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# Prospects for Worlds & Ukraine's Information Economy in Creating and Improving Supercomputers Based of NBIC-Technologies

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author Igor Matyushenko designed the study, performed the statistical analysis, wrote the protocol and the first draft of the manuscript. Authors VV, OB and Iuliia Makhanova managed the analyses of the study. Author Iuliia Makhanova managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aims:** The aim of the article is to analyze the modern prospects of creating supercomputers for information economy in the World and improving supercomputers of SCIT family in Ukraine basing on NBIC-technologies.
**Study Design:** The reviews were carried out in the period 2009–14 on the basis of studying the world countries supercomputers development trends as well as on the basis of the research results obtained by Ukrainian academic institutions.

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**Place and Duration of Study:** Department of International Economic Relations and Tourism Business of VN Karazin Kharkiv National University conducted the research between June 2016 and November 2016.

**Methodology:** Content analysis has been use as the main method of research, which allowed making a meaningful analysis of classic papers and researches of modern economists practitioners devoted to the peculiarities of the modern prospects of supercomputers creating for information economics in the World and Ukraine with using of NBIC-technologies. We also apply the methods of dialectic cognition, structural analysis and logic principles that provide for making authentic conclusions as regards the investigated topic.

**Results:** The article reviews modern trends in the World information economy development based on supercomputers with principally new schemes (e.g., cluster structure). This paper demonstrates that in the result of implementing comprehensive scientific-technical programs to develop supercomputers during 2009–2014 in Ukraine will create a multi-national grid network elements from a centralized management based supercomputers with cluster SCIT-structure that will allow to take into account sectoral and regional interests and ensure its integration into European and global IT-infrastructure.

**Conclusion:** The authors developed the modern prospects of creating supercomputers based on NBIC-technologies for information economics in Ukraine namely:

General many times growth of SCIT supercomputers productivity increase would ensure solving benchmark scientific-technical problems and public administration problems;

Qualitatively new level of parallel development of applications for graphic accelerators and flow-data architecture processors would be supported. Furthermore, tooling would be developed to be tested in the adaptation to hybrid clusters of the available intellectual IT and in developing the new intellectual IT; New intellectual IT to analyze and substantiate management decisions for economy and social sphere using knowledge bases and data bases would be developed and created.

*Keywords: Information economics; supercomputers; SCIT cluster structure; NBIC-technologies; intellectual IT for economy.*

## 1. INTRODUCTION

NBIC-convergence of technologies is the basis for a "breakthrough" XXI century innovative technologies and enable significantly accelerate the development of social sphere and take it to a qualitatively new level. Scientific research in that sphere concerns development of supercomputers, quantum- and bio-computers, which in future are called to replace the existing technological platforms based on silicon technologies. Revolution in NBIC-technologies sphere as well as global challenges and crises also contribute to modifying traditional innovation policies and strategies of the industrially developed countries.

The named problem was tackled by many renown scientists, including M. Roco, W. Bainbridge, B. Tonn, G. Whitesides [1,2]; R. Campano [3]; R. Silberglitt, P. S. Anton, D. R. Howell [4]; R. Voyer, N. Makhija [5]; L. Stenberg, H. Nagano [6], who studied the issues of knowledge, technologies and society convergence. Also many renown organizations, for example European Commission [7]; European Parliament [8]; Organization for Economic Co-operation and Development [9]; National Intelligence Council [10]. And also Russian scientists A. Kazantsev, V. Kisilev, D. Rubvalter, O. Rudenskiy [11], together with Ukrainian scientists M. Kyzym, I. Matyushenko, O Khanova [12-24] dealt with the development and prospects for NBIC-civilization. At the same time, the growing implementation of NBIC-technologies into developed countries information economics requires review of the prospects for their use to develop supercomputers in Ukraine. The aim of the article is to study design and production trends for information economy in Ukraine creating and improving Ukrainian supercomputers of SCIT family based of NBIC-technologies.

