JINR Grid-infrastructure - Present Status and Perspectives

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The JINR participation in the LHC experiments and in other large-scale projects asked for a substantial increase of its networking and information resources as well as the deployment of a large volume of work toward the development of the JINR Grid-segment and its integration in the Russian Grid-infrastructure RDIG (Russian Data Intensive Grid). The implementations has been done by staff of the Laboratory of Information Technologies (LIT), which is responsible to the computing infrastructure development in JINR and hosts the Central Information and Computing Complex (CICC) of the Institute.

Further perspective tasks follow from the decision of the JINR Committee of the Plenipotentiary Representatives, adopted at its March 14-15 2008 meeting [1], concerning the radical improvement of the JINR computer telecommunication links with major partner laboratories in the JINR Member States during the years 2010-2015 and the development of a unified Grid-environment of the JINR Member States. This is a cornerstone task of the JINR seven-year plan on 2010–2016 within the direction "Networks. Computing. Computational Physics".

In what follows we discuss the present status of the JINR Grid-environment, lessons learned during its implementation, and sketch the perspective directions of this activity. Three levels within the JINR Grid-environment can be distinguished: network, resource, and applied. These topics are discussed in the next sections. The formation of the Grid-environment of the JINR Member States is addressed in the last section.

Grid-network level

The network level involves high-speed telecommunication links and backbones.

Telecommunication channels

The development and upgrade of the JINR telecommunication links include a wide spectrum of activities focused on the growth of the cooperation with the Russian Satellite Communications Company (RSCC), the development of a high-speed network infrastructure in Russia, the improvement of the system of international computer channels for science and education in Russia, the data links with the JINR-participating countries.

JINR-Moscow channel. The development of the JINR telecommunication links on the Dubna-Moscow segment is achieved in cooperation with RSCC, owner of the optical fiber. Other participants to the project are NORTEL, JET Infosystems, RosNIIROS, the Computer Networks Interaction Center "MCK-IX".

At the 31-st meeting of the JINR Programme Advisory Committee for Particle Physics [2], the new telecommunication link between Dubna and Moscow, with a throughput of 20 Gbps, on the basis of the state-of-the-art technologies DWDM and 10Gb Ethernet, was officially inaugurated.

In perspective, the mentioned technologies allow the creation of up to 80 channels of 10 Gbps each, resulting in a total throughput of up to 800 Gbps.

International channels. The main JINR service-provider for access to the Internet is RBNet (Russian Backbone Network). The parent organization on the support of the RBNet network, the RosNIIROS, is operating the international channel for science and education and is the trustworthy organization for the Internet Exchange (IX) functioning in Moscow. Important roles in the development of the national scientific infrastructure are also held by the networks RUNNet, RASNet, RUHEP and by several departmental and regional networks. The process of transition of the trunk lines of these networks to the DWDM technology was started. This will allow a substantial increase of the throughput of the channels (from 10 Gbps up to several hundreds Gbps) and to reach a new level of the service.

JINR takes active part in the development of the segment of the international channels for science and education joining Russia with the Europe, with a throughput target of 10 Gbps in 2009, and subsequent growth in 2010-2016.

JINR LAN

By the end of 2008, the JINR LAN comprised more than 6000 computers and computing nodes. During the last years, the LAN backbone was substantially modernized with the purpose to create a fault-tolerant kernel of the LAN communication structure and to provide the possibility of significant increase of the information streams, to achieve a suitable level of the network security, to get good parameters of data transfer and a toolkit for the control, maintenance, access, and reliability of the network.

The plan for the JINR LAN development for the years 2010-2016 foresees several general purpose tasks as well as specific site-related ones. A selective enumeration points to the: upgrade of the JINR backbone to a data transfer rate of 10 Gbps and gradual connection to the it of various JINR laboratories; increase of the performance of the LAN central telecommunication node kernel; increase of the data transfer rate at the level of Institute subdivisions up to 1 Gbps and increase of the LAN protection at the hardware level; wireless access to the LAN within the JINR territory; implementation of new solutions and methods for the traffic control, information security, development of effective tools for control and the quality of service of JINR LAN; development of the system of protection of the JINR LAN resources from non-authorized access.

Grid-resource level

The resource level consists of highly-efficient computing clusters, supercomputers, and data storage systems joined in a unified Grid-environment with the help of basic software and middleware.

