DEVELOPMENT OF A GRID-INFRASTRUCTURE FOR THE EDUCATIONAL AND RESEARCH SEGMENT OF THE INFORMATION SOCIETY IN UKRAINE WITH A FOCUS ON ECOLOGICAL MONITORING AND TELEMEDICINE

A.I.Petrenko

Dept. of Computer - Aided Design, National Technical University of Ukraine, "Kiev Polytechnic Institute"
E-mail: petrenko@cad.kiev.ua

ABSTRACT

The Grid today plays the role of a universal infrastructure for data processing with a great number of services that allow not only solving the concrete applied tasks but also helping to search for necessary resources to collect information about their state and to save and to deliver data. The grid-infrastructure in hand is able to provide the Ukrainian universities, research centres, and virtual laboratories with needed information and required computational resources. As an example, the system of ecological monitoring and telemedicine support for the Chernobyl Nuclear Power Plant area is considered.

Keywords: Grid infrastructure, Grid Computing, Supercomputers, Middleware, Chernobyl Nuclear Power Plant

1 GRID TECHNOLOGIES FACILITIES

The Grid infrastructure provides networking, computing, and data resources in such a way that they are readily available to users regardless of their geographical location and in this way improves the efficiency of scientific and industrial research. It additionally promotes networked collaboration of specialists in joint projects, allowing them to use the same infrastructure for solving different problems. Therefore, today the Grid plays the role of a universal infrastructure for data processing with a great number of services, allowing not only solving the concrete applied tasks but also helping to search for necessary resources to collect information about their state, and to save and to deliver data.

What encourages scientists to build the Grid?

First, as a necessity to process *the huge number of data* that is saved in different organizations (possibly placed in different parts of the world). Pictures of Earth from satellites are a good example. It probably would take centuries of trying to copy such data on one central computer for their subsequent analysis in different projects. Consequently, scientists want to execute calculations with data where they are located.

Second, as a necessity to execute *a huge number of calculations*. For example, determining the interaction of the thousands of molecules (potential medical treatments) on the albumens related to illness would occupy a few centuries on a single computer or even on a cluster or a supercomputer. Though computers are improving quickly (the power of processors is doubled approximately every 18 months), their progress still does not meet all the requirements of scientists.

Third, the wishes of scientific teams, whose members work in different parts of the world, to use jointly large data sets, quickly and interactively to carry out complex analysis, and discuss results in videoconferences. The program of the International Data Centers is an example, which deals with collection, accumulation, saving, and global data processing from Earth physics, Sun-Earth physics, hydrology and seismology, gravimetrical and magnetic measuring, and more.

If a user must analyze a great number of data, which are on different computers distributed sparsely throughout the world, then the Grid will be able to define for the unassisted user the most proper data source and execute his/her analysis. If a user must conduct such analysis in an interactive mode in collaboration with colleagues from different countries, the Grid will link their computers so that joint work will not differ from work in a local network. Thus users will not need to worry about the great number of passwords – the Grid is able to understand,

who has a right to take part in joint work. It is considered that the influence the Grid will have on the development of society will be as effective and ***revolutionary*** as previous prominent inventions: the computer and the Internet.

2 PRE-CONDITIONS OF THE CREATION OF THE UKRAINIAN GRID

2.1 The Government decision about National Grid development

For a long time, Ukraine in the framework of the former USSR had strong traditions in the fields of cybernetics, mathematics, and computer sciences. For example, in 1952 Ukraine was the third country after the USA and Great Britain capable of building a computer. In spite of social and economic problems, Ukraine has made progress, especially after Geneva's WSIS-2003, in the direction of creating the information society. This aim was recognized as one of the priorities of the state. First of all, a several related laws were adopted. Among them - the Order of the President of Ukraine, more than 30 legislations and laws, the State program "Information and communication technologies (ICT) in education and science for 2006–2010" with National Grid Initiatives. These legislative acts regulate the relationships between state institutions, professional communities, and business in creating all segments of the information society.

2.2 The Ukrainian research and academic network (URAN)

URAN has been in operation since 2001 as the **first segment** of the Ukrainian Grid-infrastructure [1]**.** Its structure is based on the main nodes in the six largest cities of Ukraine — Kiev, Kharkiv, Dnepropetrovsk, Lviv, Odessa, and Donetsk. In total, 20 out of 26 regions of Ukraine are connected to the network**.** The total open access traffic of URAN has increased 50 times within the last 5 years, and today it constitutes 1.5 Tb (terabyte) per a month. In every region both optic fiber and satellite communication segments are being developed, which ensure the rate of data transfer up to 1 Gb/s.

