting National Grid infrastructures or their segments, developing additional services for expanding the range of possible users (except science) on the representatives of different layers of society: engineering, business, and social sphere.

In detail the research being run is as such:

### 4.1 NTUU 'KPI'

- Knowledge portal developing.
- Exploration of middleware interoperability.
- Creating Grid application for modern micro- electronic -mechanical systems (MEMS) design.

### 4.2 NTU 'Lviv Polytechnics'

- Creating the powerful system of data storing on the base of usage of IBM BladeCenter QS21 system which consists of 14 computational blade servers on the basis of Cell processors, and one coordinating node [12].

### 4.3 ZNTU, Zaporoje National Technical University. .

- Parallel structures of genetic algorithms development by the parallel realized multi-layered neuron networks and application a cluster for the direct construction of neuron network.
- Construction and realization of algorithm of parallel method of parallel implementation of molecular dynamics simulation method

### 4.4 KNURE, Kharkiv National University of Radio Electronics [8-10,14-17]:

- Software for PVM library productivity testing.
- The use of Grid for the construction of the distributed imitation systems of design

### 4.5 ISPE, Institute of Simulation Problems in Energetics of NASU

- Research of methods of Grid-technologies using for the solving technological tasks to energy [18];
- Methods of effective exchange by information between the nodes of the system in the HPC-claster ;
- Numeral design of associate electromagnetic, thermal and rydromechenical transients in the electromagnetic systems on the example of research of dynamics of plasma - a metallic electrode systems;
- development of mathematical models and programs which allow to simulate the processes of Thermo-mass-transients in the tof reactor of RBMK-1000 ?et al ;

Realizing that the question of filling the National Grid infrastructure with application programs for parallel calculations in different branches of modern science and techniques becomes of special sense in Ukraine, Ugrid project executors plan to pay special attention to it at the next stage of executing the State ICT program.

## 5 CONCLUTIONS

At the beginning Grid technologies were targeted to solving intricate scientific, production and engineering problems which can not be solved in clever terms by separate computing options. But now the application domain of Grid is not limited only by these types of tasks. As far as the Grid technologies are dissimilated they penetrate into industry and business and major concerns start to create own Grid for solving their production tasks. So Grid applies to-day on the role of **universal infrastructure** for the data processing with the great number of services, which allow not only solve the concrete applied tasks, but also help to search of necessary resources, to collect information about their state, to save and to deliver data.

Grid computing can give a new quality of solving next types of tasks:

- Mass treatment of large volume data flows;
- Many parametrical data analysis;
- Remote design and simulation;
- Realistic visualization of large data sets ;
- Complicated business tasks with the large volumes of calculations.

Grid - technologies already are actively used in the world by both state organizations (defensive and public utilities spheres) and private companies, for example, financial and power ones. An application Grid domain now includes nuclear physics, ecological monitoring and environment defense, weather forecast and design of climatic changes, numeral design in MEMS and aircraft building, biological design, pharmaceutics.

What do encourage scientists to build Grid?

*At first*, a necessity to process *the huge number of data*, that are saved in different organizations (possibly, placed in different parts of the world). The pictures of Earth, being got from satellites, can be a good example. It probably will take centuries for trying to copy such data on one central computer for their subsequent analysis in different projects. Consequently, scientists want to execute calculation with data where they are placed.

*Secondly*, a necessity to execute *the huge number of calculations*. For example, it is in a case of influence determination of thousand molecules (potential medical treatments) on the albumens related to some illness. It would occupy a few centuries on one computer, or even on a cluster, that is supercomputer.

Though computers are improved quickly (power of processor is doubled approximately every 18 months), however their progress dissatisfies to all requirements of scientists.

*Thirdly*, wishes of scientific teams, the members of which work in different parts of Earth, jointly use large data arrays, quickly and interactive to carry out their complex analysis and, here, discuss results in videoconferences.

Ugrid project realization will allow:

- Ensure the people's right of open access to important scientific and educational information.
- Solve the social problems connected with providing equal conditions for an access to education and science.
- Create conditions for continuous life-long education.
- Raise the efficiency of public administration of education and science.
- Promote Ukraine's integration into the global research and educational area.