Computing cluster and data storage system

The kernel of the resource level of the JINR information infrastructure consists of the high-efficiency computing cluster and the data storage systems of the LIT JINR CICC.

The requirements of the LHC experiments stimulate the development of a global Grid-infrastructure, together with the resource centers of all the cooperating organizations. This is of primary concern for such large research centers as the JINR. To reach the established targets for the effective processing and analysis of the experimental data, steep increases in the performances of the CICC cluster and disk space are needed. For the time being, the total CICC installed computing power is 2300 kSI2K and the disk storage capacity is 500 TB.

Two essential constraints have to be satisfied by the CICC configuration. First, the floating point computation runs at the CICC cluster have to accommodate requests for traditional sequential applications, parallel computing applications, as well as Grid applications launched within various virtual organizations. Second, its upgrade by new acquisitions is always subject to tough financial constraints. As a consequence, new modules are acquired from vendors offering the best price of the day, resulting in heterogeneous computing cluster and disk storage area structures, with home made implementations of the various module interconnects and of the supervising software.

In order to check the actual performance of the resulting configuration and to rise it at the state-of-the-art level, we have decided to perform independent measurements of system performance by worldwide accepted benchmarks. The characterization of computer performance is usually associated to parallel computing. Since the three classifications of the most performing computing systems, TOP500 [3], CIS TOP50 [4], and China TOP100 [5] are based on outputs obtained from the High Performance LINPACK (HPL) Benchmark [6], we decided to use the HPL benchmark as well (version 1.0a of January 20, 2004). We used an Intel C Compiler v10.1 and the Intel Math Kernel Library 10.0.

Performance measurements made in 2007 and 2008 [7]-[10] and system exploitation evidenced the existence of bottlenecks which were identified and alleviated by parallelization of the information transfer between the different modules of the system. As a result of the implemented optimizations, the system works efficiently for all three above-mentioned categories of jobs. Within the Russian Data Intensive Grid (RDIG) consortium, which comprises, besides the CICC JINR, 14 Russian computing centres, our cluster covered a sizeable part of the RDIG share to the LHC projects since 2007. Performance measurements using the High Performance LINPACK Benchmark showed relative figures at the level of the best results reported in the June 2008 TOP500 edition of the most performing computers in the world [10]. The 2009 upgrades of both the computer cluster and the disk area were heavily based on the use of the lessons learned from the 2007–2008 system developments.

Center of primary Grid-services

In order to manage the joint Grid-infrastructure, the setting up of a center of primary Grid-services (CPGS) is planned which will provide the coordinated functioning of geographically distributed resource centers. The service-oriented approach can be considered as a step of the software evolution. The Open Grid Service Architecture (OGSA) has been developed as the standard of the Grid software architecture, which considers the service as a basic Grid object. The middleware is a crucial component of any development in the field of the Grid-technologies.

In the frame of the EGEE (Enabling Grid for E-sciencE) project, which is done with JINR participation, the new gLite middleware was developed which unites components of the middleware projects Condor and Globus Toolkit and components of the LCG project (LHC Computing Grid). The gLite middleware is relied on to be used at the initial stage as a platform for the CPGS construction; it supplies three types of resources - computer, data storage and information ones, as well as unified services on distributed computing and intensive operations upon data on the basis of uninterrupted basic Grid-services operation.

Specific work on setting up the CPGS foresee the preparation of the hardware and software basis of the CPGS; creation of tools for service development; realization of CPGS basic services; standardization of the service of information service; granting services on support of functioning the Grid-environment; opening a certification center; development of service for accounting the resource consumption; development of rules for the work with resources; creation of a Grid software depository; connection of resource units of the JINR-participating countries; user support; creation of a web-site with CPGS information materials.

Participation in the work on solving the interoperability problem of the different existing Grid-structures (affording joint use of Grid-systems developed on different middleware: gLite, ARC, UNICORE) is being projected. This will allow the development of Grid-systems with universal middleware.

Information and primary software

A necessary condition towards the creation of a unified information environment of JINR and its Member States is the provision of information and primary software support of the research-and-production activity of the Institute.