## 2. METHODOLOGY

Content analysis has been used as the main method of research, which allowed making a meaningful analysis of classic papers and researches of modern economists-practitioners devoted to the peculiarities of the modern prospects of creating supercomputers with principally new schemes and with using of NBIC-technologies for information economics in the World and Ukraine. General scientific methods make up a methodological foundation of the research. They include: description, comparison, statistics review, system analysis, which help characterize this phenomenon development in a more comprehensive way. We also apply the methods of dialectic cognition, structural analysis and logic principles that provide for making authentic conclusions as regards the investigated topic. Official statistical data of the state institutions and international organizations, publications of reference character, analytical monographs, annual statistical bulletins, Ukrainian National Academy of Science reports [25-30], which free, serve as an information grounds for our research.

## 3. RESULTS AND DISCUSSION

In the latest time the volume of the stored and processed information has become million times more than it had been during the whole previous period of information technologies development. The capacity of the world computation resources has been growing very quickly, but the need in this capacity growth is even more. That need is not only limited by the necessity of information processing. Due to the development of inter-disciplinary research (and with implementation of the concept of NBIC-technologies converging we are approaching to the consolidation of these four areas into a single scientific-technological knowledge domain), scientific industries that require supercomputer resources to solve different tasks of simulation, forecasting, optimization, etc., have started to boom. In other words, the need in super powerful computation has been growing faster than the need in processing the accumulated data [25;346–347].

Therefore, the improvement of the available supercomputers and development of principally new schemes of supercomputers (e.g., with cluster structure) – is one of the most prospective directions for ICT development in any country that considers itself to be technologically developed [13;110–112].

The advanced world countries consider development of this industry to be one of their national priorities. For example, in the USA the pentaflops range (computer processing speed) – $10^{15}$ operations/sec. – has already been reached and they are moving to the exaflops range – $10^{18}$ operations/sec. Russia has the program of high-productive computations development “Scith-Grid” and several federal programs with annual budget financing of more than 5 bln. Rubles. Aggregate processing capacity of Russian supercomputers is planned to bring to 20000 teraflops ($20x10^{15}$) (teraflops is the speed of computer’s performing $10^{12}$ operations/sec.). At the end of 2010 the clusters “Lomonosov” (Moscow State Univrsity named after Lomonosov) with the productivity of more than 500 teraflops and К-100 (Keldysh Institute of Applied Mathematics, Russian Academy of Science) – 100 teraflops. As a reference: in 2011 the aggregate peak productivity of Ukrainian National Grid clusters did not exceed 27 teraflops [26].

According to the world TOP-500 supercomputers rating 50 the most powerful computers work in China, USA, Japan, France, Germany, Russia, South Korea, Brazil, Saudi Arabia, Switzerland, Canada, India. The first place in that rating belongs to Chinese computer Tianhe-1A, the second one belongs to the US computer Cray XT5 Jaguar and Blue Gene/L (installed at the Lawrence Livermore National Laboratory, USA). It performs 479.2 trillion operations with floating point per second [27]. Russian computer “Lomonosov” ranked $17^{th}$ in that rating list.

In 2008 the research center in the town Julich (Germany) witnessed an official ceremony of commissioning a powerful supercomputer JUGENE belonging to Blue Gene/P family, IBM corporation. The new supercomputer has about 65 thousand PowerPC 450 processors and its productivity is 167 teraflops (trillion operations with floating point per second) [27]. Computation capacities of JUGENE, JUMP and JUBL systems are accessible to about two hundred research groups. Supercomputers resources are also used during projects computing connected with new materials development, search for the next generation medical drugs as well as when simulating climate change, elementary particles behavior, complex chemical reactions, etc. A group of independent experts distributes computing capacities between different projects.

In 2004 in the Ukrainian National Academy of Science (NASU) institutions created two high efficient computation cluster systems SCIT-1 and SCIT-2 on the basis of Intel Xeon and Intel Itanium 2 microprocessors, the characteristics of which go in line with the world analogues. Exactly the intellectual component of the developed clusters in combination with the distributed databases provide for efficient intellectual processing of big data volumes and also ensures considerable competitive advantages in comparison with other world analogues [25;347].

