DORII – Deployment of Remote Instrumentation Infrastructure

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Abstract

In the paper we present the EU funded DORII project (RI-213110). It intends to deploy e-Infrastructure for new scientific communities specifically for experimental equipment and instrumentation that are today not or only partially integrated with the European e-Infrastructure. DORII is focusing on communities concerning earthquake, environmental science and experimental science community. Working closely with end-users, solutions will be put in place that build upon the success of past and ongoing projects in such areas as remote instrumentation (GRIDCC[5], RINGrid[6]), virtual laboratories (VLAB[13]), interactivity (int.eu.grid[3]), software frameworks for application developers (g-Eclipse[7]) and advanced networking technologies (GN2[15]) with EGEE-based middleware[1,2]. Remote control of scientific facilities with usage of virtual laboratories and solution proposed by DORII has the potential of revolutionizing the mode of operation and the degree of exploitation of scientific instruments.

1 Introduction

The necessity of using unique and expensive equipment infrastructure, which is often locally unavailable, as well as of broad international cooperation are the key issues for the success of a great number of science disciplines, especially those based on experiments, requiring advanced equipment and on-line access.

Thus the development and spreading of remote instrumentation techniques and technologies that allow virtualized, remote and shared access to such infrastructure opens up new opportunities for scientific communities.

The DORII project (RI-213110), started in February 2008 and funded by the European Union under the Seventh Framework Programme (FP7) intends to deploy e-Infrastructure for new scientific communities specifically for experimental equipment and instrumentation that are today not or only partially integrated with the European e-Infrastructure.
DORII is focusing on the following selected scientific areas:

earthquake community (with various sensor networks): earthquake early warning system design and simulation, network-centric seismic simulations

environmental science community: oceanographic and coastal observation and modeling, inland waters and reservoirs monitoring

experimental science community: on-line data analysis in experimental science coming from increased efficiency of the light sources (synchrotron and free electron lasers) and of the detectors with higher and higher resolution and faster readouts.

The scientific communities targeted by the project are well recognised and organised, even in industry areas represented by SMEs. Working closely with end-users, solutions will be put in place that build upon the success of past and ongoing projects in such areas as remote instrumentation (GRIDCC[5], RINGrid[6]), virtual laboratories (VLAB[13]), interactivity (int.eu.grid[3]), software frameworks for application developers (g-Eclipse[7]) and advanced networking technologies (GN2[15]) with EGEE-based middleware[1,2].
The goal of the presented paper is to highlight basic aims of the DORII project. The paper is organized as follows. We first discuss aims and objectives of the project. We present the action plan that covers major project activities. Then we describe application requirements and instrumentation devices of the DORII scientific communities. Next sections give an overview of the research activity, proposed middleware and the infrastructure architecture. Finally we present the standardisation efforts.

2 Project objectives

One of the major goal of the DORII project is to support the selected communities in the development and deployment of their respective applications in the e-Infrastructure, i.e. – earthquake, environment, and experimental science communities. These scientific groups of users and their experimental equipment and instrumentation are not integrated or integrated only partially with the European infrastructure, and their daily activities will benefit greatly by this opportunity. The direct support will be provided by the research and infrastructure service-oriented work packages.

Another goal of the DORII project is to build a production quality distributed computational and visualisation infrastructure, integrated with the distributed instrumentation environments of the selected scientific area. DORII would like to provide and support added values of e-Infrastructure (like interactivity, parallelization, collaborative tools, dynamic measurement scenarios - workflows, low latency) that would be used in the integrated environment of scientific and engineering instrumentation, networking, visualisation and computational infrastructures. The new generation services provided by the GEANT2 networking infrastructure will be used, i.e., quality of service, ipv6.

DORII is planning also to prepare an approach which can be used for further deployment, not only at the mentioned scientific areas. The scientific communities represented by the project are members of bigger consortia that focus on research aiming to have a better experimental environment. This major objective secures the work performed by DORII and proves the ability of using the software framework and procedures for further deployment done in a reasonable time, including appropriate performance, scalability and reliability.

