Plenary Session

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NATIONAL UKRAINIAN GRID INFRASTRUCTURE (UGRID) FOR SCIENCES AND EDUCATIONS

Development of Ukrainian national GRID infrastructure is considered. Main components of this GRID are: Ukrainian Research and Academic Network, the system of distance learning, distributed information resources in education and science, electronic libraries and the administrative and educational system "Osvita". Grid-infrastructure provides the Ukrainian universities, research centres and virtual laboratories by the information and required computational resources. In conclusion the international collaboration of Ukraine with Europe in GRID development is considered.

1.GRID technologies facilities

GRID, geographically distributed infrastructure, compels existing in a network computers (thousand of PC, work stations and super-computers) to work how a sole enormous and mighty computer is, uniting the great number of resources of different types (processors, large memories, data depositories and data bases, networks), access to which users can get from any points, regardless of place of their location. GRID assumes the collective mode of access to the resources and to related to them services of the within the framework globally distributed virtual organizations, that consist of enterprises and separate specialists which jointly use shareable resources.

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 Figs 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. The program of the International Centers of Data can be an example which deals with collection, accumulation, saving and global data processing from physics of hard Earth, Sun-Earth physics, hydrology and seismology, gravimetrical and magnetic measuring and others like that .

And as scientists are limited usually financially by grants, they wish that all these possibilities would be given them *cheap, possibly, even free of charge.*

If , say ,a user needs to use the program of molecular simulation of his colleague, GRID, executing the proper task, will make to attempt, foremost, remotely to start the program on the computer of this colleague. If colleague's computer is busy, GRID will copy the program on other computer, or will find elsewhere in the Earth a few computers which are out of use and will start the program there. In actual fact, a user does not need to ask nothing in GRID – the last itself will find the best place for the start of the program.

If a user must to analyze the great number of data, which are on different computers sparse on a whole world, then GRID will be able to define for unassisted user the most proper data source and execute their analysis. If a user must conduct such analysis in the interactive mode in collaboration with colleagues from different countries of world, GRID will link their computers so, that joint work will not differ from work in a local network. Thus he will not be needed to worry about the great number of passwords - GRID is able to understand, who has a right to take part in joint work. That is GRID functions as **a sole operating system of virtual mighty computer.**

It is considered, that GRID influence on development of society will be the same effective and ***revolutionary***, how influencing of previous prominent inventions are - computer and Internet.

2. Pre-conditions of creation of Ukrainian GRID

2.1. **There is the Government decision about National Grid development**. For a long time, Ukraine in the frame of former USSR had strong traditions in the field of cybernetics, mathematics and computer sciences. For

example, in 1952 Ukraine was the third after USA and Great Britain county capable to build up the computer. In spite of some social and economic problems, Ukraine has made some steps, especially after Geneva's WSIS-2003, in the direction of creating of the information society. This aim was recognized as on of priorities of the state. First of all, a number of the 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 are regulating the relationships between state institutions, professional communities and business in the creating of all segments of the information society.

2.2. The **Ukrainian research and academic network** (URAN) is in operation since 2001 as the **first segment** of the Ukrainian Grid-infrastructure [1]**.** Its backbone is based on the main nodes in six largest cities of Ukraine — Kiev, Kharkiv, Dnepropetrovsk, Lviv, Odessa, and Donetsk. Totally, 20 out of 26 regions of Ukraine are connected to the network (Fig.1).

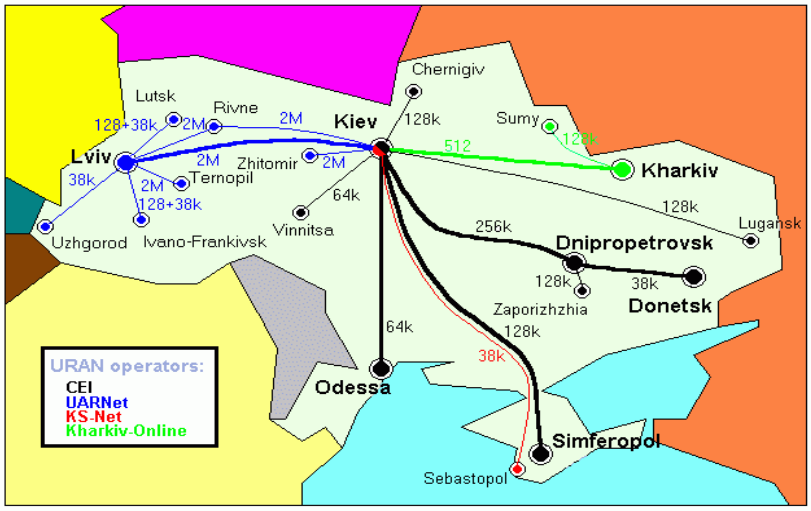

Fig.1. URAN operators

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 the optic fiber and satellite communication segments are developed, which ensure the rate of data transfer up to 1 Gb/s.