Since 2007 in CIS countries' similar rating (TOP-50) Ukraine was represented by SCIT-3 and by National Technical University of Ukraine 'Kyiv Polytechnic Institute' (NTUU "KPI") cluster, which initially were among the first 5 of the rating. However, Ukraine may stop being the part of the rating in the result of which the Ukrainian research institutions and universities would lose the chances to win tenders by international scientific-technical programs and would have limited capabilities to solve complex tasks. The reason for that is insufficient budget financing. For instance, to improve the SCIT-3 system it was necessary to bring its capacity to 400-500 teraflops (specialists of the Cybernetics institutes of NASU could accomplish that in 1 year). The aggregate cost of the project was UAH 50 mln. while the expected runtime period of the upgraded computer was 5 years [26].

Moreover, supercomputers' daily running and improvement are also very costly. In the result, the scientists are more interested in middle-range supercomputers, like, for example, the supercomputer INPARCOM designed by Kyiv Cybernetics institute and produced by Kyiv "Electronmash" factory. That supercomputer capacity (which is 1.5-2 teraflops) is lower than the capacity of big supercomputers of SKIT type, but it is much cheaper and it does not required huge volumes of electric power during its running. At the same time it can solve rather complicated tasks on the basis of computation process parallelization. In other words, such supercomputers can ensure preparation of software and complex computer technologies while their implementation, if required, could be transferred to more powerful computers. According to the specialists, exactly INPARCOM computers should be supplied to the institutes, universities and government agencies [26]. Moreover, in case of the government order availability "Electronmash" is ready to start serial production of that computer.

Though Ukraine is lagging behind in developing supercomputers, it is one of the leading countries in developing modern software for computers and computer systems [26]. Modern mathematic methods of optimization and system analysis, mathematical simulation methods and complex objects and processes research, programming theory and methods to protect information when forming up knowledge bases (KB) and databases (DB), transfer of that data via communication channels to different computers and systems make up the foundation of those developments. Exactly in those science industries Ukraine is rather strong. Globally known scientific schools in those spheres function at the NASU institutions (including also the NASU Cybernetics center institutes) and in the profile universities, like Shevchenko Kyiv National University, NTUU "KPI", Kharkiv National Radio Electronics University (KNRU), etc. At the same time, if the hardware component of ICT is not efficiently developed in parallel, the achievements of the Ukrainian mathematicians, system programmers and generally ICT specialists would be downgraded.

Thanks to supercomputers utilization NASU scientific-research institutions obtained very important fundamental and applied results in biophysics, biochemistry, physical chemistry, theoretical physics, materials science, medicine, geology/geophysics, nanotechnologies, etc. Within the frameworks of accomplishing research topical plans, government orders' programs, participation in the national and international scientific projects Ukrainian scientists constantly use SKIT supercomputer system of the NASU Glushkov Cybernetics Institute to solve the tasks of simulating molecular dynamics, quantum-chemical computations, simulating thermo-physical, hydrodynamic and geophysics processes. Supercomputers compute the properties of chemical compounds, alloys, biologically active substances and Nano-objects, processing of satellite pictures and seismological research results, medical populations and genome research, simulation of physical and social-economic processes.

Supercomputer computations agree with grid-computations, though they do not replace one another. Grid is an infrastructure of distributed computations, when the objective is subdivided by several separate sub-objectives, which are solved independently, even not simultaneously, and their results are copied into files, and only after that they are combined. Supercomputer is designed to perform parallel computations, i.e., sub-objectives are computed simultaneously and interact via data messages transfer. Generally speaking, Grid may use and actually is using supercomputers as nods. But for many tasks of huge volumes there are no algorithms of subdividing a huge task by independent sub-tasks, and stability conditions limit sizes of atoms, ergo, the size of the required memory. Generally speaking, such tasks could not be solved without a supercomputer.