One selected method of URAN infrastructure development is based on dark optic fiber cables. The signal to these fiber cables is supplied by the customer (Customer Empowered Fiber - CEF). As seen from the experience of many countries, for example, the Netherlands, Poland, Hungary, the Czech Republic, and others, this approach in the framework can increase system efficiency by 100 times. Other advantages of a CEF-infrastructure have also been taken into consideration. It was also important for us that the European research multi-gigabyte network GEANT–v2 is mostly based on dark fiber.

One more important characteristic of URAN is its orientation to the project "Porto Optica" ("optic doors"), which was initiated by the Association of Research and Educational Networks of Central and Eastern Europe (CEENet) and aimed at decreasing the "great digital divide." The objectives of the project are:

- To study the possibility of developing regional and international CEF-segments of research and educational networks in Eastern Europe with the aim of their connection to GEANT-2. We already have an agreement about the channel to the European network GEANT – 2 for URAN through Vienna;
- To develop interconnections and to start operations of the CEF-infrastructure of the national research and educational networks.

2.3 Distance learning and distributed information resources in education

This system of distant learning and distributed information resources in education and the administrative and educational system, named "Education", works successfully as the **second segment** of the Ukrainian Grid-infrastructure [2]. The national system of distance learning comprises (Figure 1):

- Coordination and provision centers,
- Distance learning and professional orientation centres,
- "Central and Eastern European Virtual University" (CEEVU),
- Educational and research institutions that are developers and users of distance learning resources.

At present in Ukraine, there are more than 20 regional nodes of the distance learning system, which are connected in the integrated medium by the URAN network.

The **CEEVU project** unites, under the aegis of UNESCO, thirteen partners from eight countries of Europe. They are: Eastern European Networking Association (CEENet,), Technical University of Sofia (Bulgaria), Brno

University of Technology (Czech Republic), University "Polytechnic of Bucharest" (Romania), Kaunas University of Technology (Lithuania), State Engineering University of Armenia, Tallinn University of Technology (Estonia), National Technical University of Ukraine "Kyiv Polytechnic Institute" (Ukraine), Lviv Polytechnic National University (Ukraine), National Technical University "Kharkiv Polytechnic Institute" (Ukraine), Donetsk National Technical University (Ukraine), International University of Finances (Ukraine), and Virtual University of Europe – NETTUNO (Rome, Italy). The directions of collaboration and main objectives of the virtual university are the joint educational and research activities of all partners, development and use of electronic educational facilities, and distance learning in accordance with the coordinated educational programs.

The partner universities develop joint distance courses and arrange the teaching process. The coordination centre of CEEVU provides technical support for the distance learning system. The information resources of the virtual university have a distributed structure with open access to users by connecting to the servers at individual

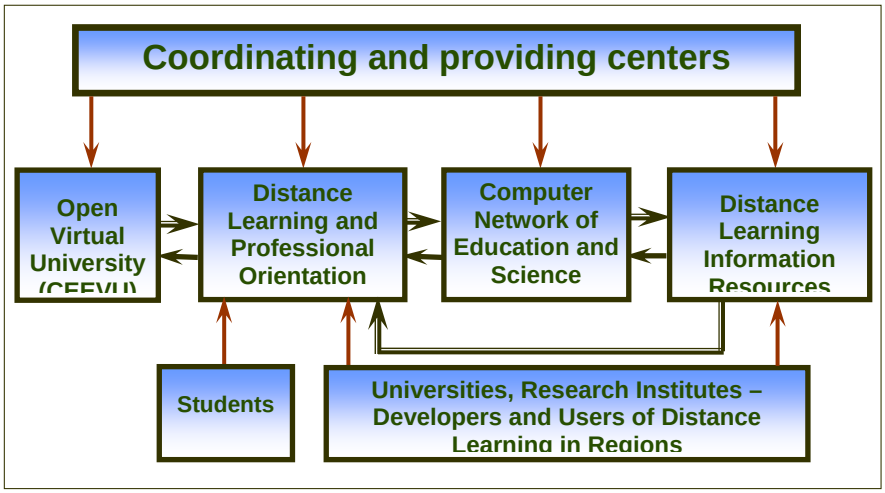

Figure 1. Distance Learning System at the National Level

university centres. Education is based either on the curricula of the chosen university or on jointly developed programs of CEEVU. Students are free to choose either of these curricula.

