УДК 681.3.07

INTEGRATING UKRAINE INTO EUROPEAN GRID INFRASTRUCTURE

A. ZAGORODNY, M. ZGUROVSKY, G. ZINOVJEV, E. MARTYNOV, A. PETRENKO

Ukrainian Grid community has established Ukrainian National Grid Initiative (UNGI) which has joined up the major active European projects EGEE and EGI. The community of objectives based on the involvement in world leading scientific projects is elucidated. General features of UNGI and European Grid structures and projects together with various Grid-based applications supported by UNGI are discussed. Current UNGI activities and its future plans in view of realistic computational and human resources are described. The problems and prospects of rapidly progressing Ukrainian Grid infrastructure on the way of international cooperation and integration are illuminated.

INTRODUCTION

The rapid progress of Grid technologies initiated in 1998 by the pioneering book by I. Foster and C. Kesselman has quickly led to the understanding that high-productive distributed computations are the natural ground of future development in research and practical applications of fundamental knowledge about animate and inanimate nature. The Grid technologies enabled to solve such scientific and technical tasks which required before the impossibly large amount of computing time even at using super-powerful supercomputers. It is enough indicative to mention the examples of exploring the NH5NA1 bird flew, or decoding the genomes of plants and animals. The tasks which required the tens and hundreds years for the modern computers to work continuously are solved in a few weeks or months.

The Grid technologies available for solving scientific, practical and social tasks, economic planning and prognostication put on the agenda in developed countries the creation of effectively functioning Grid infrastructures which unite the computational resources of scientific, educational and industrial spheres. Traditionally, so large-scale projects begin their life in the scientific research sector (as it happened to the electronic mail and Internet), but then they spread fast on all the spheres of social activity. In case of the Grid technologies the Internet history has recurred but it has occurred even with faster steps what is confirmed by a growth of investments into the Grid technology sector. In 2003 it was invested about $300 million into Grid technologies, in 2006 it was already $1.8 billion and according to the predictions for 2011 it can be about $25 billion [1].

Many countries, having begun with implementing the separate Grid projects dedicated to the scientific research (physics, biology, geophysics, etc.), are actively working to establish the national Grid infrastructures which enable to use the existing computational resources of the countries even in more effective and comprehensive way. At the same time the process of uniting the national Grids into the global world Grid infrastructures takes place. In Europe, under the aegis of European Commission, the EGI (European Grid Initiative) organization [2] is established and today it includes National Grids of 38 European countries. EGI is at the stage of formation but there are no doubts this organization will be running full profile already in 2010 as it is planned. Certainly, with such an organization acting the common European computational resource will provide very powerful impact on further scientific and social integration of European countries.

In this paper we present the process of implementing the Grid technologies in Ukraine focusing on the difficulties faced and the positive experience gained. After the brief historical introduction we describe the current status of Grid in Ukraine, discuss the possible ways of its development and propose the concrete practical steps to speed up an activity of bringing this powerful instrument to the scientific research and practical applications. We emphasize the specific aspects of what Ukraine could effectively use from the world experience of exploiting the Grid technologies and what Ukraine could propose to the world Grid society.

1. HISTORY AND STATUS OF GRID TECHNOLOGIES IN UKRAINE

The Grid history in Ukraine is very short and starts from two projects which at the beginning were independently developing because the corresponding communities have demonstrated different professional interests. National Academy of Sciences of Ukraine (NASU) has started in 2005 and Ministry of Education and Science of Ukraine (MESU) has launched the project up in 2006. We briefly consider the status of both projects today.

1.1. Project of NASU

The first computational clusters in Ukraine appeared at the commencement of current century and, in particular, the first Grid cluster was put to operation in 2004 in National Scientific Technical Center "Kharkiv Institute of Physics and Technology" (KIPT). The process of creating was strongly supported and assisted by the experts of Joint Institute for Nuclear Research (JINR, Russia) and Moscow State University (MSU).

KIPT within the collaborative work for future CMS experiment at CERN. The cluster was registered and successfully operates today as the resource pledged by Russia-Dubna Intensive Grid (RDIG) organization.

In 2005 due to an initiative of Bogolubov Institute for Theoretical Physics (BITP) of NASU the systematic building of Grid clusters and creation of the academic Grid infrastructure have started. The first cluster was built at BITP in 2005 and was immediately pledged as the Grid resource of the ALICE Collaboration at CERN together with the cluster of Taras Schevchenko Kiev National University (KNU).