Capacity of the modern supercomputers provide for creating information technologies, which from the perspectives of system (comprehensive) analysis and optimization reveal the essence of the naturally interconnected researched phenomena. Due to supercomputer technologies development the cost and time of digital simulation have decreased in comparison with the experimental testing of the real objects. Modern IT and supercomputers, as tooling in solving classes of super complex tasks, have become one of the determining factors in economic competitive advantage, and directly impact the national capacity to satisfy the population and business entities in information society.

Creation of supercomputer IT requires development of mathematic models, efficient methods for their analysis, algorithms and reliable programs. Complex character of the relations within the subject domain and growing requirements to the parallel implementation efficiency provide for the success of intellectual IT, capable to adjust independently to the task properties and to computation environment. Fundamental scientific component of this topic is in conducting research and development of efficient mathematic methods and algorithms to solve the jobs classes, which by the requirements to memory size and computation productivity exceed the capacities of the accessible computers, even to solve the jobs of trans-computation complexity.

The cluster system SCIT being the biggest computation resource of NASU and the foundation of the Ukrainian National Grid (UNG) resource center, since 2005 has been ensuring on a free basis highly productive computations for NASU agencies and institutions, Ministry of Education and Science establishments and Ukrainian National Space Agency units. Three generations of supercomputers SCIT (SCIT-1, SCIT-2 and SCIT-3) had been created and successfully used in the research conducted by "Intellect" program in 2007-2009. During the period 2010–2011 a hybrid segment SCIT-GPU was implemented for experimental research of new approaches to jobs parallelization. On its basis in 2012 in supercomputer SCIT-4 a new comprehensive architectural project to build cluster computation systems was developed and implemented to provide for reaching two times more productivity than the previous supercomputer generation SCIT-3 productivity - nearly 12 Tflops. Moreover, it also helped considerably increase its energy efficiency, power consumption of which (15 KWh) is 4 times less than the power consumption of SKIT-3. Thus, SCIT-4 by energy efficiency ranks the 99$^{th}$ in the world rating of the most environmentally friendly computers (Green 500), and further increase of its capacity is stipulated.

As of today supercomputer SCIT-4 is the most powerful Ukrainian computation means. It is connected to the SCIT system as a component, and the SCIT system is a foundation of the Ukrainian National Grid resource center. It has already passed certification by the European Grid-initiative (EGI). Thus, we may say that the further progress of computations implementation for NASU fundamental and applied science purposes requires development of the supercomputer capacities.

Consequently, NASU Presidium decree #785 dated 26.12.2012 approved the NASU scientific research program concept "Development of intellectual supercomputer systems of SCIT family, ensuring their efficient functioning and creating information technologies, modern mathematical, software/hardware support to solve complex and super complex scientific-practical tasks ("Intellect") for the period 2013-2015 [28].

The Program had two sections:

1. Further capacity increase, implementation area spread-up and providing for efficient functioning of intellectual supercomputer systems and intellectualization means to solve super complex profile tasks, as is already carried out by scientists from NASU;
2. Developing the available IT, creating new and implementing information technologies, modern mathematical support and software to solve complex and supercomplex scientific-practical tasks, with the first priority given to public administration, economics, medicine, biology, science, space exploration, environmental protection, information protection, etc.

The work planned in Section 1, was needed due to the fact that the retardation of the Ukrainian supercomputers from the similar computers in the developed countries had been growing very rapidly. The world trends review shows that USA, EU, China, Japan, Russia etc., consider computers development to be their priorities. EU, for example, allocates dozens of billion Euros; USA – nearly 8 bln.USD/year, Russia in 2009-2012 period had commissioned several powerful supercomputer centers, and before 2014 Russia had spent 7.3 bln.Rub. for developing high productive computation industry [28]. If in 2008 Ukrainian supercomputers competed with the Russian supercomputers and were in the first 10 of the CIS rating Top50, at the beginning of 2013 the capacity of the Russian computer “Lomonosov” was 75 times higher than the best Ukrainian supercomputer capacity, and retardation from the fastest in the world US computer “Titan” is 1500 times. Such a gap slows down Ukraine’s scientific-technical and innovation development, because thanks to the accelerated supercomputers development the computation experiments have become both cheaper and faster than the natural testing almost in all science and technology branches.