The National Educational and Administration System is a complex of administrative, legal, software, and hardware facilities, which ensures the automation of many administrative functions and information processes at the national level and the follow-up of preparation of state documents on education. Here, their validity and integrity is preserved, and reliable mechanisms are developed for protection of certain segments of information and provision of open access to others.

2.4 Distributed information resources and network computational facilities

These resources and facilities comprise the **third segment** of the Ukrainian Grid-infrastructure (Figure 2) for serving the Ukrainian universities, research centres, and virtual laboratories [3]. In the first place they give the opportunity for remote access to data bases in different fields, for example, economics, natural sciences, ecology, medicine, telemedicine, and others.

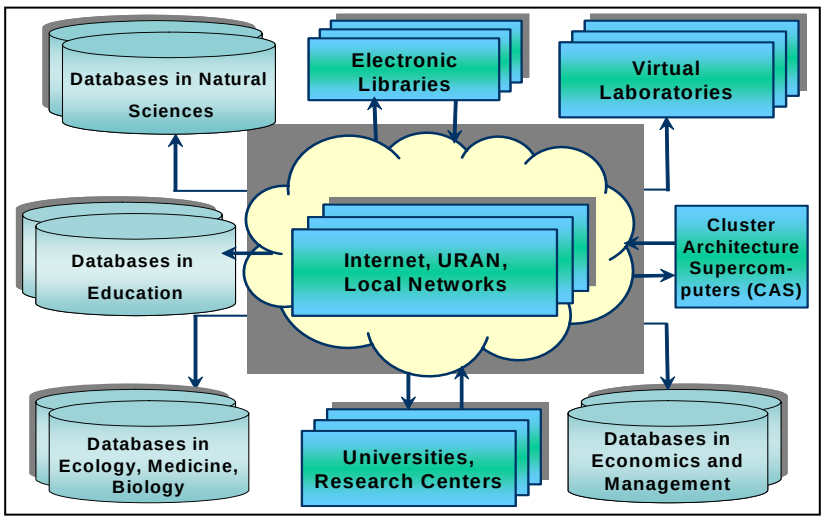

Figure 2. Information & Computational Resources of Science and

At the National Technical University of Ukraine "Kiev Polytechnic Institute," the cluster architecture supercomputer (CAS) was installed this October with parameters: 168 processors with general productivity of 2,016 TF (Teraflops), 64 bit word, operative memory - 12 Tb, and fixed storage (HDD) - 20 Tb. The use of this supercomputer together with supercomputers of the Institute of Cybernetics (with capability a bit less than at the supercomputer NTUU "Kiev Polytechnic Institute") is planned to be part of the Ukrainian Grid-infrastructure through the network URAN. It will allow research centers and universities from different regions of Ukraine to be connected to these supercomputers to solve problems with great volumes of computations. In the construction of these supercomputers, distributed data bases and new intellectual technologies developed by Ukrainian mathematicians and engineers were used [4]. NTUU "Kiev Polytechnic Institute" itself possesses many years experience in theory, models, and methods of distributed data processing investigation; development of algorithms and decision methods for applied tasks in the environment of distributed computing; and designing and exploiting the distributed informative systems.

As an example, we mention the system of **ecological monitoring and telemedicine support** for the Chernobyl Nuclear Power Plant area, which is devoted to analysing remotely the health of various professional groups of the 4300 persons who work at the reactor. This system consists of two centres. One is the diagnostics and rehabilitation centre, which is situated in the town of Slavutych near the Chernobyl Power Plant and collects health data in accordance with individual programs of its patients. These data are transferred via the URAN network to the International Centre of Telemedicine, which is located in Kiev at the NTUU "Kiev Polytechnic Institute," where these data are analyzed and recommendations on prevention and treatment are worked out.

2.5 Electronic libraries for education and science

More than 200 electronic libraries in the field of education and science are united to-day as the **fourth segment** of the Grid-infrastructure. They include:

- Libraries of the universities (more than 100),
- Libraries of institutions of National Academy of Sciences (more than 50),
- Public libraries (more than 30),
- Libraries of distance learning centres (more than 20).

The system is built upon the unified operational, software, and hardware platforms based on the library system ALEPH and contains information centres, which are connected by optic fibre channels of data transfer to the URAN. There are many unique publications in this system (Figure 3).