In 2006 NASU approved the Program "**Grid technologies implementation and cluster building in Ukraine"** which is almost completed today. In the course

of this program realization the academic Grid infrastructure uniting computational resources of 16 academic institutes was established. It provides those institutes with the corresponding services for the research in physics, astronomy, biology and informatics and their intensive cooperation with the international partners. We expect another five academic clusters will join this project until the end of this year. Then common computational resource of Ukrainian Academic Grid (UAG) will consist of about 1500 processor cores and more than 150 TB of disk space for data storing (see http://uag.bitp.kiev.ua).

In two last years considerable amount of scientific tasks in physics, astrophysics and biology were successfully solved with the UAG clusters. Grid technologies were used for processing the results of satellite monitoring of surface, water and air resources of Ukraine in estimating the biological diversity in Southern regions of Ukraine. About 40000 tasks concerning the experimental program of ALICE at CERN have been solved with the UAG clusters.

The concept of further development of UAG is under the process of completing. New phase of activity envisages together with widening and strengthening the UAG infrastructure to pay more attention to the development of specialized Grid applications and the creation of virtual organizations which are occupied by the topical problems in various fields of human activity.

1.2. Project of MESU

Project of establishing the Grid infrastructure for information society development in Ukraine appeared as the part of wider task of creating educational and research segments of Ukrainian information society with two main directions: a) a wide use of information and communication technologies at all stages of scientific research and education and b) development of an information management of corresponding activities [3,4].

Main tasks *of the first direction* were

- Building Grid infrastructure for education and scientific research support.
- Infrastructural development of Ukrainian research and academic URAN net and its integration into European GEANT-2.
- Getting experience of work in Grid infrastructure and distributed information systems exploitation, developing algorithms and methods of solving applied tasks in distributed computing environment.

Second direction proposed

- Implementation of effective 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 and to the World Data Centers net.

"National GRID infrastructure modeling for scientific research support" project. (**UGrid project (**www.grid.ntu-kpi.kiev.ua)_is dedicated to building Grid segment of MESU and exists within "State task program "Information and communication technologies in education and science for 2006—2010". In the process of project realization the following tasks are being solved [5, 6]:

- Supporting servicing of World Data Center Ukrainian Branch (WDC UB), providing its clients with remote access to world scientific data repositories, possibility of efficient common share of computers, unique experimental sets, and devices.
- In cooperation with NASU enhancement of the existing scientific and educational computational and communication infrastructure at national level and its connection to European Grid infrastructure.
- Development of Certificate Authority of Open Keys in Ukraine registered in EUGridPMA.
- Organization of national Grid infrastructure servicing by creating regional resource-operational centers and permanently working groups of supporting the necessary Grid services.
- Assistance to creating common projects within international virtual organizations (VO).
- Spreading in society the knowledge on Grid technologies and advantages of their use in scientific research and practical applications.

UGrid project is considerably connected with providing servicing of World Data Center Ukrainian Branch (WDC UB). Its task is, particularly, to provide clients with remote access to world scientific data repositories, possibility of efficient common share of computers, unique experimental sets and devices. WDC UB is an element of World data Centers system which is created and supported by International Council for Science. It collects, stores and exchanges data with the other Centers in wide range of research and practical applications:

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". These are NTUU "KPI", G.E. Puhov Institute of Simulation Problems in Energetics of NASU (ISPE), Kharkiv National University of Radio Electronics (KNURE), Lviv National Technical University "Lviv Polytechnics" (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.

Common computational resource of UGrid contains about 1000 processor cores and more than 100 TB of disk space for data storing. The cluster of NTUU "KPI" (now 688 processors) is connected to NASU clusters network. Status and perspectives of Educational Ukrainian are described in more details in [7].

1.3. Software

National Grid infrastructure of Ukraine will be grounded on the existing potential of computational and instrumental resources and data repositories of scientific and educational centers of Ukraine and the other potential participants of national Grid infrastructure. It is proposed to install gLite software in NGI what will give the possibility to use the latest achievements in middleware development, to build safe, flexible and well-scalable Grid environment and also to avoid excess obstacles and interaction with the other infrastructures within EGEE project and the other European projects.

Today the academic Grid works under the direction of ARC NorduGrid (gLite is installed on clusters of KIPT and KNU and is being tested). It is known that some international virtual organizations work with software different from gLite. Obviously, it would be reasonable to build infrastructure in that way that different Grid software could function there simultaneously and transparently for users.

The basic terms at common use of several Grid infrastructures are "**interoperability**" and "**interoperation**"**.** The interoperability is defined as possibility of Grid systems to exchange information and use the exchanged information. The interoperation is defined as possibility of Grid systems to interact. Providing of interoperability is the first and necessary step on the way to the Grid systems interaction.