A selected way of the URAN infrastructure development is based on the 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 frameworks of one and the same budget can increase the system efficiency by 100 times. Other advantages of 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 is initiated by the Association of research and educational networks of the Central and Eastern Europe (CEENet) and aimed at decreasing of a "great digital divide". The objectives of the project are:

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

2.3. **There are the system of distance learning, distributed information resources in education** and the administrative and educational system, named "Education", successfully working as the **second segment** of the Ukrainian Grid-infrastructure [2]. The national system of distance learning comprises (Fig.2.):

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

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

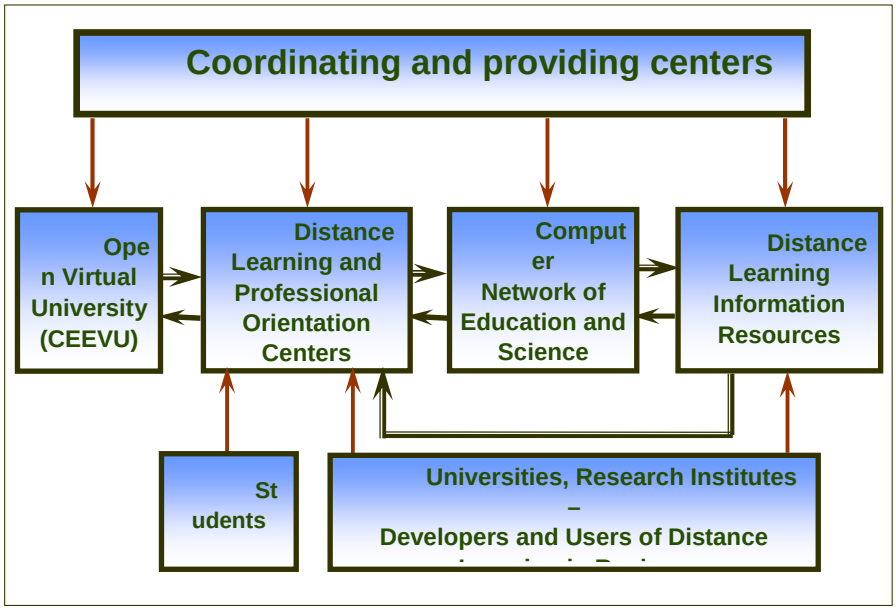

Fig. 2. Distance Learning System at the National Level

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), 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, 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 of the distance learning system. The information resources of the virtual university have the distributed structure with the open access to users by connecting to the servers of the 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 ensure automation of a lot of administrative functions and information processes at the national level and 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. **There are distributed information resources and network computational facilities** as the **third segment** of the Ukrainian Grid-infrastructure (fig. 3) for serving the Ukrainian universities, research centres and virtual laboratories [3]. On the first stage it gives the opportunity of the remote access to the data bases in different fields, for example, economics, natural sciences, ecology, medicine, telemedicine and others.

At the National Technical University of Ukraine "Kyiv Polytechnic Institute" the cluster architecture supercomputer (CAS) was installed this October with such calculable parameters: 128 processors with general productivity of 1,9 Teraflops (Teraflops), 64th bite word, operative memory - 2 Tb (terabite), the fixed storage (HDD) - 20 Tb. The use of this supercomputer together with supercomputers of Institute of Cybernetics (with productivity a bit less than at the supercomputer NTUU" Kiev Polytechnic Institute") is planned in 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 for solving problems with great volume of computations. In the construction of this supercomputers there were used the distributed data bases and new intellectual technologies developed by Ukrainian mathematicians and engineers [4]. NTUU "Kiev Polytechnic Institute" possesses itself many years experience in theory, models and methods of the distributed data processing investigation; development of algorithms and decision methods for the applied tasks in the environment of distributed computing, designing and exploiting the distributed informative systems.

As an example let mention about the system of **ecological monitoring and telemedicine support** for the Chernobyl Nuclear Power Plant area which is devoted to analyse remotely health of various professional groups from 4300 persons, those working 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 URAN network to the International Centre of Telemedicine, which is located in Kiev at the NTUU "Kiev Polytechnic Institute", where the data being obtained are analyzed and the recommendation on prevention and treatment are worked out.