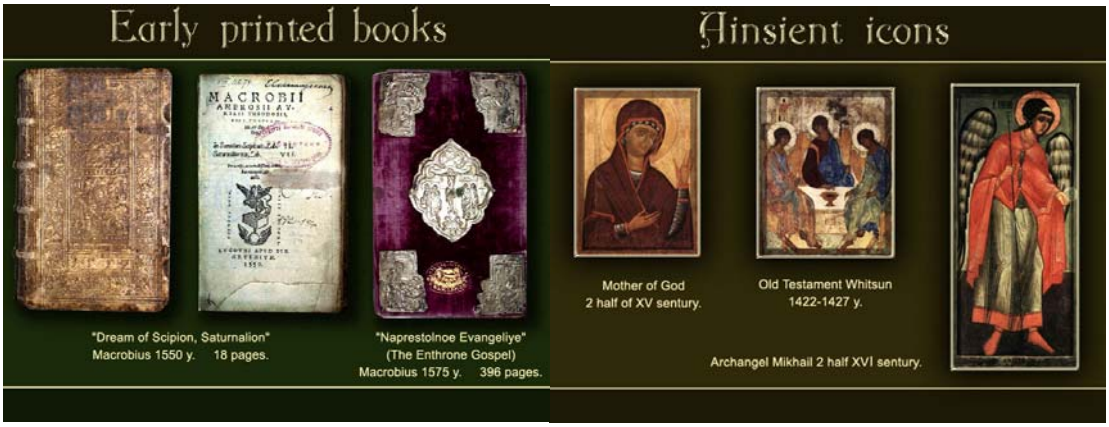

Figure 3. Library system riches

2.6 The Ukrainian branch of the International Centers of Data (UB ICD)

The UB ICD was established under the Agreement with the Geographical center of the Russian Academy of Sciences and operates as the **fifth segment** of the Grid-infrastructure. It carries out the accumulation and preservation of national and world data collected by the institutes and organizations that belong to the National Academy of Sciences of Ukraine, Ministry of Education and Science, Ministry of Architecture, etc., and provides on-line catalogs, databases, and data processing. We hope that in the nearest future valid information about the Earth (for example, SILEX data from the satellite ARTEMIS through the Tenerife Observatory, Canary Islands) will be available for scientists of the Physics and Astronomy division of the National Academy of Science of Ukraine.

3 STAGES OF THE CREATION OF UGRID

The NTUU "Kiev Polytechnic Institute" already has contacted directly Dr. Bob Jones from CERN, the leader of the main European project EGEE (Enabling Grids for E-sciencE**),** and agreed in principle to the possibility of Ukraine joining this project, as Russia did earlier. In addition, the NTUU "Kiev Polytechnic Institute" agreed with the Baltic countries to joint collaboration in the project BalticGrid (a coordinator Dr. Per Őster), which was begun two years ago.

There are now nine main executors of the UGrid project : National Technical University of Ukraine, Kiev Polytechnic Institute, Kharkov National University of Radio Electronics, Lvov National Polytechnic University "Lvov Polytechnika," Zaporozhian National Technical University, Donetsk National Technical University, Institute of Applied System Analysis of National Academy of Science, Institute of Modeling Problems in Energetics of National Academy of Science, Lvov Open Company "Lvov Radiotechnical Institute," and company "USTAR."

We are going to make use of the European Grid development experience. In analogy with European prototypes, the Ukrainian Grid infrastructure will consist of Resource centers (RCs) of organizations-participants and two types of operating centers: Base Infrastructural Center (BIC) and Regional Operating Centers (ROCs). RCs are the main centers of the Grid infrastructure; ROCs are accountable for the operations in the regions, and the BIC will be at the NTUU "Kiev Polytechnic Institute" and will provide services related to the resources of the EGEE.

Because of associated membership in the BalticGrid, the EGEE gLite middleware software (Figure 4) is adapted at Ukraine. Its main subsystems (Information System and Monitoring, Security Infrastructure, Workload Management, Data Management) simultaneously serve three basic roles: a supplier of services, a servant for the user, and a broker. A supplier of services registers his resources at some broker; a servant helps a user to find necessary services there; whereupon a connection between the two is established, and a necessary operation is carried out through a broker. Middleware eventually makes access to resources held on widely distributed computers as easy as access to resources on the user's own desktop.

The Grid infrastructure that provides networking, computing, and data resources in such a way that they are readily available to users regardless of their geographical location will improve the efficiency of scientific and industrial research and be of great benefit to the wider society. In addition, it will benefit those domains which traditionally have not had access to large-scale existing computing facilities. The potential of Grid technologies is already estimated ever-higher: it has a strategic character, and in the near future the Grid will become an important tool for the development of advanced technologies in different spheres of human activity.