This problem was explored and already partially solved in KIPT. To provide interoperability between the main infrastructure of NASU under the direction of NorduGrid ARC (testing the institute sites which work under the direction of Globus software [8]) it was decided to choose adapters and translators, because this method is being successfully used for solving such tasks. It was necessary to design full-grown adapter which working on the level higher than middleware would have its resource broker and its own scheduler along with user's interface convenient enough.

The program product GridWay was chosen for adapter. At the moment of beginning the work with GridWay in NASU NorduGrid ARC software was not included into the list of software supported in the basic version. To provide interoperability between ARC and Globus, taking into account peculiarities, caused by the given NorduGrid ARC software, information, transport and executive modules which use GridWay, were changed or developed. Information and transport ARC system has much common with analogical systems, based on Globus, that is why information and transport access drivers which are the components of GridWay, required modification only. What for executive ARC system, it is created in different way than executive component of Globus and executive ARC access modulus must have been re-written.

The put task was successfully solved, and test exploitation showed that KIPT users, by the help of mega scheduler, can send their tasks to the main NASU infrastructure as well as to KIPT test sites. Work on software interoperability improvement is in progress.

The SDGrid portal **(**www.sdgrid.org.ua) for access to Grid infrastructure was developed under Ugrid project 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. SDGrid portal was built on GridSphere 3 with applications for gLite, Globus 2 and Globus 4 software supporting, and GridSphere provides the developers with highly effective mechanism in developing new applications which use the portlet system.

In order to give to the researchers a possibility to use the Grid computing resources in habitual working environments the NetSolve software was installed on NTUU "KPI" cluster. Now an user (working say with MATHLAB) 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.

1.4. Internet channels in NASU and MESU

It is well known that Grid infrastructure can work effectively only with the high-speed Internet channels available. The fiber optic channels with corresponding equipment satisfy the modern claims to capacity of channels (from tens of Mbps to tens of Gbps). Such channels are at disposal of URANET (which services mainly academic institutes) and URAN (which works mainly with educational structures). Inter-regional net of these providers which covers the territory of Ukraine, is shown in fig. 1. URAN and URANET have also the branched subnets in the lines of Ukrainian cities.

Fig. 1. Fiber optic channels for UNGI

Grid clusters of academic net are connected with channels with capacity of 100 Mbps. It must be emphasized this inner traffic is provided by URANET free for the academic Grid clusters. Foreseeing the considerable increase of the amount of clusters in educational structures of MESU and the other organizations which occurs if the State program (see paragraph 2.2) approved the questions of upgrading and intensifying the Grid infrastructure communication sector must be posed already now.

Among the first and foremost tasks in this direction the following ones should be mentioned:

1. Increasing the capacity of inter-regional and intracity channels no less than to 1 Gbit/sec. There are two aspects here, technical and financial. The technical component (laying the new or replacing the existing fiber optic channels and installation of the corresponding equipment) can be solved at the expense of the State program means. The payment of required traffic by cluster owners is (at current prices and level of financing the budgetary organizations) the great problem which should be solved in a centralized way. This question is now at the stage of discussing and searching the possible ways of solution.

2. The channels of going out the Ukraine bounds require a serious improvement (strengthening). Now the agreement is signed between URAN and GEANT-

2 which claims Ukraine is provided by all the attainments of European academic net, but the main problem here is payment for traffic, again. It appears that at current financial opportunities of the NASU institutes it is more profitable to use the other channels of going out of the Ukraine boundaries.

So today we see unfortunately more problems than achievements in National Grid communication sector. But we are sure these problems will be resolved in the nearest future.

2. UKRAINIAN NATIONAL GRID

2.1. Necessity, tasks and goals

Information technologies have already begun the inalienable part of economical and social life of modern society, but many countries feel the deficit of information, computing capacities for research and a progress in solving actual scientific-technical and social problems. The number of different tasks which are solved by the using the computers, their complexity and resource-intensiveness are rapidly increasing. The tasks which cannot be solved for reasonable time by the personal computers or in the separate computer centers appears more often. Such tasks include, for example, online maximally detailed environment monitoring, real-time mode control of increasing transport threads, modeling of complex processes in modern high-technology production, economic and social prognosis. The examples of scientific problems, such as experimental data processing and analysis in high energy physics, deciphering animals and plants genomes, new medical products modeling and constructing, have already become proverbial. There are no enough the supercomputers in Ukraine which can be compared to the best world examples that is why in order to solve aforementioned and similar tasks the other methods must be used. There are the Grid technologies which can and must soften and, perhaps, remove the deficit of highest class computational resources in Ukraine.

In conditions of world economy globalization, growth of world companies and corporations with geographically distributed departments, the role of distributed control systems increases. In their activity planning, it is necessary to take into account not only the market needs, but also the peculiarities and state of economies of many countries and regions of the world. Analysis of such polyvalent tasks can be the most effective at uniting efforts of groups and collectives from many countries. Similarly, the share of large international projects increases in scientific research.