With regard to the prospects for SCIT system development at the beginning of 2013 the lowest teraflops cost, the best ratio productivity/electric power consumption for work and cooling had been provided by hybrid assemblies on the basis of general purpose graphic accelerators. SCIT-4 architecture and technical project were developed in the result of detailed experimental research of modern hardware different configurations. In the result SCIT-4 demonstrates now not only high real productivity and energy efficiency, but also adaptability to different class tasks. For example, the algorithms that are specifically adjusted for graphic accelerators could reach peak productivity of more than 25 teraflops. The usual programs, not adapted for graphic accelerators, receive advantage of using 192 central processors cores Intel Xeon E5-2600 2.6 GHz (up to 32 flows per nod) and a big volume of RAM (64 Gb per nod). Speed of processor access to the nod RAM is 0.7-0.8 ms that provides to work with all 768 Gb memory in program emulation mode with supercomputer unified memory array.

Research of the SCIT system usage history shows that the biggest part of resources (more than 90%) is consumed for solving tasks of molecular dynamics, quantum chemistry, hydro- and aero-dynamics as well as for developing customized software. To use SCIT-4 efficiently for those purposes the supercomputer has the installed software with supporting graphic accelerators: Packages GROMACS, NAMD and Abalone for molecular dynamics, NWChem and Quantum ESPRESSO for computational chemistry, OpenFOAM with plugin Vratis for the tasks in hydro-dynamics, mathematic library of foreign and domestic production, programs for astronomy and geo-physics developed by Ukrainian scientists – UNG users. At the same time, the issue of efficient computations in heterogeneous environment remains unsolved, i.e., it is necessary to develop algorithms and programs that could have simultaneously solved and used different by technology and characteristics appliances, like, for example, graphic accelerators and multi-core processors of different types and manufacturers. The theory of flow computations and standard language of flow computations OpenCL could become a technological foundation for such problem solving.

The jobs mentioned in Section 2 are required to be done because according to the statistical analysis of the SCIT supercomputers usage about 80% of the tasks could be accelerated dozens of times if using graphic accelerators [28]. These are the tasks of quantum chemistry, molecular dynamics, space photos processing, geophysics simulation, crypto-analysis, etc. Information search in internet and popular magazines on supercomputer computations proved the topicality of developing and implementing versatile software for clusters with graphic accelerators and availability of numerous projects in developing scientific and application programs.

According to the corresponding sections of the Program its aims are as follows:

- Further considerable development of SCIT cluster system, decrease of the computation resources deficit and decrease of the gap with the modern computation capacity level available in CIS and in the world;
- Development of the initiated and creation of new specific intellectual IT, modern mathematic support and hardware/software means directed to solve topical tasks in the spheres of public administration, economy, medicine, biology, analysis of complex scientific

research databases, developing methods of parallel solving of trans-computation complexity tasks using supercomputers with applying graphic accelerators.

The Program stipulates for the period 2013–2018 to develop analogues of major methods of intellectual libraries on computation mathematics and data processing to be performed at graphic accelerators. We mean the development of qualitatively new algorithms, other means for data exchange and load balancing, considerable improvement of the "intellectual" part of the library, connected with the algorithm selection and selection of the accomplishment parameters depending on the hardware specifics. Algorithms and programs, directed to work in hetero-geneous environment and capable to maximally use all the available hardware means to solve the biggest tasks – is a special direction of this work.

