Grid Infrastructure Development as Support for e-Science Services

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Abstract: - During last years the e-Infrastructure concept has been extensively elaborated and promoted as an essential pillar for the implementation of ERA (European Research Area). The main components of this infrastructure are the network for education and research and the Grid infrastructures. At the European level important efforts and resourced have been devoted to the development of both components, with joint financial support provided by Framework Programmes 6 and 7 of EU and national research programmes. At the national level, the high-speed communication network for education and research, and national grid infrastructure for research are included in the list of priority investment projects in the Information and Communications Technologies domain. The main financial support for the development of these projects is provided by the Sectorial Operational Programme "*Increase of Economic Competitiveness*". ICI Bucharest is among beneficiary organizations of this support.

This paper presents the European context for e-Infrastructure development as support for e-Science concept implementation, the evolution and current status of Grid infrastructures at the European and national levels, a short review of the development of Grid computing at ICI Bucharest, the main objectives and activities of the structural funds grant awarded to the institute for a significant upgrade of the current grid site RO-01-ICI.

Key-Words: - e-Infrastructure, e-Science, Grid infrastructure, EGEE, SEE-GRID, EGI, RoGrid, GridMOSI, Virtual organization, RO-01-ICI grid site.

1 Introduction

ERA - European Research Area is one of the core elements of the Lisbon Strategy for Growth and Employment, which aims to build the world's most competitive and dynamic knowledge-based economy.

The list of main features of the ERA includes world-class research infrastructures, integrated, networked and accessible to research teams from across Europe and the world, notably thanks to new generations of electronic communication infrastructures [1]. They are meant to support the formation of research and innovation clusters including "virtual research communities", mostly specialized in interdisciplinary areas and attracting a critical mass of human and financial resources, as well as effective knowledge-sharing notably between public research and industry, as well as with the public at large.

A priority class of research infrastructure is electronic infrastructures (e-Infrastructures) including high-speed networks such as GEANT, grid technologies, supercomputing and data repositories.

To emphasize the crucial impact of these infrastructures on the quality, efficiency and competitiveness of scientific research activity in ERA the concept of e-Science was introduced. The main paradigm shift proposed by this concept is the transition towards virtual research environments. meaning the wide adoption research of environments powered by advanced ICT to effectively accommodate unprecedented the requirements of today's scientific communities for connectivity, computing and information access [2]. The rapid transition to e-Science, should be a joint effort of the European Commission and all Member States making significant investments in e-Infrastructures.

In our country a confirmation of the attention paid to the development of e-Infrastructures is provided by the 2007 Report of the Romanian Committee for Research Infrastructures (RCRI), where projects regarding high-speed communication network for education and research, and national Grid infrastructure for research are included in the list of proposals for priority investment projects in the Information and Communications Technologies domain [3]. The Sectorial Operational Program "Increase of Economic Competitiveness" (SOP-IEC) provides the financial support to develop these projects through the call for projects organized in 2008. ICI Bucharest is among the beneficiaries of this support, which includes other four national research and development institutes and five universities. The SOP-IEC grant entitled "Development of the RO-01-ICI site as a node in the national grid infrastructure for research – RO-01-ICI v.2" aims at implementing a significant upgrade of the current version of the site in order to bring its computing and storage resources at the European standards.

The paper presents the objective and the current status of the project in the context of grid infrastructure development at the European, regional and national levels. Section 2 starts with a review of the current European context for e-Infrastructure development, with emphasis on the programmatic documents defining a sustainable development of the field and bodies at European level in charge with formulation of related policies and recommendations. The second subsection shortly presents the contribution of two main European projects to the development of grid infrastructure at the European and regional levels, respectively. The final subsection introduces the European Grid Infrastructure (EGI), which provides the framework for the next phase of grid infrastructure development and operation. The current status of the national grid infrastructure and the main lines of its development are outlined in Section 3. Section 4 presents the main contributions of the Grid computing research team in ICI Bucharest to the development of the grid infrastructure and virtual organization modeling, for simulation and optimization. In Section 5 the RO-01-ICI v.2 project is detailed: motivation of the project, its objectives and deployed activities, main beneficiaries. Some concluding remarks are presented in the final section.

