

## JINR Participation in the WLCG Project

S.D. Belov<sup>1</sup>, P.V. Dmitrienko<sup>1</sup>, V.V. Galaktionov<sup>1</sup>, N.I. Gromova<sup>1</sup>, I.S. Kadochnikov<sup>1</sup>,  
V.V. Korenkov<sup>1</sup>, N.A. Kutovskiy<sup>1,4</sup>, S.V. Mitsyn<sup>1</sup>, V.V. Mitsyn<sup>1</sup>, D.A. Oleynik<sup>1</sup>,  
A.S. Petrosyan<sup>1</sup>, G.S. Shabratoval<sup>2</sup>, T.A. Strizh<sup>1</sup>, E.A. Tikhonenko<sup>1</sup>, V.V. Trofimov<sup>1</sup>,  
A.V. Uzhinskiy<sup>1</sup>, L. Valova<sup>1</sup>, A.S. Zhemchugov<sup>3</sup>, V.E. Zhiltsov<sup>1</sup>

e-mail: korenkov@jinr.ru, <sup>1</sup>Laboratory of Information Technologies, Joint Institute for Nuclear Research, Dubna

<sup>2</sup>Veksler and Baldin Laboratory of High Energy Physics, Joint Institute for Nuclear Research, Dubna

<sup>3</sup>Dzheleпов Laboratory of Nuclear Problems, Joint Institute for Nuclear Research, Dubna

<sup>4</sup>National Scientific and Educational Centre of Particle and High Energy Physics of the Belarusian State University, Minsk, Belarus

JINR participates in the international grid activities from 2001, after starting the EU Data Grid project on development of grid middleware and testing the initial operational grid infrastructure in Europe [1-2]. The Joint Institute for Nuclear Research takes an active part in a large-scale worldwide grid project WLCG (Worldwide LHC Computing Grid) in a close cooperation with the CERN Information Technology department since the 2003 year. JINR made a significant contribution to the WLCG, EGEE (Enabling Grids for E-science) and EGI (European Grid Infrastructure) projects. JINR is an active member of the Russian consortium RDIG (Russian Data Intensive Grid) which was set up in September 2003 as a national federation in the EGEE project. As a result, JINR employees have been actively involved in the study, use and development of advanced grid technologies. The most important result of this work was the construction of a grid infrastructure at JINR that provides a complete range of grid services. The created JINR grid site (T2\_RU\_JINR) is fully integrated into the global (world-wide) infrastructure (the name of the JINR grid site in the WLCG /EGI infrastructure is JINR-LCG2). The resources of the JINR grid site are successfully used in the global infrastructure, and on indicators of the reliability, the T2\_RU\_JINR site is one of the best in the WLCG infrastructure.

A great contribution is made by the JINR staff members to testing and development of the grid middleware, the development of grid-monitoring systems, and organizing support for different virtual organizations. Constantly working to train the grid technologies, JINR created a separate educational grid infrastructure. In the field of grid JINR actively collaborates with many foreign and Russian research centers. Special attention is paid to cooperation with the JINR Member States.

By September, 2013 the JINR computing farm consists of 2420 slots, a total capacity of the Storage Element structured as dCache and XRootD (eX-

tended Root Daemon) storage system was extended to 1400 TB. The Central Information and Computing Centre (CICC) software includes a number of program packages which form the grid environment. A current version of the WLCG software is mostly EMI(European Middleware Initiative) ver.2/3. A monitoring and accounting system has been developed at JINR and is in use by the entire Russian WLCG segment. The JINR external optical communication channel provides up to 2x10 Gbps data link.