As to the Section 2, the following is stipulated:

- Continue working in developing new intellectual IT for new important tasks classes – both for the hybrid ones and for usual clusters;
- Use SCIT supercomputers as "cloud" foundation for national information-analytical systems and data processing centers (as it is done in the USA, EU member countries, Russia, China);
- Conduct informatization of the Ukrainian economy public administration sphere (the Ministries and Agencies really received computer equipment and communication systems, internet access has increased, national information resources have been developing with the priority for several registers of state significance and information-analytical systems);
- Create and implement IT-grounding for management decisions on the level of the government, Verhovna Rada (Parliament), local self-governance bodies;
- Arrange electronic documents circulation;
- Create new information-analytical systems and systems to analyze distributed databases for different branches of economic and social performance in the constantly changing conditions and situations.

Table 1 shows the most prominent results of the Program accomplishment in the period 2013–2014 [29,30].

**Table 1. The most prominent results of accomplishing STSTP of NASU "Developing intellectual supercomputer systems of SCIT family, ensuring their efficient functioning and creating information technologies, modern mathematic support and hardware/software support to solve complex and super complex scientific-practical tasks ("Intellect) in the period 2013-2014**

| Year | Program direction | Most prominent result | Practical value |
|---|---|---|---|
| **1** | **2** | **3** | **4** |
| 2013 | Further development of SCIT cluster system | Data repository for SCIT supercomputer system was upgraded; its usable volume was increased up to 120 Tb; its speed was increased up to 1 Gbyte/s (in 8 times) | SCIT system characteristics improved |
| | | Usage of supercomputer SCIT-4 interconnection was adjusted | SCIT-4 adjusted |
| | | Topology of SCIT system data transfer network was upgraded, which provided for additional increase of data exchange speed between parallel file system and SCIT-3 and SCIT-4 cluster nods by 5% | Data exchange speed increased |
| | | Data repository of SCIT system is used by scientific agencies to process and store super-big data volumes | SCIT system data repository used |
| | Development of intellectual IT, modern mathematical support and hardware/software | Methods to solve vector discreet big size optimization tasks in the conditions of uncertainty and risks, connected with parallelization of optimization process were developed | Cost and time of taking decisions in complex situations decreased |
| | | Gradient methods to identify parameters | Methods to identify |

| Year | Program direction | Most prominent result | Practical value |
|---|---|---|---|
| **1** | **2** | **3** | **4** |
| | support | were built up for: layered media in the frameworks of the established and unestablished diffusive processes; layered cylindrical bodies within the frames of the established and unestablished diffusion | parameters for layered media and cylindrical bodies developed |
| | | Customized program tooling was developed for NADRA-3D system to create and edit digital models of multi-component layered 3D media | Program tooling to create and edit digital models provided |
| | | Methods to identify different parameters of mathematic models of diffusion in layered bodies and layered revolved solids were developed. They provide for identifying characteristics of the mentioned bodies' separate components with nondestructive method with the aim of solving the problem of extending service life of complex modern objects of various designation, solve the problem of environment conservation, determining characteristics of new materials, etc. | Solving the problems of heat-power engineering, machine engineering, environmental problems research, nature conservation and drinking water and oil products purification, etc. |
| | | Approaches to building mathematical models of economic and production processes optimization were proposed together with the models of energy saving & computation biology which are formed in the terms of computer optimization. | Possibility to obtain scientifically grounded applied results to take decisions in different application spheres provided |
| 2014 | Further development of SKIT cluster system | SCIT supercomputer system was upgraded to increase data imaging system to 150 Tb | SCIT computer imaging system characteristics improved |
| | | Research computation nod with hybrid architecture of 1.17 TFlops was developed and commissioned into the SCIT system composition. It matches productivity of SCIT - 3 cluster 25 nods | Productivity of SCIT-3 computations increased |
| | | All SKIT system grid-services transferred to virtual machines which provided for energy efficiency triple increase | SCIT system energy efficiency increased |
| | Development of intellectual IT, modern mathematical support and hardware/software support | New efficient parallel algorithms to research and solve basic tasks of computation mathematics with crude data at the computers of hybrid architecture (with multi-core and graphic processors) were developed | Algorithms of solving tasks with crude data at the computers with hybrid architecture developed |
| | | A series of stochastic algorithms for global equilibrium search were developed and researched | Algorithms of designing communication networks, super-big integrate circuits, phased antenna arrays, drawing of neuron networks, image recognition developed |
| | | Mathematical models and software for high-productive computations on the basis of video-graphic accelerators were proposed | Models and software for efficient solving of the tasks to forecast meteorological processes on Ukrainian territory created |