2 European Grid Infrastructure

2.1 e-Infrastructure

The term "e-Infrastructure" refers to a new research environment in which all researchers have shared access to unique or distributed scientific facilities, regardless of their nature or location. It was launched in 2003 to mark the vision about the next generation of trans-national research ICT infrastructure at European level. In [2] e-Infrastructure is defined as e-Infrastructure is defined as "an environment where research resources (hardware, software and content) can be readily shared and accessed wherever this is necessary to promote better and more effective research". Such an environment integrates networks, grids and middleware, computational resources, experimental workbenches, data repositories, tools and instruments, and the operational support for global virtual research collaboration.

Specifically for the Grid component of e-Infrastructure, the document emphasizes the role of Member States in consolidating and further development of National Grid Initiatives, as well as the importance of EC support for the transition to new governance models for European e-Science grids, their efficient deployment and interoperability to serve a wide range of research fields.

With regard to development policies of e-Infrastructure, the key role is played by the e-Infrastructure Reflection Group (e-IRG). As a forum of delegates appointed by the ministries of research in member countries its mission is to facilitate progress towards a European e-Infrastructure utility and has as main objective the formulation of policies and recommendations concerning developments in this field (www.e-irg.eu).

The e-IRG White Paper 2008 [4] highlights the following topics of interest to develop this area: grid and cloud computing, security as a holistic approach, education and training in the use of e-Infrastructure, global collaboration, sustainability of the computing-related e-Infrastructure, remote instrumentation, virtualization.

For the first section the following recommendations are formulated: to investigate the integration of cloud-like technologies, especially virtualization, into existing e-Infrastructures, to promote the development of open-source components to build clouds, as well as standardsbased grid interfaces to cloud services, to explore the application of grid technology for the federation of clouds.

e-IRG collaborate with the European Strategy Forum on Research Infrastructures (ESFRI) to identify the support that e-Infrastructure could provide to other kind of research infrastructures in terms of access to state of the art computing and data resources and in order to extend the benefits of their operation across Europe.

2.2 Grid Infrastructure in Europe

DataGrid (2001-2003) was the first representative project dedicated to the European Grid infrastructure, undertaken by a consortium of 6 partners, in coordination of CERN Geneva (http://eu-datagrid.web.cern.ch/eu-datagrid/). Since 2004, the development of Europe-wide Grid infrastructure has been supported by the European project "EGEE - Enabling Grids for E-sciencE" (www.eu-egee.org), partially funded by EU FP6 and FP7 programs for research. The main activities undertaken in the EGEE project covered: grid middleware development, management and operation of European grid infrastructure, technical assistance for migration of applications on grid, support to virtual organizations dedicated to different users communities, training, dissemination and international cooperation. Virtual organizations are defined as thematic groups of users crossing administrative and geographical boundaries.

During its terminal phase EGEE III concluded in May 2010, the project consortium included about 140 organizations from 33 countries. Romania was represented in the project by a Joint Research Unit of 7 member organizations, coordinated by ICI Bucharest. The current level of the EGEE infrastructure development is illustrated by the following parameters [5]: 140,000 CPU cores, 260 grid sites, 25 PB disk memory, 39 PB tape memory, 12 million jobs per month (an increase of 45 % as compared with last year), about 13,000 users. High energy physics is the most important contributor and user of this infrastructure, but other areas have a highly dynamic growth: astronomy and astrophysics (53 applications, 20 VOs and 373 users) Life Sciences (46 applications, 9 VOs and 379 users), computational chemistry (12 applications, 4 VOs and 347 users), Earth sciences (15 applications, 7 VOs, 142 users).

EGEE has developed collaboration links with 27 grid projects in Europe and other areas, including the South-eastern Europe regional grid initiative SEE-GRID, which aimed at developing a grid regional infrastructure based on technology transfer and operation solutions from EGEE. The most recent component of this initiative was the FP7 "SEE-GRID SEE-GRID-SCI project eInfrastructure for regional e-Science" (www.seegrid-sci.eu). Its consortium included $\Delta \Delta$ organizations from 14 countries in the region, where Romania was represented by a consortium of 4 organizations led by ICI Bucharest [6]. The SEEinfrastructure currently includes GRID 40 production sites, 1086 CPU cores exclusively dedicated to this infrastructure and 288 TB storage capacity. In addition to providing services under a production Grid infrastructure, the project also included two priority activities: (a) creation of international communities of users of these services in the fields of seismology, meteorology, environmental protection and provision of applications for these areas, (b) support to National Grid Initiatives (NGI's) in countries represented in the project consortium, to join the new model of organization and operation of the Grid infrastructure in Europe.