3 Action Plan

The DORII project consists of three phases: The first is the integration and adaptation of the selected products from previous projects that have been successfully carried out by the projects like GRIDCC, Int.EU.Grid, gEclipse or VLAB[5,3,7,13]. It will take advantage of best practices and operate the Remote Instrumentation Infrastructure. The second phase is a deployment of the project applications on the infrastructure and middleware enhancement. The third phase is standardisation and deployment of the results to a wider community outside the project. It is planned to increase the deployment phase on a bigger consortium called MOON (Mediterranean Ocean Observing Network), not being a partner of DORII, which is represented in the project by OGS. The project will promote standardisation and knowledge transfer via e-IRG and OGF research groups. Project takes active role in a research group in the Open Grid Forum[9], which exactly focuses on topics presented in the project, i.e. RISGE - Remote Instrumentation Services in a Grid Environment.

4 Applications and their requirements

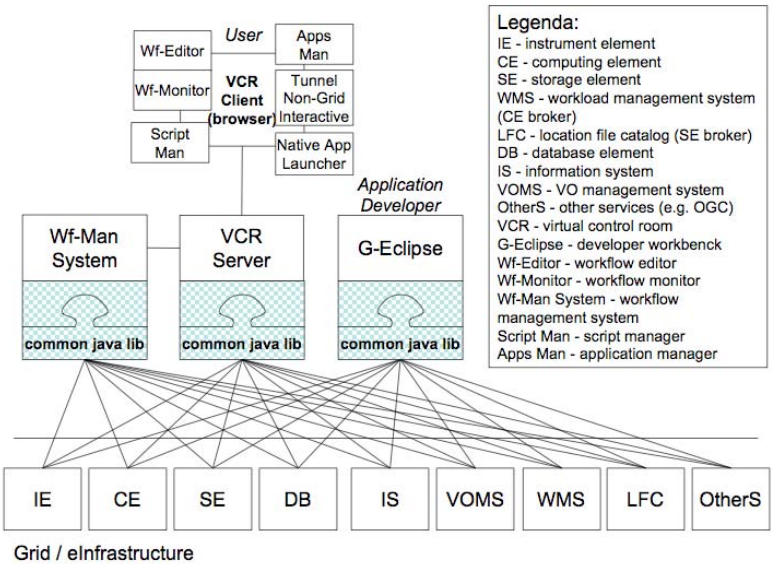
There are number of the applications identified and selected at the beginning of the project:
- Network-centric seismic simulations
- Earthquake early warning system
- Oceanographic and coastal observation and modeling Mediterranean Ocean Observing Network: an integrated system from sensors to model predictions (FLOATS)
- Oceanographic and coastal observation and modeling Mediterranean Ocean Observing Network: an integrated system from sensors to model predictions (GLIDER)

- Oceanographic and coastal observation and modeling Mediterranean Ocean Observing Network: an integrated system from sensors to model predictions (OPATM-BFM)
- HORUS bench
- Simulation and Monitoring System for inland waters and reservoirs
- On-line data analysis in experimental science

Since description of each of the mentioned applications could be longer then limit of this paper we would focus on the general requirements coming from these applications. Taking into account variety of the applications different aspects has to be carefully considered within DORII project. Basic requirements are related to accessing the remote instrumentation distributed in a wide geographical area – it concerns applications like floats, the glider or monitoring through images. This should be done in standardised and unified way mostly in real time. Some of the applications are expecting to use virtual laboratory environment in order to access remotely to sometimes expensive equipments located in a real laboratory – this concerns mostly applications like the earthquake networked simulations. Most of the DORII communities would also like to profit from the Grid infrastructures in order to improve their work, by reducing the time of the computation and increasing the storage possibilities (storage requirements can grow up to the order of Petabytes). Some of the applications are also challenging in terms of the network requirements – in case for example of on-line processing applications data set of Gigabytes should transferred in real time, processed and visualized to the user. Among others there are also requirements related to visualization, scientific workflows, interactive behavior, security. Whole list of the requirements has been collected in [4,16].

5 Research activity and proposed middleware

Research activity aims at fulfilling the user communities (and their applications) requirements on the Remote Instrumentation Services integrated with Grid environment. One of the main challenge of this activity is to combine and integrate number of different components and services within a common architecture (presented below). For this purpose, for accessing the services of the DORII e-Infrastructure the Common Library was proposed. It will be a common access layer between integrated middleware components and the infrastructure. This solution will enable handling the integration of all enhanced components. Also it will allow to expose the same interface for all the tools and services included into the architecture.