WLCG (Worldwide LHC Computing Grid) and EGEE (Enabling Grids for E-sciencE) projects are the examples of modern level of different institutes and laboratories cooperation for running large-scale scientific research. It is notable, that in EGEE, range of interests and application being developed spread from micro and macro world problems to tasks of medicine, business, and industry.

Thus, the necessity of creating National Grid infrastructure in Ukraine is conditioned by both internal and external factors. The task actuality and Ukrainian Grid availability don't even require the detailed documentation; it is enough to refer to world tendencies in the field of information computing technologies.

The main goals of national Ukrainian Grid are:

1) creating the powerful information computing environment for solving scientific and practical computer tasks of any complexity;

2) providing the wide access to computational resources for specialists who need extraordinary computational capacities for research and solving scientific, scientific-technical and the other tasks;

3) integrating the Ukrainian institutes, establishments and separate specialists into the world Grid community, their participation in the international research and technical projects.

2.2. Program of Grid technology development in Ukraine

Bogolyubov Institute for Theoretical Physics of NASU propounded the initiative to develop the State scientific-technical Program of Grid technology development in Ukraine. Such a Program was oriented in the name of NASU and MESU and presented to the Cabinet of Ministers of Ukraine. It is assumed that Program will be financed mainly from state budget, and that it will be performed during five years starting on 2009.

The modern state of Grid technologies in Ukraine is represented in the Program in the following way. "*The main problem is that for now in Ukraine exists the critical need of using modern information-communication technologies (in the first place, Grid technologies) for processing the super large arrays in the interests of science, industry, and social sphere, but the necessary national Grid structure is absent. Presence of such infrastructure separate elements does not meet the modern level of Grid technologies development, and does not assist to solving the whole line of actual scientific, scientific-technical and some other problems, holds back European integration processes in these fields*".

In Program the reasons of such a state are analyzed, necessity of building National Grid is proved, fields of possible use of Grid technologies are enumerated, economical and social gains which can be received as the result of Program execution, are stressed.

"***Goal of the program is national Grid infrastructure creation, and wide implementation of Grid technologies into all the spheres of social-economical life in Ukraine.***

Program priority tasks are:

1. *creation the system, taking into account the information safety providing, integration of necessary elements of one national Grid: computing, communication and program resources;*

2. *Grid technologies adaptation and application in Ukrainian multiprocessor computational systems;*

3. *Grid technologies implementation and application in scientific research, integration of Ukrainian scientific establishments into the world scientific space, attraction of Ukrainian scientists to participation in modern unique experiments and computer processing of their results, to participation in virtual scientific forums;*

4. *implementation of new methods of population medical service (creation of distributed diagnostic data bases, consultation with the use of telecommunication means, including large scale computer data analysis);*

5. *providing efficient, real-time processing the results of geophysical, meteorological, and space observations;*

6. *creating conditions for grid technologies implementation in economics, industry, financial activity, and social sphere;*

7. *creating the system of training specialists for the work with grid technologies.*

Computer resources, different at technical realization and at the type of construction with the purpose of providing user with the aggregate computer resource, will be united into the single system. User will get service from grid infrastructure as from the system in whole, independently on where and what computer stores or processes his information, what transmission lines work at this. Creating such systems will radically increase the efficiency of using the aggregate computer resources of the country, will give in the main new possibilities for solving the complex scientific-technical and practical tasks and problems."

2.3. Premises for UNGI creation

The decision was taken to create Ukrainian National Grid proceeding from the existing projects: NASU and MESU and to use the already existing and working Grid infrastructure of National Academy of Science as the basis.

Due to the terminology accepted in EGI the infrastructure being created received the name **Ukrainian National Grid Initiative (UNGI).** Each project as it was already mentioned above has features and properties which can provide UNGI functionality and efficiency:

NASU	**MESU**
High-productive computational resources.	Powerful KPI computational cluster.
Practical experience of creating academic Grid infrastructure.	Wide net of educational resources in the country regions.
International relations, participation in CERN and WLCG work.	Possibility of training the specialists in the Grid technologies.
Presence of specialists on computer technologies in specialized institutes of NASU.	Experience of solving computer tasks in technical applications.
Experience in scientific computer applications development.	Certification Center, collaboration with EUGridPMA.
Develop the UARNET communication network.	World data Center Ukrainian Branch.
	Telecommunication URAN worknet, collaboration with GEANT.