2.2 European Grid Initiative

Starting from May 2010 all activities related with European grid infrastructure are coordinated according to the new cooperation model provided by the European Grid Initiative - EGI (www.egi.eu). According to [7], the main aim of EGI is to provide a common access infrastructure to national or international projects or disciplines, enabling the sharing of computing and data resources with minimal overhead. Without EGI each project or each discipline would have to develop its own solution for computational and data interoperability. The EGI cooperation model involves National Grid Initiatives and a central, coordinating part, called EGI Organization (EGI.org). The Romanian grid community is represented in the EGI model by the RoGrid-NGI initiative, coordinated by ICI Bucharest.

Effective implementation of this model is supported by the FP7 EGI-InSPIRE (Integrated Pan-European Infrastructure Sustainable for Researchers in Europe) project (http://www.egi.eu/projects/egi-inspire/). Continue towards a sustainable production infrastructure and provide support to current structured international research communities are the main objectives of this project. The EGI-InSPIRE project will support the transition from a project-based system to a sustainable pan-European e-Infrastructure, by supporting 'grids' of high-performance computing (HPC) and high-throughput computing (HTC) resources. It will provide also the integration framework for new Distributed Computing (DCIs) such as clouds. Infrastructures supercomputing networks and desktop grids, to benefit the user communities within the European Research Area. To achieve these objectives the following project activities have been initiated:

- provisioning the reliable operation of the production infrastructure (monitoring, accounting, operational security, helpdesk & support teams, validation of new technology & operational tools);
- provisioning the specific software infrastructure;
- external relations (dissemination, community building events);

- support for heavy user communities (e.g. High-Energy Physics, Life Sciences, Earth Sciences, Astronomy and Astrophysics);
- support for operational tools;
- user community coordination (supporting technical services for: applications and tools DB, virtual research communities, training).

3 National Grid Infrastructure

In a first period, the development of the network of Grid resource centers in our country was based on the participation of academic and research organizations to the national or international projects, with the main contribution of the RoGrid consortium member organizations: ICI Bucharest coordinator, University "Politehnica" of Bucharest (UPB), National Research - Development Institute for Physics and Nuclear Engineering "Horia Hulubei" (IFIN-HH) Bucharest, National Institute for Aerospace Research (INCAS) Bucharest, University of Bucharest (UB), Technical University of Cluj-Napoca (UTCN), West University of Timisoara (UVT).

An important role in consolidation of these centers and their adaptation to operational requirements specific to production regime played their integration in European grid infrastructures, neutral in terms of supported research domains (e.g. EGEE, SEE-GRID) or dedicated to CERN experiments in high energy physics.

The first attempt to formulate a coherent set of principles and objectives regarding the development of this domain was the proposal for the "National Strategy for Grid development in Romania" (December 2002), a project developed by the RoGrid consortium members (ICI, UPB, IFIN-HH, INCAS, UB) [8]. The overall objective of this strategy was the organization, development and operation of a Grid infrastructure in Romania, to accessibility. reliability. scalability. increase security and efficiency of complex scientific applications. In line with this objective the following set of principles was formulated: achieve an open infrastructure, ensure a balance between investment in specific hardware and software development infrastructure and application software, valorize the national production of scientific software, actively promote research results, and ensure the utilization of RoGrid infrastructure in economic and social life areas.

In March 2006 the "Strategic plan for pilot implementation of the national Grid infrastructure" was published, based on the "e-Infrastructure" concept and recommendations from the previous strategy [9]. The document was prepared by a national task force coordinating by the National Authority for Scientific Research (NASR), with the main contribution of the RoGrid consortium and RoEdu.

In accordance with this Strategic Plan, the Report for 2007 of the Romanian Committee for Research Infrastructures [3] included in the list of proposals for priority investment projects in the Information Technology and Communications field, the following projects: *"High-speed communications network for education and* research" and *"National Grid Infrastructure for Research (RoREGI)"*. The national grid infrastructure will include medium and large grid resource centers, interconnected through the high-speed network for education and research.

Currently, 16 grid sites have been registered at the national level, their number reflecting the growing interest in major academic and research centres to promote grid technologies, not only in traditional areas (like nuclear physics), but also in mathematical modeling, biomedicine, chemistry, environment protection, seismology. 12 sites are operating in production regime, according to the availability and reliability requirements specific to EGEE and SEE-GRID infrastructures, while the remaining 4 sites are in different stages of their certification as active sites.