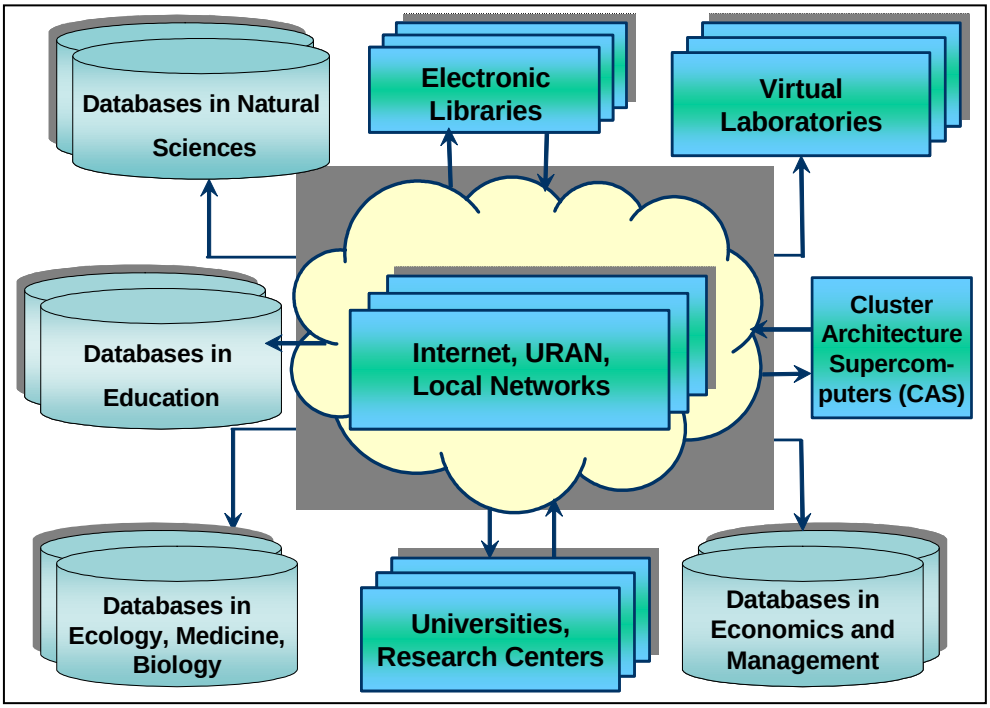

Fig. 3. Information and Computational Resources of Science and Education

2.5. **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 the information centres, which are connected by optic fiber channels of data transfer to the URAN. There are many unique publications in this system (Fig.4,5).

Fig.4. Libraries system riches

2.6. **The Ukrainian branch of International Centers of Data (UB ICD)** being established under the Agreement with the Geographical center of the Russian Academy of Sciences starts to operate as the **fifth segment** of the Grid-infrastructure . It carries out accumulation, saving national and world data, collected by institutes and organizations which are belong to the National Academy of Sciences of Ukraine, Ministry of Education and Science, Ministry of architecture, etc., and provides for clients **online catalogs and databases** and data processing

We hope that in the nearest future very valid information about Earth (for example, SILEX data from the satellite ARTEMIS through the Tenerife Observatory, Canary islands) will be available for scientists of Physics and Astronomy division of the National Academy of Science of Ukraine(Fig.5).

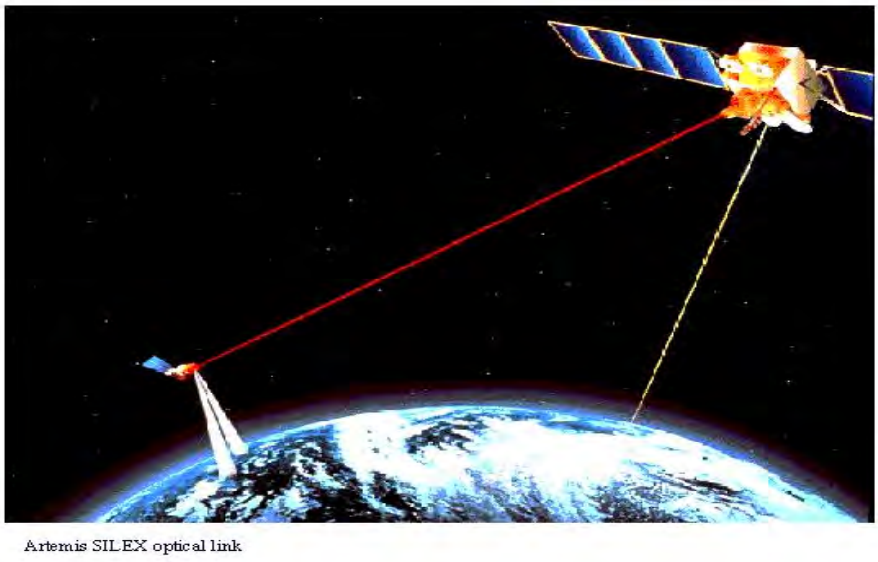

Fig.5. Optical communication experiments with geostationary satellite

3. Stages of creation 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 about of principle possibility of joining Ukraine to this project, as already Russia did earlier. In addition, the NTUU "Kiev Polytechnic Institute" agreed with Baltic countries about joint collaboration in the project* ***BalticGRID*** *(a coordinator Dr. Per Őster), which they started two years ago.*

There are six main executors of UGRID project now : National technical university of Ukraine „Kiev Polytechnic institute", Kharkov National university of radio electronics, Lvov National polytechnic university

”Lvov Polytechnika”, , Zaporozhian National technical university, Institute of Theoretical Physics of National Academy of Science and Lvov Open joint-stock company "Lvov Radiotechnical Institute".