The specific activities planned on the mentioned problem include the following directions: centralized support of the operating systems and compilers used at JINR; elaboration of a unified technical policy in the field of licensing software products, the support and update of the bank of licensed and freely distributed products, elaboration of a programme for the alternative development based on the use of freely distributed software for OS Linux for office work; development and maintenance of information WWW/FTP-servers; development, creation and support of information systems with web-interface: thematic portals, paperless document circulation, workshop and conference sites, etc.; creation, development and maintenance of general-purpose and specialized program libraries, first of all for topics in nuclear physics, particle physics, solid state physics, condensed matter physics, as well as computer algebra and graphic packages; support and development of object-oriented specialized software for modeling experimental installations and processes, as well as for experimental data processing of problems arising in nuclear physics, particle physics, solid state physics and condensed matter physics; support of administrative databases together with the creation of a unified information space for the research-and-production activities of the Institute.

Grid-applied level

The applied level encompasses sets of research topics the solutions of which have been adapted to the Grid-environment in the frame of corresponding virtual organizations(VOs).

Formation of virtual organizations

In the existing Grid-systems, a VO defines a collaboration of specialists in a particular area, it being created to concentrate human forces and resources for achieving common aims. The virtual organization is a flexible structure that can be formed dynamically and may have a limited life-time. Within a VO, the research is conducted in scientific collaborations distributed both geographically and administratively.

For the time being, there is a great number of VOs included in various Grid-associations (EGEE, RDIG, OSG, TeraGrid, NAREGI, NorduGrid, etc.). As an instance, the Grid-infrastructure of the EGEE project is used by more than 290 VOs from such research fields as the high energy physics, astronomy and astrophysics, computing chemistry and the technology of the materials, geophysics, thermonuclear synthesis (ITER project), bioscience, biomedicine and medicine development, finance and business, multimedia applications, etc.

Instances of VOs working within the WLCG project are the VOs on the LHC experiments — ATLAS, CMS, Alice, LHCb, the first three being carried out with the noticeable and direct participation of the JINR.

Nowadays, as a Grid-segment of the EGEE/RDIG, the JINR CICC supports computations of the virtual organizations registered in RDIG. Alongside with the LHC experiments, the main users of the JINR Grid-segment are currently the virtual organizations BioMed, PHOTON, eEarth, Fusion, HONE, Panda.

In the future, as the interest arises at a large-scale level, VOs can be organized at JINR in the fields of nuclear physics and condensed matter physics and, most probably, in the new promising direction related to the research of the nanostructures. The creation of new VOs gets possible and necessary under maturation of the algorithmic approaches to the problem solution, the development of corresponding mathematical methods and tools.

Mathematical and algorithmic support of the studies conducted by JINR

The main part of this activity is related to the development of the mathematical description and algorithmic reformulation of the physical models such as to get significant numerical solutions; development of methods and algorithms able to extract physically insightful information from experimental data; simulation of physical processes within experimental installations; algorithm implementations into effective and reliable hardware adapted program environment.

This subject area covers a wide spectrum of studies in the high energy physics, nuclear physics, solids physics and condensed matter physics, biophysics, information technologies, conducted in close cooperation with all JINR Laboratories.

During 2010–2016 work is foreseen to be done along the following key directions: development of mathematical methods for modeling physical processes and analysis of experimental data, development of software and computer complexes for experimental data processing; the elaboration of methods, numerical algorithms and software for modeling complex physical systems; research in elementary particle physics and nuclear physics, including participation in the development of physics programs at LHC, FAIR, etc.; development of methods, algorithms and software of computer algebra; research in the fields of computational biophysics, bioinformatics, biosensor (nano)technologies; numerical simulation of nanostructures for the creation of materials with predefined properties; research in the quantum information technologies; development of self scaling algorithms for computational physics problems with the purpose of increasing the efficiency of parallel and distributed computing, primarily taking into account the multicore structure of the last generation processors; elaboration of new computing paradigms; adaptation of specialized software for solving problems within the Grid-environment.

Grid-environment of JINR Member States

The JINR-participating countries develop regional and national research and educational networks, many of which are being connected to the European network GEANT. As a result of this joint activity, the integration of the Grid-infrastructures of JINR and its European Member States will be realized through the high-speed GEANT network. This is the overall adopted approach to the integration of the regional networks for science and education in Europe.

This activity will be based on the creation of a working group of the representatives of the JINR-participating countries for the development of the main directions of the activity toward forming a joint Grid environment, the formation of the applied level of the Grid environment of the JINR Member States, devoted to the preparation and implementation of common projects within multi-side agreements.

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