*Composed by: [29,30]*

After the Program accomplishment the following results would be achieved:

1. Many times growth of SCIT supercomputers productivity would be ensured to solve typical scientific-technical tasks and public administration tasks;
2. Qualitatively new level of applications parallel development for graphic accelerators and dataflow architecture processors would be supported; tooling would be developed to be tested in the adaptation to hybrid clusters of the available intellectual IT and in developing the new intellectual IT;
3. New intellectual IT to analyze and substantiate management decisions for economy and social sphere needs with using knowledge bases and data bases would be developed and created. IT for the needs of space and biologic research, efficient utilization of energy resources, medical diagnostics and development of medical drugs, telecommunication and information-analytical systems, etc., are planned to be developed with using the basic methods of solving trans-computational complex tasks. The work in solving the tasks connected with environmental control would be continued. They involve the problematic of monitoring and data analysis as well as simulation problems to include atmospheric simulations, models of water basins and soil grounds. Basing on the experience and achieved results in 2007–2012 the generic solutions to protect information in virtual data processing centers would be developed and tested.

Successful accomplishment of the mentioned programs would enable a wide circle of scientists and practitioners to use supercomputer and grid-technologies to create information economy in Ukraine, perform scientific research and development of high level, increase National Academy of Science of Ukraine (NASU) participation in implementing competitive projects ordered by public administration, improve conditions for attracting and implementing international grants projects.

## 4. CONCLUSIONS

The results indicate that due to the need in the accumulated information processing under the conditions of explosive-type growth of information volumes. Moreover, due to the need in super powerful computations for interdisciplinary research improvement of the available supercomputers functional diagrams and development of new cluster structure - one of the most prospective directions to develop information communication technologies (ICT) in any technologically developed country.

Review of the world trends shows that supercomputer development direction is accepted as top priority in the USA, EU, China, Japan, Russia, etc.

Ukraine also has created high-efficient computation cluster systems SCIT-1, SCIT-2 and SCIT-3. There are at the expense of the intellectual component of the developed clusters in combination with distributed databases there have appeared a chance to perform efficient intellectual processing of big knowledge bases and databases as well as to receive considerable competitive advantage in comparison with the supercomputers produced in the world.

Moreover, in 2012 Ukraine developed and implemented in supercomputer SCIT-4 a new comprehensive architectural project of cluster computation systems build-up, which provided for achieving a two times more productivity in comparison with the previous generation supercomputer SCIT-3 – nearly 12 Tflops. Moreover, it helped considerably increase its energy efficiency, power consumption of which (15 KWh) is 4 times less than the power consumption of SCIT-3.

In the result of accomplishing the NASU scientific research program “Development of intellectual supercomputer systems of SCIT family, ensuring their efficient functioning and creating information technologies, modern mathematic, software/hardware support to solve complex and super complex scientific-practical tasks (“Intellect”) for the period 2013-2015”.

Many times growth of SCIT supercomputers productivity increase would ensure solving benchmark scientific-technical problems and public administration problems;

- Qualitatively new level of parallel development of applications for graphic accelerators and flow-data architecture processors would be supported;
- Tooling would be developed to be tested in the adaptation to hybrid clusters of the

available intellectual IT and in developing the new intellectual IT;

- New intellectual IT to analyze and substantiate management decisions for economy and social sphere needs with using knowledge bases and data bases would be developed and created.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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