The CICC provides the following services in the WLCG environment: Storage Element (SE) services; Computing Element (CE) services as grid batch queue enabling access for 13 Virtual Organizations (VO) including ALICE, ATLAS, CMS, LHCb, HONE, FUSION, BIOMED, BES; Information Service (BDII- Berkley DB Information Index); Proxy service (PX); the advanced service for access to the LCG/EGEE resources (MyProxy); Workload Management System + Logging&Bookkeeping Service (WMS+LB); LCG File Catalog (LFC) service and VOboxes special services for ALICE, CMS, CBM and PANDA. It should be mentioned here that we have the batch queues enabled for PANDA and CBM. Also there are three NFS-servers dedicated to VOs. A global file system CVMFS for the access to Virtual Organization's software has been installed, software required for LHC experiments is currently installed (XRootD, AliROOT, ROOT, GEANT packages for ALICE; CMSSW packages for CMS; LHCb and ATLAS are supported from CVMFS global installation). JINR currently supports and develops the JINR WLCG-segment in the frames of the WLCG infrastructure in accordance with the requirements of the experiments for the LHC running phase.

Current computing activities for ALICE, CMS and ATLAS are carried out in coordination with LHC experiments:

- **ATLAS:** The main activity of JINR in the ATLAS computing is connected with the

data processing in scope of ATLAS RuTier-2. ATLAS jobs use about 35% of total CPU resources of CICC, which corresponds to about 1/3 of total CPU resources of RDIG used by the ATLAS experiment;

- **CMS:** participation in CMS Phedex test data transfers; support of Phedex server installed at the CMS VObox at JINR; CMS data replication to the JINR SE; participation in CMS Dashboard data repository maintenance and CMS Dashboard development [3], in particular, in improvement of CMS job monitoring and CMS job failures reporting; CMS jobs use 30% of total CPU resources of CICC, which corresponds to about one half of total CPU resources of RDIG used by the CMS experiment;
- **ALICE:** regular update and testing of ALICE software (AliEn), update and support of VO box operation; installation and support packages required for ALICE production and distributed activities – in 2012-2013: update of XRootD, CREAM-CE installation of p2p torrent application software transport directly to Working Nodes; management of whole RDIG ALICE activity not only at the JINR-WLCG site but also at 7 other ALICE sites in Russia; installation, upgrade and support of PROOF cluster of Alice Analysis Facility - JRAF with 48 workers and 24 TB disk space; development and support for common AAF (ALICE Analysis Facilities) setup including PROOF settings with stager daemon and cache storage managed by XRootD and monitored by ALICE monitoring tool MONALISA; support for JINR ALICE users; installing and updating ALICE software on alicepc farm in VBLHEP at JINR; ALICE jobs use about 23% of total CPU resources of JINR LIT, which corresponds to about 1/3 of total CPU resources of RDIG used by the ALICE experiment;
- tests of readiness of the JINR site to store and process data for all the experiments JINR participates in (ALICE, ATLAS, CMS).

Several activities in the field of development of the ATLAS distributing computing have been continued. Work for development, maintains and improvements of ATLAS DQ2 Deletion Service was provided by specialists of from JINR LIT. DQ2 Deletion Service serves deletion requests for 130 sites with more than 700 endpoints (space tokens), it's one of critical data management service in ATLAS. A set of improvements aimed to increasing

of productivity of service was done. The deletion rate is more than 10Hz for some sites, and overall deletion performance is more than 6 million files per day.

Also JINR staff members take an active part in development of AGIS (ATLAS Grid Information System) [6].

JINR has a large and long-term experience in Grid monitoring activities. Currently the main areas of activity are:

- RDIG monitoring and accounting system for the WLCG infrastructure of Russian Tier-2 sites (<http://rocmon.jinr.ru:8080>) and a continuous support is providing for grid site administrators;
- participation in development of global WLCG data transfer monitoring system (<https://twiki.cern.ch/twiki/bin/view/LCG/WLCGTransferMonitoring>) [7];
- Tier-3 monitoring project [8-9] - the overall coordination and development at CERN (<https://svnweb.cern.ch/trac/t3mon>): software environment and development infrastructure (code repository, build system, software repository, external packages built for dependencies) and, in particular, at JINR: VM-based infrastructure for simulating different Tier-3 cluster and storage solutions was deployed [10]. For the moment it consists of the following parts: Ganglia server, Torque, Condor, PROOF, OGE-based clusters, two XRootD and one Lustre-based storage systems.

Within the Dashboard project, there was a participation in development of XRootD large-scale federated data storages, which is important for the main LHC experiments.