4 ICI Contribution

4.1 RO-01-ICI Site Evolution

The first version of the RO-01-ICI site was installed in late 2003 to support the activity of the grid research team in ICI, in accordance with the R&D strategy adopted by the institute, with the objectives of the National Research Programme and of the European FP6 and FP7 Programmes. Initial configuration (4 processors) was funded by investment effort of the institute, while further upgrades, operational and maintenance expenses were supported by national research projects coordinated by the grid research team, i.e.: "IComGrid - Pilot Communications Infrastructure for Grid" (RELANSIN contract no. 2003/2004, 2004-2006), "GridMOSI – Grid enabled Virtual Organization for High Performance Modeling, Simulation and Optimization" (CEEX contract no. 95/2005, 2005-2008), "PEGAF - Experimental Grid Platform for the Development of Workflow Oriented Applications with Dynamic Allocation of Resources" (PN II contract no. 11064/2007, currently in progress).

Since 2004, the research team has been participated in EU projects EGEE and SEE-GRID, which allowed the accumulation of significant experience in the administration of Grid resources and Grid infrastructure. In May 2004, the site was certified in regional infrastructure, and in November 2004 was the first Romanian site registered in the EGEE infrastructure as a production site, i.e. working in 24 /7 regime, ensuring rapid response to operational incidents and continued compatibility with the software platform used in the European and regional infrastructures (operating system and middleware).

Based on this experience, during the GridMOSI project, a functional Grid infrastructure including 5 sites was installed, with high level of autonomy in relation with the external infrastructure, which demonstrated the feasibility of the future national grid infrastructure implementation.

The current hardware configuration includes 9 main servers: a Supermicro server with two Intel Quad-Core Xeon 2.67 GHz, 16 GB RAM; 4 Dual Xeon servers, 2.4 GHz, 2 GB RAM; 4 Servers Pentium 4 servers, 3 GHz, 1 GB RAM. The other servers of the site are Pentium 4 computers with 3 GHz and 2 GB RAM. The computing cluster can reach a maximum of 9 Gflops, according to HPL benchmark applied for the top 500 supercomputers. Storage capacity is provided by a disk array Vtrak Promise with SCSI interface.

The operating system is Scientific Linux 4.x and 5.x. The middleware is gLite version 3.2, with the following components:

- testbed001.grid.ici.ro: Computing Element (the interface between computing cluster and the Grid infrastructure);
- testbed002.grid.ici.ro: Storage Element;
- testbed003.grid.ici.ro: User interface (for user login, job submission and execution, replication of files, other grid specific commands);
- testbed004.grid.ici.ro: Monitoring Node (monitoring server for the R-GMA system and the collector node for the accounting client APEL);
- testbed005.grid.ici.ro: Berkeley Database Information Index – BDII (to maintain accurate information about the available grid resources).

RO-01-ICI cluster is being administrated with the Torque application, an improved version of the more popular OpenPBS, and the Maui scheduler. Also, according to infrastructure administration responsibilities specific to project coordinator, on the RO-01-ICI have been installed and managed various services whose availability is essential for the operation of grid infrastructure (e.g. Helpdesk service for SEE-GRID and EGEE infrastructures) or for functioning of virtual organizations supported by the site (e.g. gridmosi.ici.ro and SEE-GRID).

The site operates in a location without specific facilities, except the office type air conditioning, small to medium capacity UPSs and a secure access system.

The experience in operating and using the site, as well as the current performance level of grid sites at the European level and requirements of the national grid infrastructure evolution have led to the conclusion that a significant upgrade should be implemented for this site in terms of computing power, storage capacity and operational conditions.

4.2 GridMOSI Virtual Organization

Modelling, simulation and optimization (MOSI) procedures and tools are widely used for design and operation of advanced man-made systems, as well as for investigation or improvement of all king of complex technological, economical or biological processes. The parallel scientific computing approach is being promoted as a powerful approach for mathematical and computational methods in science and engineering [10]. Also grid computing techniques and tools are being adopted and developed in modeling and simulation problems that have to deal with large-scale collaboration, massive distributed data, and distributed computing problems ([11], [12]).