The Grid network created in NASU exists less than three years but in spite of limited financing it was turned into rather powerful computational resource. It is expected that in the nearest future it will be considerably increased. For the time being ARC NorduGrid is mainly used in UAG but on some nodes gLite software is already installed; it was accepted as a standard in European Grid organizations. High speed optical channels for UAG are supported by UARNet - **(**Ukranian Academic & Research NETwork) State enterprise and Scientific-communication center. It is very important that, understanding the Grid technologies prospect and being the establishment created in NAS of Ukraine, UARNET granted free traffic on speed 100 Mbps for connection between clusters of NAS of Ukraine. Thus, the basis of national Grid resource-technical base already exists. There are specialists (though few for now) who have almost mastered Grid technologies, and can share their knowledge with all the future participants of UNGI.

It must be noted that UAG is the infrastructure intended mainly for solving tasks of computational character though the possibilities of Grid technologies are much wider. Using the Grid technologies in the tasks of technological and social processes control, in medical service, in the system of electronic libraries and museums, in banking, transport and may other spheres has big perspectives as the world experience shows. For example, it is a need in organizing information-computing support of special equipment of collective use. The devices of such a kind include telescopes, microscopes, measuring equipment, research platforms, controlled machines, sensors, etc.

World Data Center (WDC) began its autonomic work in Ukraine from 2008**.** Ukrainian scientists and specialists can now count on using the large data volumes from different fields which can be processed in united cluster network. At creating Ukrainian WDC the following tasks were put: creation of analytic system for data initial collecting and processing; data sources search; establishing direct and feedback between the centers, design and development of data base subject to information objects safekeeping; data base completion with information objects; design and development of corresponding software. All these tasks and problems expect international cooperation at their solving. As Ukrainian WDC is created at NTUU "Kiev Polytechnic Institute", which is the basic one in MES project, it is natural to expect that directions of UNGI activity close to it will be performed by specialists from NTUU "KPI".

Undoubtedly, part of the UNGI work important in the education is also the sphere of responsibility of that UNGI part which grows out of the MESU project. Certainly, in the process of educating the specialists on Grid technologies, NASU will not stand by but in the conditions of Grid technologies use, educational base, programs, and tutorials must be created mainly in educational establishments.

In the plans of UNGI development considerable place is occupied by using of information-computing technologies of Medical Sciences (Ministry of Health of Ukraine) from medicine clinics and hospitals will be interested to use The Grid infrastructure of Ukraine to raise the level of servicing patients to the far higher, system level.

In the institutes of NASU, the educational institutes and universities of MESU and also in establishments of the other ministries and departments there are many computer specialists of a very high level. It is also necessary to organize the work in such a way to arouse these experts interest in new technologies to demonstrate perspectives and possibilities. The very considerable aspect must be development and realization of the new specialist training programs in higher educational establishments. No doubt that Grid technologies implementation will require a great number of young ambitious people to this new IT sphere. Taking into account novelty of the matter, perspectives and world tendencies in the field of Grid technologies, it must be achieved that the staff of any institute, university, establishment which has computing resources, were jobs of system administrators with the level of salary which will eliminate the large wastage of such specialists into commercial structures where IT specialist's wage fund is much higher now.

2.4. Principles of UNGI creation and functioning

Defining the principles of national Grid infrastructure organization and work, we came from understanding that Grid infrastructure and three its components (com-

putational resources, software, communication channels) must meet the following requirements:

1. wide representation of academic, educational, industrial and the other components of society;
2. support of the infrastructure development on the state level program;
3. international standards of Grid infrastructure control and work;
4. affirmed center for international certificate authorities;
5. high level of computer safety;
6. high speed Internet channels and connection to European GEANT network.

Taking into account the fact that national Grid infrastructure will be built as interdepartmental organization we consider that it must have multilevel hierarchy with the elements of centralized management which takes into account peculiarities of Grid technologies use in different departments and regions. This is the variant which will enable to take in account maximally the specific conditions and demands of the UNGI participants not only during the exploitation but also at the stage of design, it will provide fast users integration into the international Grid projects and organizations.

According to Memorandum which was signed by each participant UNGI is the voluntary, equal in rights association of scientific-technical, educational, industrial, and the organizations of Ukraine interested in development and implementation of Grid technologies in their activity, in integration with European and world Grid society. UNGI is the continuously working association opened at every stage of its development for attracting new participants from Ukraine. It is expected that, besides academic and educational establishments, UNGI will include establishments from Ministry of Health, Ministry of Transport and Communication, Ministry of Economics, National Space Agency, and many other departments (fig. 2). Virtual organizations formed within UNGI can interact with international VOs both directly and through UNGI coordinating bodies.