For ALICE experiment it was created a service to acquire grid sites' traffic information and put it to the Dashboard. A distribution package and management tools for UCSD collector were developed to provide a reliable monitoring of data transfers in ATLAS and CMS XRootD federations.

JINR participates in the FAX project (Federating ATLAS storage systems through XRootD). This is an effort to provide WLCG data for analysis within a single namespace to any location, including Tier-3 sites, with the benefits of the XRootD protocol's awareness of the Root file structure. In total over the year 190 TB of data was transferred from JINR through the FAX access host.

In the domain of Grid monitoring where JINR has a large and long-term experience, there were several areas of development:

- continued work in developing the global WLCG data transfer monitoring system (<https://twiki.cern.ch/twiki/bin/view/LCG/WLCGTransferMonitoring>);
- deployment and research of new storage technologies for use as a back-end and/or archive for monitoring data to simplify and integrate different Grid monitoring systems (<https://twiki.cern.ch/twiki/bin/view/LCG/WLCGMonitoringConsolidation>).

The JINR local monitoring system (<http://litmon.jinr.ru>) developed at JINR is an important basis to the global monitoring systems providing actual information on the status of the JINR infrastructure to the higher levels of monitoring [11].

The dCache monitoring system for the JINR WLCG-segment has been developed using Nagios, MRTG and custom plug-ins. The system provides information on input/output traffic and requested and utilized space for both ATLAS and CMS experiments (<http://litmon.jinr.ru/dcache.html>).

We continue to take part in the WLCG middleware testing/evaluation. During last two years the directions and results were the following:

- development and modernization of FTS (File Transfer Service) certification tests: fts3-crash test testing package for FTS3 has been developed for testing different configurations of data transfer systems;
- deployment of few gLite 3.2, EMI (European Middleware Initiative) and UMD (Unified Middleware Distribution) components was tested;
- in a framework of developing of tests for LFC (LCG File Catalog) perl API functions a separate LFC server (gLite 3.2) was installed on gLite testbed at JINR and the corresponding GGUS (Global Grid User Support) tickets were submitted.

Participation in the LCG Monte Carlo database (<http://mcdb.cern.ch>) results in:

- added support for XRootD and EOS interfaces to CERN storage;
- service reliability improved: database now hosted in CERN central database service, updated authorization system, MCDB service is monitored with SLS (Service Level Status) tools;
- optimized search engine of MCDB knowledge base;

- support for CMS users.

We support users (conducting courses, lectures, trainings) to stimulate their active usage of the WLCG resources [12-14]. Also a special grid-training infrastructure for JINR and the JINR Member States (Russia, Uzbekistan, Armenia, Bulgaria, Ukraine) has been created. During the 2011-2012 years a number of schools and training events has been held:

- JINR-CERN Schools on JINR/CERN Grid and Advanced Information systems were held on May 14-18, 2012 (<http://ais-grid-2012.jinr.ru/>) and on April 22-26, 2013 (<http://ais-grid-2013.jinr.ru/>);
- basic training courses on gLite 3.2 services deployment for system administrators from Mongolia, Kazakhstan and Azerbaijan were held;
- 23.07 - 03.08.2012: a training on basic set of EMI2 grid services deployment for system administrators from Egypt, Mongolia and Azerbaijan;
- 24.09 - 28.09.2012: training courses for users and system administrators from Bogolyubov Institute for Theoretical Physics - BITP (Kiev, Ukraine), National Technical University of Ukraine "Kyiv Polytechnic Institute" - KPI (Kiev, Ukraine) and Institute for Scintillation Materials - ISMA (Kharkov, Ukraine) had been held. These courses were focused on several topics: 1) introduction lectures on LHC experiments, NICA, AliEn; 2) practical training on AliRoot; 3) EMI2, XRootD and AliEn services deployment;
- 26.09-12.10.2012: practice on grid basics for student from Republic of South Africa.