According to a basic definition given in [13], VOs "enable disparate groups of organizations and/or individuals to share resources in a controlled fashion, so that members may collaborate to achieve a shared goal". Shared resources are physical (computers and storage provided through the Grid infrastructure) and logical ones (data, application software supporting VO community objectives). The physical resources may be shared between several VOs, while logical resources are specific to a given VO. Therefore VO provides to its registered members a flexible and secure distributed environment to use their data and applications. The conditions of the expected and acceptable usage of VO or Grid resources are specified in AUP (Acceptable Use Policy) documents. Every VO running on the infrastructure must have its own acceptable use policy, and must enforce its acceptance by each VO member.

The creation of a virtual organization (VO) based on Grid technology for high performance modeling, simulation and optimization aiming to provide a convenient access of various users and organizations to powerful computing and computational resources and associated software tools was the main result of the GridMOSI project, mentioned above [14]. Applications addressing the following MOSI domains were gridified [15]:

a) Computer-aided advanced system modelling and control:

- GridModRed application for finding reduced order models which preserve the essential dynamical properties of the original models. It includes algorithms working on linear timeinvariant dynamical system models. Balance and truncate methods, singular perturbation approximation, and Hankel norm approximation methods are implemented;
- GridIdent application for finding mathematical models via system identification, which includes algorithms operating on existing or generated (by dedicated experiments) input-output data of dynamical systems or processes. The application generates models of linear time-invariant (LTI) discrete-time multivariabile dynamical systems, described in state space;
- The GridWident application to determine multivariable discrete-time state-space models of nonlinear Wiener-type dynamical systems using input-output data records. Specialized Levenberg-Marquardt algorithms are implemented for estimating the parameters of the nonlinear part and then of the whole system.

b) *Large-scale unconstrained optimization*, based on major algorithmic developments and state-of-the-art solutions for a board range of unconstrained problems:

- SCALCG application implementing a scalable conjugate gradient algorithm;
- CGALLP a nonlinear unconstrained optimization package implementing 23 conjugate gradient algorithms;

c) *Complex numerical modeling and MDO in industrial applications:*

- OpTG Optimizer based on Grid Technology application, dedicated for large optimization problems where the computation of the cost function needs evaluation performed by complex applications requesting high performance computing resources,
- MFCC Modern Field Code Cluster, a cluster of applications using state of the art numerical models in flow physics and advanced techniques in domain decomposition and parallelization; this includes pre-processing, solver and postprocessing phases and the basic orientation is towards CFD (Computational Fluid Dynamics) simulations.

d) *Evolutionary multiobjective optimization*:

DEMO/G Distributed **Evolutionary** Multiobjective Optimization on Grid, providing support for efficient solving of multi-objective optimization problems: conduct experimental design of multi-objective evolutionary algorithms in order to efficiently explore the stochastic character of these algorithms, reduce the high computational cost of sequential implementations by dividing a large population of candidate solutions in smaller subpopulations, deal with problems having a distributed character (e.g. mining of distributed data). The current implementation of DEMO/G allows the execution on different environments: single nodes, clusters and grid.

e) Applications scheduling using genetic algorithms: DIOGENES - DIstributed near-Optimal GENEtic algorithm for grid applications Scheduling is devoted to achieve a distributed, fault-tolerant, scalable and efficient method for optimizing task assignment in heterogeneous and dynamic Grid environments. A near-optimal schedule is computed by the Scheduler based on the Scheduling requests and the Monitoring data provided by the Grid Monitoring Service (MonALISA). The schedule is then sent as a Request for task execution to the Execution Service. The user receives feedback related to the solution determined by the scheduler, as well as to the status of the executed jobs in the form of the Schedule and task information.

f) Cryptographic and cryptanalytic algorithms:

CryptoGrid library, including well known algorithms adapted for grid execution, which belong to the following main classes of cryptographic and cryptanalytic solutions: block ciphers, stream ciphers, public key algorithms, hash functions, random number generators, randomness testing algorithms and factoring algorithms. The selected algorithms were validated in different scenarios based on several execution modes, which were defined according to an original taxonomy proposed for the grid environment, derived from Flynn's taxonomy.