Such high predictions can be accounted for by the Grid's ability to solve the following two problems on the basis of safe and reliable remote access to the resources of the globally distributed infrastructure:

- Development of distributed computer systems of very high carrying capacity from the equipment, that is manufactured serially, with simultaneous rising of the efficiency (to 100%) by the use of temporally free resources in the Grid ;
- Development of large scale systems of monitoring, management, complex analysis, and service with the globally distributed data sources, able to support the vital requirements of state and private organizations and corporations.

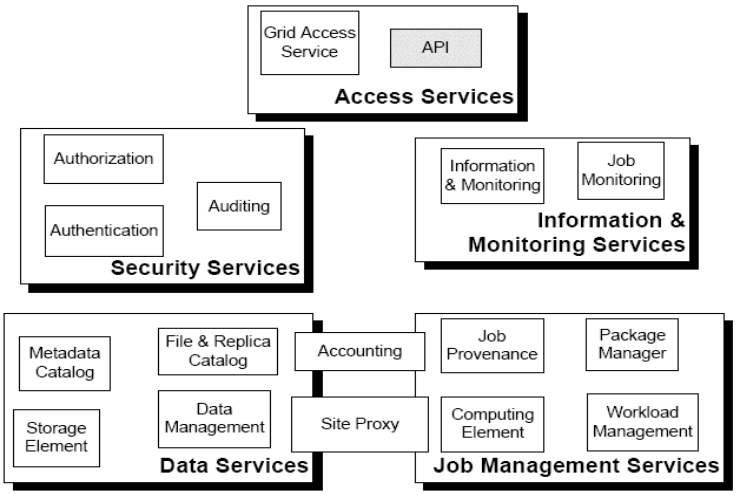

Figure 4. Middleware gLite services

The primary objectives of Ukraine within the framework of the project in hand are the inclusion of the UGRID into the European Grid infrastructure (*EGI*) and the provision of the UGRID functioning as a valuable operating and functional *EGI* component [5]. The offered project, **foremost**, is intended to facilitate scientific data exchange between research workers and to organize their collective data processing. Among a number of key factors that promote Grid installation are not only a rise in the efficiency of the use of resources and economy of charges but also the possibility of a flexible change of infrastructure according to new requirements. Most establishments presently have opened small Grid installations with a limited set of equipment and applications. An important task is the effective use not only of computing but also of human resources because the Grid promotes networked collaboration of specialists in joint projects, allowing them to use the same infrastructure for solving different problems.

At the beginning, Grid technologies were targeted to solving intricate scientific, production, and engineering problems that can not be solved in clever terms by separate computing options. Now, however, the application domain of Grid is not limited to these types of tasks. As far as the Grid technologies are disseminated, they penetrate industry and business, and major concerns have begun to create their own Grid for solving their production tasks.

Grid technologies already are actively used in the world by both state organizations (defense and public utility spheres) and private companies, for example, financial and power utilities. Applications of the Grid domain now include nuclear physics, ecological monitoring and environment defense, weather forecasting and design of climatic changes, numeral design in MEMS and aircraft building, biological design, and pharmaceuticals.

4 CONCLUSIONS

The UGRID project realization allows:

- Ensuring the people's right of open access to important scientific and educational information,
- Solving the social problems connected with providing equal conditions for access to education and science,
- Creating conditions for continuous life-long education,
- Raising the efficiency of the public administration of education and science,
- Promoting Ukraine's integration into the global research and educational areas.

5 REFERENCES

1. Paton, B., Zgurovsky, M., & Yakimenko, Y. (1999) The state and prospects of development of the national telecommunication research and educational network. *Cybernetics and system analysis* 5, pp.3-9

2. Zgurovsky, M. (2004) Development of Educational and Research Segment of Information Society in Ukraine. *WSIS,* Tunis, Morocco.

3. Zgurovsky, M. & Petrenko, A.(2006) National Ukrainian Grid infrastructure(UGRID) for science and education. *Intern. Conference on Computer Science and Information Technologies*, (pp.6-12) Lviv, Ukraine.

4. Sergijenko, I., Koval, V. (2005) SKIT-Ukrainian Supercomputer's Project. *Messenger of the National Academy of Science of Ukraine 8*, pp. 3 –13.

5. Jones, B. (2006) A sustainable e-Infrastructure for Europe. *EGEE Newsletter.*