At the end of 2012 the grid site of the Institute of Physics of Azerbaijan National Academy of Sciences (Baku, Azerbaijan) had been set up and integrated into educational grid infrastructure. Apart from that in order to utilize underloaded computational capacities of personal computers at JINR and its member states organizations a DesktopGrid (DG) testbed was deployed with core services at LIT JINR. That work was performed with a kind help of MTA SZTAKI team working in the IDGF-SP. The plans are to use those kinds of resources for performing calculations in interests of different JINR and member states research groups. DesktopGrid testbed is based on SZTAKI DG package which is in turn based on BOINC. Right now DG testbed consists of the BOINC-server with 3G Bridge and a few BOINC-clients. The JINR grid site of the

t-infrastructure has a separate EMI CREAM CE with EDGI Executor enabled what allows to submit jobs from EMI UI to DG resources. It is planned to build DG production infrastructure consisting of JINR and its member states organizations' resources and port some apps able to run in such environment. More details about grid training infrastructure can be found on the portal with the URL: <http://gridedu.jinr.ru>.

The traditional international conferences "Distributed computing and Grid technologies in science and education" are organized and hosted by JINR. These conferences gather scientists from Russia and CIS countries and it is the only conference in the Russian Federation devoted especially to modern grid technologies. The fifth conference was successfully held at JINR in July, 2012.

Information on JINR activities in the WLCG is currently presented at the JINR Grid Portal (<http://grid-eng.jinr.ru>).

We provide a continuous support for the JINR Member States and associated JINR Member States in the WLCG activities working in a close cooperation with partners in Ukraine, Belarus, Azerbaijan, Germany, Czech, Slovakia, Poland, Romania, Moldova, Mongolia, South Africa, Kazakhstan and Bulgaria. Protocols and agreements for cooperation in the field of grid technologies are signed between JINR and Armenia, Belarus, Bulgaria, Moldova, Poland, Czech and Slovak. A review article was published as result of many years of cooperation in grid activities with Czech colleagues [15].

Currently, the JINR realizes a large-scale project to create a Tier-1 computer center for the CMS experiment in the accordance with a decision (adopted by the WLCG project in 2011) to construct a Tier-1 level distributed center for the LHC experiment in Russia on the base of RCC "Kurchatov institute" and JINR. A full-functionality prototype of Tier-1 center for CMS at JINR should be put into operation by the end of 2012 and is now at a testing phase. A full-scale CMS Tier-1 at JINR will be operational in the second half of 2014 [16].

During 2012-2013 years the results of JINR grid activities were presented at ALICE T1/T2 workshop, (Karlsruhe, 24-26 January 2012), CHEP'2012 conference (New York, US, May 21-25, 2012), the conference "Distributed computing and Grid technologies in science and education" (Dubna, July, 2012, <http://grid2012.jinr.ru>), 39th meeting of the PAC for Particle Physics at JINR (<http://indico.jinr.ru/materialDisplay.py?materialId=22&confId=594>) and at NEC'2013 symposium in Varna, Bulgaria (September, 2013) (<http://nec2013.jinr.ru>).

The resources of the JINR grid site are ac-

tively used by different virtual organizations and the JINR's contribution into the resources provided by Russian grid sites in the 2012-2013 years is the most significant one: 35%.

The experience accumulated during the participation in the WLCG project helps JINR staff members to accomplish a wide range of works with the usage of grid technologies in different areas, in particular: simulation of off-line data processing for a large JINR project NICA [17], development of grid-services and problem-oriented web-interfaces for Russian grid network [18], development of a special grid commander [19] as a graphical user interface to simplify user's work in grid environment, development of conception of cloud computing resources usage for cosmic data processing [20] and adapting the applied software packages for running in Grid-environments [21].