5 SOP IEC Support for Site Upgrade

5.1 Grant objectives

The funding grant for RO-01-ICI site upgrade is provided by the Sectorial Operational Program "Increase of Economic Competitiveness" (SOP-IEC), Priority 2 "Enhancing economic competitiveness through research, development and innovation" (SOP IEC - RD), Major Intervention Domain 2.2 "Investment in research-developmentinnovation infrastructure", Operation 2.2.3: "Development of networks of R&D centres, coordinated at the national level and connected to European and international networks (GRID, GEANT)". This operation aims to increase the involvement of Romanian researchers in very specialized, grid type international research networks, with important implications in future development of science and technology, as well as in the improvement of the Education and Research Network (RoEduNet) capacity according with the GÉANT standards.

At the level of international infrastructures referred before, after a period of extensive development, when the number of set-up sites was important, the increasing number of virtual organizations has generates a steady improvement of the degree of grid resources utilization and consequently a demand for grid sites extension in terms of size and performance level. In case of RO-01-ICI site, the GridMOSI project proved its capacity limitations for certain classes of problems. Also, experience in working with application developers in this project has shown their interest for additional facilities, such as software components necessary for development and implementation of scientific applications.

The overall objective of this grant is to adapt the RO-01-ICI site to these requirements.

The list of derived objectives includes:

- adapting the current operating conditions (power supply, cooling, access security, fire protection) to those specific to production type working regime of the site;
- upgrading high-performance computing cluster to 1 Tflops and storage capacity to 20 TB;
- developing an experimental model for a knowledge-based system, dedicated to assist / automate monitoring and control activities dedicated to site operation;
- improving the support provided to scientific applications developers and users by providing access to the grid version of MATLAB and by installing open source applications of wide interest.

Since the probability of a site to meet the performance requirements of various applications launched Grid infrastructure is direct proportional to the resources offered by the site, it is expected that the upgraded version of RO-01-ICI site will have a much greater potential for job execution in grid infrastructures where the site will operate.

An objective of wider interest is to valorize the support that this powerful computing cluster is able

to provide for initiation of research in such priority, Grid complementary topics of distributed systems infrastructure as "cloud computing" ([16], [17]) and "autonomic computing" [18].

5.2 Deployed activities

To implement these objectives, the project implementation plan includes the following classes of activities:

- arrangements for the grid site location: technical design services; arrangements and installation of utilities (electric power, cooling, access security, fire protection, communications);
- purchase and installation of tangibles fixed assets: CPU cores, data storage and networking equipment; back-up solution for power supply; air-conditioning equipment;
- purchase of intangible fixed assets: licenses software dedicated to different scientific communities, with emphasis on MATLAB license for cluster configuration, together with various dedicated toolkits (in such fields as distributed computing, control systems);
- starting the new version of the RO-01-ICI site: development and installation of specific software; monitoring and intelligent assistance system for Grid resource management; installation of gLite middleware; and certification as production site;
- installation of essential services for VO operation: VOMS - Virtual Organization Management Service, BDII - Berkeley Database Information Index, WMS - Workload Management Service, LFC - LCG File catalog, MyProxy;
- installation of application development support and open source scientific applications;
- dissemination activities: project presentation at national and international scientific events, publications, web site design;
- information and publicity about the project: press releases, posters, leaflets and promotional CDs;
- project management: detailed planning of activities and sub-activities, distribution of tasks between implementation team members; monitoring and periodic reporting of project implementation status;
- final project audit.

5.3 Site configuration

The hardware configuration of the site is oriented towards the High Performance Computing domain, in addition to the Grid Computing requirements support. The Grid infrastructure is more suitable for long running application, where the throughput is important, whereas in the HPC realm it is sought to maximize the performance and obtain fastest results. The overall site architecture is presented in figure 1.

Computing nodes will be equipped with multiprocessor and multi-core systems, and with 2 GB memory per core. The computation network will use the Infiniband at 40 Gb/s technology, each computing host having Infiniband QDR 4x HCAs.

The theoretical peak performance of the cluster is approximately 7 Teraflops, so it is possible to get an actual computing performance over 1 Teraflop, if the efficiency will be more than 15% as we expect to have.

The storage resources are deployed in one disk array which have attached two additional enclosures to host disk drives. Together they provide 36 TB, as each unit has a capacity of 1 TB, which become common nowadays.

This storage capacity will be made available to the computing nodes by Infiniband interconnects. In order to manage the storage devices two server nodes are connected to the storage system in a Direct Attached Storage configuration using SAS connections. These servers are setup in a redundant configuration, and are interconnected with the computing nodes in an Infiniband 40 Gb/s network.