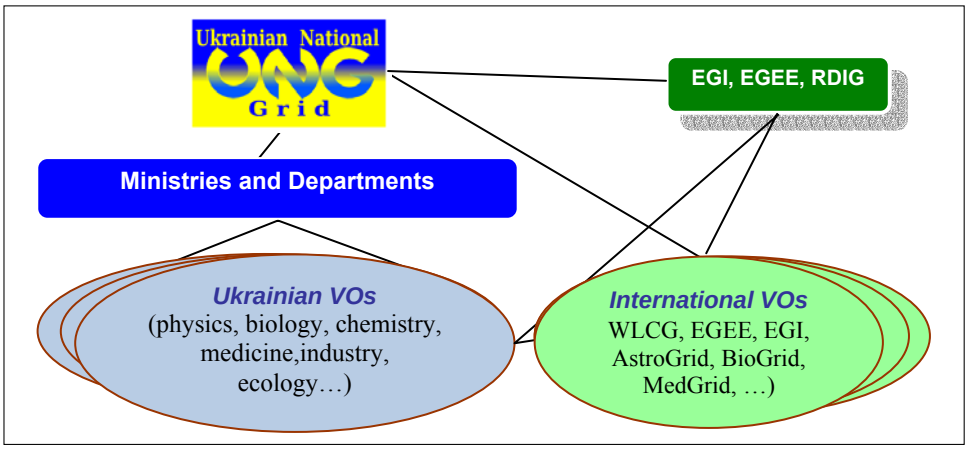

Fig. 2. UNGI and interaction between Ukrainian and international VOs

Organizationally (scheme is given in fig. 3), the work of UNGI is defined by Coordination Council, where all the participants of integration are represented. Coordination Council elaborates strategy and tactics of UNGI development and activity, works out principal decisions which are proposed for approval at general meeting or at UNGI conference which are held at least once a year. Coordination

Council, together with educational establishments, elaborates politics and educational programs in the sphere of training the specialists on Grid technologies.

UNGI executive committee realizes all the current UNGI activity, provides financing of projects, supports international contracts, gives needed assistance to work groups on all levels.

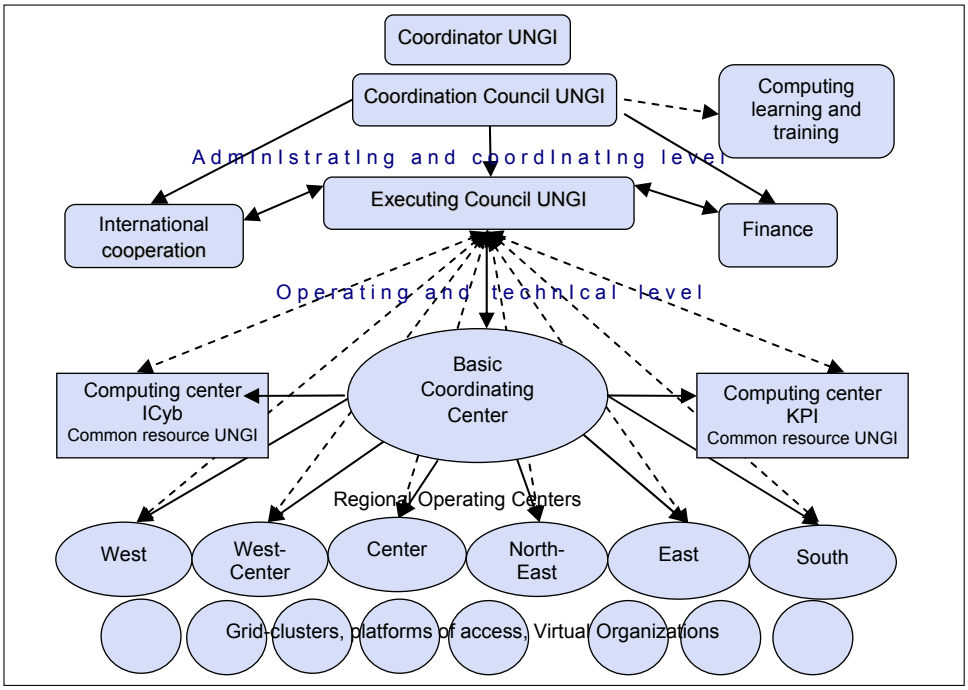

Fig. 3. Ukrainian national Grid hierarchical structure

The UNGI functioning as an infrastructure is coordinated by Basic Coordinating Center (BCC) which consists of working groups dealing with research, technical and software support of all the infrastructure elements.

It is expected that UNGI BCC will be created on the basis of structures of the existing Ukrainian Academic Grid control. Range of Center tasks include:

1. creation and development of regional resource centers;
2. providing of basic and regional centers uninterrupted functioning; development of Ukrainian Grid segment net infrastructure;
3. integration with the resources of EGEE and the other international Grid projects and organizations;
4. testing and certification of Grid clusters and software;
5. registration and support of users and virtual organizations, archiving of reserve copies and access protocols, monitoring, auditing.