We are going to use European GRID development experience. In analogy with European prototypes 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 GRID - infrastructure, ROCs are accountable for the operations in the regions, and BIC will be at the NTUU “Kiev Polytechnic Institute” and will provide services related to the resources EGEE.

Due to associated membership in BalticGrid the EGEE **gLite** middleware software (Fig.6) will be adapted at Ukraine. Its main subsystems (Information System and Monitoring, Security Infrastructure, Workload Management, Data Management) serve simultaneously three basic roles: a supplier of services, a servant for a user and a broker. A supplier of services registers his resources at some brokers, a servant helps a user to find necessary services there, whereupon a connection between them 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 large-scale existing computing facilities. Potential of GRID technologies is already estimated ever-higher: it has a strategic character, and in a near prospect GRID must become an important tool for development of high technologies in different spheres of human activity. Such high estimations can be accounted for by the GRID ability to solve two following problems on the basis of safe and reliable remote access to the resources of globally distributed infrastructure:

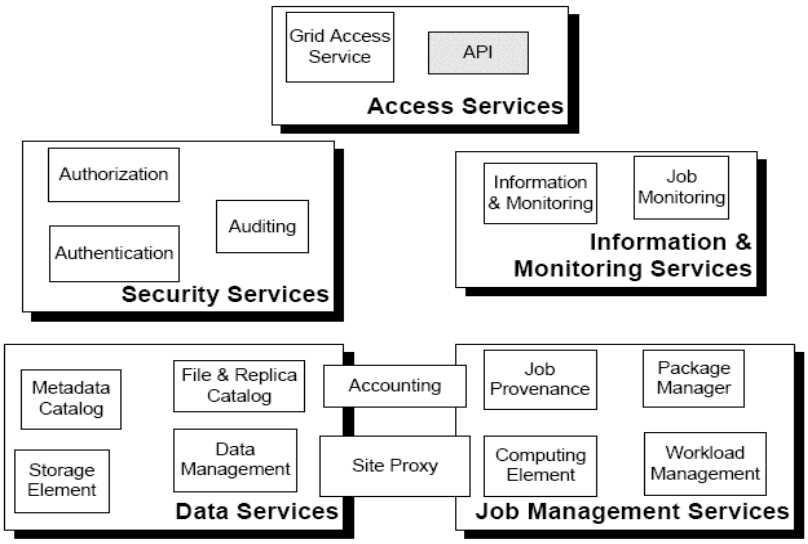

Fig.6. Middleware gLite services

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

The primary objectives of Ukraine within the framework of the project in hand are an inclusion UGRID in general *EGEE* infrastructure and providing UGRID functioning as valuable operating and functional *EGEE* component. Ukraine gets possibility „on even” to co-operate with the countries of European Union on development and realization of technology of 21-th age – GRID, which *foresees* transition from a client - server architecture to an architecture of network of calculable computers equal in rights, working as a sole virtual computer; *provides* varieties of resources of compatible access, that may include files data to the computers, sensors and networks *; realizes* the various modes of their use in one- or many users regimes, *provides* strict control, management and organization of the safety system ; *supports* heterogeneity of network, balance of loading on computing nodes and other.

The offered project, foremost, is intended for facilitation of scientific data exchange between research workers and for organization of their collective treatment. Among the number of key factors, which promote GRID installation, are not only a rise of efficiency of the use of resources and economy of charges, but also possibility of **flexible change of infrastructure** according to new requirements. Most establishments presently have opened out small GRID installations with the limited set of equipment and applications. One of important tasks is the effective use not only computing but also **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 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.

Many countries in Europe have now own National GRID Initiatives (NGIs), operating application-independent national e-infrastructures which were supported by national funding and resources Such efforts have firmly positioned Europe as a world leader in GRID computing, they have proved the success of GRID computing for the research community and as a valuable component of the future European Research Area (ERA). The technology is still developing, and the new project EGEE-II features many more application domains with related projects.

Despite these successes, the current state of European GRID computing is not sustainable. To guarantee the long term availability of high speed GRID computing for the ERA **a new model for the coordination** and operational oversight of the emerging European GRID Infrastructure has been proposed [5].

4. Conclusions

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.

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