Fig.1 - Site architecture

The computing nodes use a cluster filesystem to access the storage, and to provide a shared workspace for the computing jobs. There are a number of different solution and implementations for such a cluster filesystem, ranging from commercial products to free and open-source versions, which have different features and issues.

We have identified the Lustre clustering filesystem (http://wiki.lustre.org/index.php/) and GlusterFS (http://www.gluster.org/) as two mature opensource solution which have been used extensively in the HPC domain (i.e. Lustre) and are good candidates to use as distributed parallel fault-tolerant file systems. As we have already used GlusterFS in a second cluster in ICI Bucharest which is part of the SEE-GRID-SCI's project production infrastructure, it has a number of advantages over Lustre, as it is easier to deploy and to administrate, but it seems to have some performance penalties over Lustre, as it is a FUSE based filesystem (http://fuse.sourceforge.net/).

The deployment and configuration of the new site is planned to be automated as much as possible, using technologies like Cobbler and Puppet.

The provision of the systems will be performed (https://fedorahosted.org/cobbler/), by Cobbler which is an application developed for automatic system installation over the network. It configures the DNS's zones with hostnames, using either dnsmasq or named, and makes the setup for the ip configuration using either dhcpd or dnsmasq. Cobbler has a object oriented architecture, starting the distribution object, which is further with refined by the "profile" and "system" objects and it be integrated with can Puppet (http://www.puppetlabs.com/), used to implement the configuration of the systems, and to maintain consistent this configuration over time.

In order to manage the site two master nodes deployed in a redundant configuration. They will be used to monitor the site, and to store the logging information from the other nodes.

Because the site should be included in a production grid infrastructure, there have to be installed and configured all necessary grid services that were mentioned before. We plan to continue to support gLite middleware stack, even though there are other solutions available, other option being the Unicore middleware (http://www.unicore.eu/), which is supported by the EGI as well. These services can be collocated on the master nodes, as they will be containerized in a virtualized environment.

Recently RedHat has promoted the Kernel-based Virtual Machine (KVM) technology (http://www.linux-kvm.org/page/) in favor of Xen (http://www.xen.org/), as main virtualization solution, and it can be used by Cobbler as well. In order to manage the virtual infrastructure, which is in fact a private cloud, a solution like oVirt (https://fedorahosted.org/ovirt/) or Opennebula (http://www.opennebula.org/) is required. These systems allow to create and administrate a cloud infrastructure very efficiently.

5.4 Potential beneficiaries

Direct beneficiaries are research teams participating in virtual organizations supported site RO-01-ICI in its new version, and research institutions to which they belong. These teams include developers of Grid applications registered in that virtual organizations, users of such applications or users interested only in access to Grid resources for testing their applications.

Another category of direct beneficiaries are grid site administrators, which may, where appropriate, benefit on the experience in implementing and operating of a site at that level of performance.

Indirect beneficiaries are other research teams who are interested for their projects to access hardware and software resources and basic services provided by this site.

4 Conclusion

The innovation potential of e-Infrastructures is related with their use as cost-efficient platforms for large-scale technological experimentation. According to [2], research in 2020 cannot be imagined without the intensive use of sustainable and persistent sophisticated e-Infrastructures, which requires the coordination of efforts at national and EU level.

The active participation of the Romanian research community in international cooperation will depend at a great extent on the performance quality and interoperability level of the national e-Infrastructure in the European context. The grid infrastructure provide a good example of the efforts made so far in this respect, which should be continued in the new context provided by the European Grid Initiative.

The development of national e-Infrastructure specific components - high-speed network and national grid infrastructure - is a priority objective of investments in large research infrastructures at the national level. The major aim is to improve the availability and quality of provided e-Science services for different scientific communities. The contribution of the ICI Bucharest to this objective is based on active participation in national and international projects. The GridMOSI VO, registered into the VOs repository of the Europe wide Grid infrastructure for e-Science illustrates this contribution.

The Sectorial Operational Program "Increase of Economic Competitiveness" provides a substantial financial support for the implementation of these infrastructure components. The project accepted for funding in operation 2.2.3 "Development of networks of R&D centers, coordinated at national level and connected to European and to international networks (GRID, GEANT)" will significantly enhance the contribution of the ICI Bucharest to this national effort. By computing power and storage capacity to be achieved at the end of project, the RO-01-ICI site is placed in the current top 5 sites in the SEE-GRID infrastructure and in the top 30% sites of the EGEE infrastructure.

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