## References

- [1] S.D. Belov et al., Grid in JINR and participation in the WLCG project, in Proc. of GRID'2012 conference, Dubna, 2012, p.23.
- [2] A.Klimentov, V.Korenkov, The distributed computing systems and their role in discovering a new particle, Supercomputers, No.3 (11), 2012 p. 54 (in Russian).
- [3] I. Golutvin et al., CMS experiment data processing at RDMS CMS Tier-2 centers, in Proc. of GRID'2012 conference, Dubna, 2012, p.133.
- [4] D.Oleynik, A.Petrosyan, V.Garonne, S.Campana on behalf of the ATLAS Collaboration, DDM DQ2 Deletion service. Implementation of central deletion service for ATLAS experiment, in Proc. of GRID'2012 conference, Dubna, 2012, p.189.
- [5] V.Garonne at al., The ATLAS Distributed Data Management project: Past and future, J.Phys.Conf.Ser. 396 (2012) 032045.
- [6] A.Anisenkov et al., AGIS: The ATLAS Grid Information System, J.Phys.Conf.Ser. 396 (2012) 032006.
- [7] J.Andreeva et al., Providing global WLCG transfer monitoring, J.Phys.Conf.Ser. 396 (2012) 032005.
- [8] A.Petrosyan, D. Oleynik, S. Belov, J.Andreeva, I. Kadochnikov, ATLAS off-Grid sites (Tier-3) monitoring. From local fabric monitoring to global overview of the VO computing activities, J.Phys.Conf.Ser. 396 (2012) 032082.
- [9] A.Petrosyan, D.Oleynik, S.Belov, J.Andreeva, I.Kadochnikov on behalf of the ATLAS Collaboration, ATLAS off-Grid sites (Tier-3) monitoring, in Proc. of GRID'2012 conference, Dubna, 2012, p.195.
- [10] S. Belov et al., VM-based infrastructure for simulating different cluster and storage solutions used on ATLAS Tier-3 sites // Journal of Physics: Conference Series. 2012. Vol. 396. Part 4. 5 pp. doi:10.1088/1742-6596/396/4/042036.

- [11] P.V.Dmitrienko, V.V.Korenkov, V.V.Mitsyn, Architecture of the monitoring system of the JINR central information complex, Information technologies and computing systems, No.3, 2012 p. 31 (in Russian).
- [12] Kutovskiy N.A., Distributed training and testing grid infrastructure evolution, in Proc.of GRID'2012 conference, Dubna, 2012, p.180.
- [13] N. Kutovskiy, Cloud autonomous grid infrastructures for training, research, development and testing tasks, Informatization of education and science, 2013, vol. 4, p.19 (in Russian).
- [14] N.A. Kutovskiy, Training, research and testing grid infrastructure evolution, in Proc. of XVII conference of young scientists and specialists (OMUS'2013), Dubna, 2013, p. 196.
- [15] J. Chudoba, M. Elias, L. Fiala, J. Horky, T. Kouba, J. Kundrat, M. Lokajicek, J. Schovancova, J. Svec (Prague, Inst. Phys.), S. Belov (Dubna, JINR) et al., JINR (Dubna) and Prague Tier-2 sites: Common experience in the WLCG grid infrastructure, Phys.Part.Nucl.Lett. 10 (2013), p. 288.
- [16] N.S.Astakhov et al., Creation at JINR of the data processing automated system of the Tier-1 level of the experiment CMS LHC, in Proc. of GRID'2012 conference, Dubna, 2012, p. 254 (in Russian).
- [17] Korenkov V.V., Nechaevsky A.V., Trofimov V.V., Simulation of a grid system for off-line data processing in NICA experiment, in Proc. of GRID'2012 conference, Dubna, 2012, c.343 (in Russian).
- [18] Kutovskiy N.A, Lensky I.I, Semenov R.N., Problem-oriented web-interfaces for Russian grid network , in Proc.of GRID'2012 conference, Dubna, 2012, p.186.
- [19] Galaktionov V., GridCom, Grid Commander: graphical user interface for grid jobs and data access, in Proc. of GRID'2012 conference, Dubna, 2012, p.270.
- [20] Korenkov V.V., Kotov V.M., Rusakovich N.A., Yakovlev A.V., Integration of remote monitoring software of LHC experiments and NEST toolkit as a basis for a Tier-3 level cloud platform in the experiments' grid-infrastructure for development of applications for radiolocation cosmic monitoring, in Proc. of GRID'2012 conference, Dubna, 2012, p. 349 (in Russian).
- [21] V.V.Korenkov, N.A.Kutovsky, R.N.Semeonov , Experience of adapting the applied software packages for work in Grid-environments, Computer Research and Modeling, v. 4, No. 2, 2012 pp. 339 (in Russian).