The main work on support of full-functional, stable and safe UNGI work is entrusted to working groups who work within BCOC as well as within ROC along with Virtual Organizations Resource Centers (VORC). These groups are created at activity directions, and it is not necessary that group members are concentrated in one establishment. Let us note that the proposed system of working groups is till the certain point similar to that accepted in EGEE (NA, SA, JRA directions). Such system fully corresponds with distributed nature of Grid infrastructure itself, and allows to involve the most qualified experts into solving of

the tasks. Moreover, e.g., the task of permanent monitoring of the work of all infrastructure elements and services can be executed in turn by specialists from different Grid nodes.

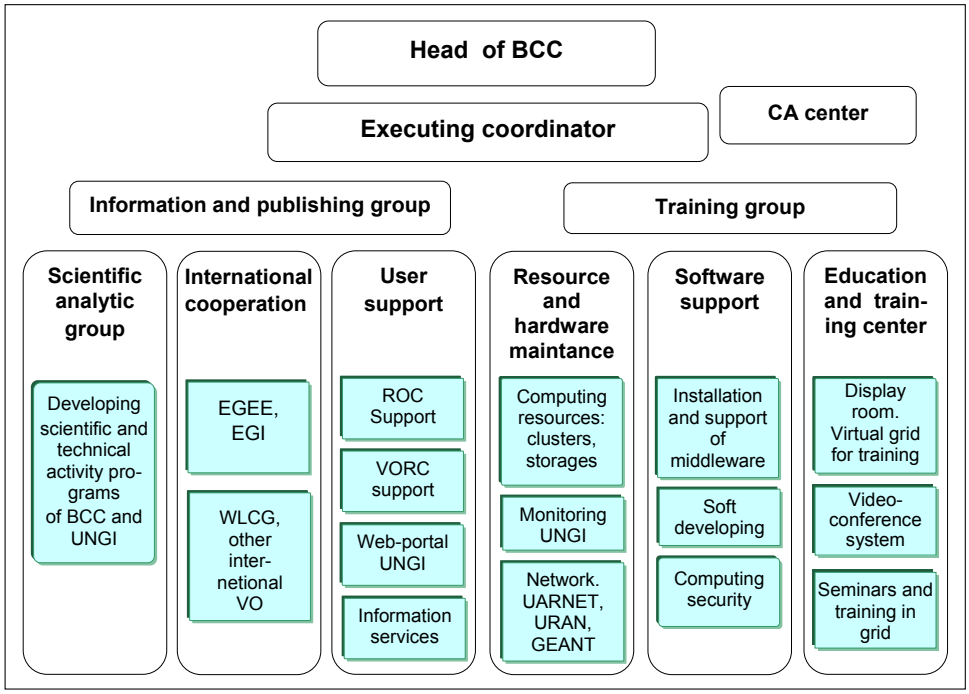

Fig. 4. Contents and functions of UNGI Basic Coordinating Center working groups

Exemplary contents of BCC working groups and their main functions are shown on fig. 4. ROC have similar structure (perhaps, with less number of groups and functions). Certainly, in the process of program realization, contents and tasks of the groups will be defined more exactly.

3. UNGI AND WORLD GRID SOCIETY

On April 25, 2005, Ukraine became officially the member of WLCG (Worldwide LHC Computing Grid) which is for now the largest thematic Grid organization in the world. The goal of WLCG is processing and analysis of experimental data which will be coming from ATLAS, ALICE, CMS, LHCb, TOTEM LHCf detectors installed in the LHC accelerator tunnel. More in detail, cluster of KPTU is being prepared for CMS experiment data processing. In AliEnGrid infrastructure which provides computational support of ALICE experiment, participants are Institute of Theoretical Physics, Institute of Cybernetics and Kiev National University. Clusters of Kiev Polytechnic Institute and Institute of Scintillation Materials are connected also. The considerable obstacle for more efficient participation of the Ukrainian Grid clusters in CERN program is not enough capacity of the Internet channels which connect clusters with CERN. The main peculiarity of tasks is large data thread at loading and at finishing the tasks being solved. For efficient task performing, high (0.1 – 0.2 Gbps) peak traffic through the channel is needed. For now, question of payment for such traffic is not solved.

In October 2007, at EGEE conference in Budapest it was announced that Ukraine had became the associated member of this influential Grid project. Within EGEE Ukrainian scientists intend to take part in the next directions and working groups.