## REFERENCES

1. M. Z. Zgurovsky. Development of Educational and Research Segment of Information Society in Ukraine. - //Proc. WSIS .-Tunis.- 2004.-P.103-107.

2. M. Z. Zgurovsky. Development of Educational and Research Segment of Information Society in Ukraine. - //Системні дослідження та інформаційні технології.-Київ.-2006.=№1.-С.7-17.

3. Petrenko A. I. Development of Grid -infrastructure\for Educational and Research segment of Information Society in Ukraine with focus on Ecological monitoring and Telemedicine . - // Data Science Journal.- Volume 6.- Supplement, 14 April 2007. – P.583-590.

4. Петренко А.І. Національна Grid - інфраструктура для забезпечення наукових досліджень і освіти.- // Системні дослідження і інформаційні технології, -Київ.- №1- 2008..- С.79-92.

5. Zgurovsky M. Impact of the Information Societ5y on Sustainable Development: Global and Regional Aspects.- *Data Science Journal, Volume 6, Supplement, 11 March 2007*

6. Петренко А.І. GRID технології в науці і освіті.-Матеріали 9-ої Міжнародної конференції «Системний аналіз та інформаційні технології», Київ,2007.

7. Petrenko A.I."Development of GRID-infrastructure\for Educational and Research segment of Information Society in Ukraine with focus on Ecological monitoring and Telemedicine". - *Data Science Journal, Volume 6, Supplement, 14 April 2007*

8. Волк М.А. Условия синхронизации распределенных имитационных моделей в гетерогенной GRID // Материалы 2-й международной конференции «Современные информационные системы. Проблемы и тенденции развития». – Харьков-Туапсе, 2007. – С. 475-476.

9. Волк М.А., Остроушко А.П., Бугрий А.Н. Анализ использования GRID для целей имитационного моделирования // Материалы 2-й международной конференции «Современные информационные системы. Проблемы и тенденции развития». – Харьков-Туапсе, 2007. – С. 477-478

10. Аксак Н.Г., Тыхун А.Ю. Вычислительные схемы параллельного алгоритма обработки изображений // Материалы 2-й международной конференции «Современные информационные системы. Проблемы и тенденции развития». – Харьков-Туапсе, 2007. – С. 277-278.

11. Lobur M., Matviykiv O., Lebedeva O., Virtual Collaborative Design Environment for Distributed CAD Systems // Proceedings of the of the IXth International Conference CADSM 2007 “The Experience of Designing and Application of CAD Systems in Microelectronics” 20-24 February 2007 Lviv-Polyana, Ukraine, p. 538-539.

12. A. Melnyk. Automatic generation of ASICs // Proceeding of ACSN-2007. 20-22 Sept., 2007.

13. Петренко А.І. Вступ до Grid технологій в науці і освіті (навчальний посібник).-Київ.-Політехніка.-2008.-124 С

14. Волк М.А. Перспективы создания харьковского ресурсно-операционного GRID – центра // Проблемы информатики и моделирования. Материалы седьмой международной научно-технической конференции. – Харьков: НТУ "ХПИ", 2007. – с.29

15. Волк М.А. Структурная организация поведенческого имитационного моделирования в grid / Системи обробки інформації. – 2007. –Вип. 9(67). - с.41-45

16. Волк М.А. Управление событиями в распределенной имитационной системе моделирования для GRID-инфраструктуры. // Системний аналіз та інформаційні технології: Матеріали X Міжнародної науково-технічної конференції (20-24 травня 2008р., Київ). – К.: НТУУ "КПІ", 2008. – с.289

17. Волк М.А. Филимончук М.А., Корниенко Т.В. Аналіз использования искусственных иммунных систем в GRID-инфраструктуре. // Системний аналіз та інформаційні технології: Матеріали X Міжнародної науково-технічної конференції (20-24 травня 2008р., Київ). – К.: НТУУ "КПІ", 2008. – с.290

18. Давиденко А.Н., Головань С.Н., Душеба В.В., Сигарев А.А. Исследование прогрессивных технологий интер-коннекта для организации высокопроизводительных вычислений -// Моделювання та інформаційні технології: Зб. наук. пр. ІПМЕ НАН України. – Вип. 47. Київ: 2008.