NA2 — control and coordination of Grid infrastructure activity on regional level, creation of the site under the guise of UNGI-EGEE. Preparation of reports, publications and materials about UNGI group, contacts with local information agencies in order to spread information about the activity of UNGI and EGEE, translation of EGEE documents, popularization of the knowledge on Grid technologies.

NA3 — creation of central and regional Grid training centers. Development of teaching materials (presentations, lectures, Web pages, tutorials), holding regular seminars on theory and practice of Grid technologies. Creating virtual Grid systems and thematic virtual organizations for practical learning in center and regions.

SA1 — accounting management and support in UNGI. Interaction with national and international Grids, creation, coordination, and support of national Grid applications. Software support and deployment for UNGI sites, Grid services providing and national Grid infrastructure monitoring. Giving online assistance to UNGI users. Creating regional ticketing system and UNGI cooperation with GGUS. Coordination of all computer safety aspects in UNGI.

SA2 — operational procedures updating and improvement. Procedures standartization, and interaction of different Grid systems. Relationship between users and providers.

SA3 — creation of administration system for timely elimination of problems which appear on UNGI sites.

SA4 — introduction and adaptation of GILDA software into UNGI, operational support of GILDA portal in UNGI.

In May 2007, Ukraine signed Memorandum on UNGI participation in pan-European EGI organization which is being created. According to plan, this organization is at stage of forming and developing the activity program till 2010, and then, after finishing the EGEE-III project, it will take all the EGEE functions. Ukraine takes part in discussing the EGI program, and it will continue the work which it performs and plans to perform within EGEE. In is expected that, by developing and activating UNGI, Ukrainian participants will enhance involvement in EGEE and EGI, taking part in the other working groups, besides the aforementioned ones.

The main astronomic observatory of NAS of Ukraine signed the agreement, and together with AstroGrid-D develops the European system of specialized GRAPE/GPU Grid clusters which are used extremely effectively for solving the line of astrophysical and astronomical tasks.

Institutes of biological specialization of NAS of Ukraine began actively to establish contacts with Grid projects the goal of which is solving scientific and practical problems in life sciences. In UNGI plans, the wish to collaborate with foreign colleagues in Grid technologies applications of practical medicine is marked.

Institute for Space Research began the fruitful collaboration with Chinese colleagues in the sphere of geosciences. In particular, there were performed monitoring, including that by the help of satellite observations data, and research of water resources of surface of someone (dangerous because of possible floods)

water resources of different regions in Ukraine and China. Negotiations are hold about creating the virtual organization which would focus n geophysical research, within EGEE.

National technical university "Kiev Polytechnic Institute" has joined the Association of universities of countries of the black Sea region (Greece, Bulgaria, Romania, Moldova, Turkey and Ukraine) with a goal of research and educational resources virtualization in these universities with the help of Grid technologies for supporting joint master's degree training programs.

It is far not the full list of interests and plans of UNGI participants' international contacts, this being the proof that Ukraine has scientific and resource potential for wide participation in the international and versatile Grid projects.

CONCLUSION

Thus, summarizing all that have been said about the statues of Grid technologies in Ukraine we should assert the matter of creating full-function national Grid infrastructure is successfully completed (albeit with some delay). Initial material technical base is already created, understanding of the task importance is present, mutual understanding is achieved between the main participants and executors. There is no doubt that in the nearest future Ukrainian National Grid will demonstrate an active and fruitful work and will be reliably integrated into the European and world Grid society.

REFERENCES

1. *Grid* computing. A vertical market perspective. — http://www.insight-corp.com.
2. http://web.eu-egi.eu/.
3. *Zgurovsky M.Z.* Development of Educational and Research Segment of Information Society in Ukraine // Proc. WSIS . — Tunis. — 2004. — P. 103–107.
4. *Zgurovsky M.Z.* Development of Educational and Research Segment of Information Society in Ukraine // Системні дослідження та інформаційні технології. — 2006. — № 1. — С. 7–17.
5. *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. — **6**. — Supplement, 14 April 2007. — P. 583–590.
6. *Петренко А.І.* Національна Grid-інфраструктура для забезпечення наукових досліджень і освіти // Системні дослідження та інформаційні технології. — 2008. — № 1. — С. 79–92.
7. *Петренко А.І.* Вступ до Grid-технологій в науці і освіті (навчальний посібник). — Київ: Політехніка. — 2008. — 124 с.
8. http://www.globus.org/.
9. *Huedo E., Montero R.S., Llorente I.M.* A modular meta-scheduling architecture for interfacing with pre-WS and WS Grid resource management services // Future Generation Computing Systems. — 2007. — **23**, № 2. — С. 252–261.
10. http://lcg.web.cern.ch/LCG/.

Received 28.01.2009

From the Editorial Board: the article corresponds completely to submitted manuscript.