Within this activity the following services and middleware will be enhanced(taking into account applications and infrastructure requirements):

- Instrument Element (IE), used for the interaction with instruments. The IE was initially developed by the GRIDCC project[5]. It is an abstraction of the instrument (or group of instruments) into a standard interface The term instrument is used in this context to define a piece of equipment that needs to be initialized, configured, operated (start, stop, standby, resume, application specific commands), monitored or reset. The DORII extension of the Instrument Element, is set of WS-I compliant web services virtualizing the concept of instrument and sensor and presenting this as a grid component that works conjoined with the EGEE gLite software[2].

- VCR (Virtual Control Room) [14] is a Grid portal which allows registered users an interactive access to all the DORII Grid resources, providing them with additional collaboration services. VCR will support DORII applications with workflows through an external workflow management system (Wf-Man System), a native client application launcher and a tunneling technology, which can be used to integrate application components and to support interactivity.

- Workflow Manager System (Wf-Man System) [8] that is supporting users in definition, management and monitoring of scientific workflow. Wf-Man System facilitates the measurement process beginning from the preparation stage through experimental and computational processes to results analysis.

- g-Eclipse – used for preparation of Common Library, development platform for the DORII. The g-Eclipse framework, initially developed within g-Eclipse project[7], provides a set of tools for accessing e-Infrastructure, including tracing and debugging tools for parallel applications. The DORII extensions of the framework will concern mainly handling of the Instrument Element and instrumentation services.

- Parallel applications support using the Message-Passing Interface. The MPI support was initially improved in the frame of Int.EU.Grid project. Major components of the Int.EU.Grid middleware are being adopted in DORII - Open MPI, PACX-MPI and MPI-Start [10,11,12] and adequate support is provided for applications.

6 Infrastructure

The DORII e-Infrastructure is based both on the services built within DORII research activity, particularly related with the management of the remote instrumentation (described in previous section) as well as grid infrastructure based on EGEE gLite [2] and the Interactive European Grid Project [3] middleware. Furthermore the DORII infrastructure will profit from the projects like GRIDCC [4] and RINGrid [5], enhancing existing Grid Infrastructure operations models aiming at the integration of instruments and the respective applications. This important novelty will allow for normative descriptions of operational procedures in order to ensure that Grid applications relying on scientific instrumentation for data acquisition will have the required facilities and functionalities in place.

Most of the computational and storage resources provided to the scientific communities of DORII are also part of the EGEE infrastructure. Therefore one of the key points for the DORII services and middleware is interoperability with EGEE sites. DORII partners will offer also extra computational and storage resources that will not be direct part of the EGEE infrastructure for testing reasons. Such solution will give flexibility to the users to deploy software and applications without any limitations. It is worth mentioning that one of the results of the DORII project will be a set of procedures that enable seamless integration of the instrumentation resources to sites that run grid infrastructure like gLite.

Concerning the hardware resources, the DORII infrastructure initially consisted of 8 grid sites that are also a part of the EGEE production infrastructure and part members of the Int.EU.Grid infrastructure. In total, these sites provide about 2200 non-dedicated CPUs and several Terabytes storage to the DORII users and their applications. DORII e-Infrastructure includes also following hardware devices used by applications:

- Actuators,sensors: Actuators are devices applying forces to the specimen, while a sensor network is used to monitor the specimen's reaction.
- seismic sensors
- Float: Lagrangian (passively following the ocean current) instrument
- Glider: Autonomous gliding Underwater Vehicle (AUV)
- Digital Cameras
- Pressure sensors
- Temperature sensors
- CTD, optical sensors
- SAXS: Small Angle X-ray Scattering
- XRD: BeamLine
- SYRMEP: SYnchrotron Radiation for MEdical Physics
- LEGO Mindstorm
- Digital Camera

7 Standardisation efforts

As already mentioned, the project will promote standardisation and knowledge transfer via e-IRG (e-Infrastructure Reflection Group - About e-IRG)[17] and OGF research groups[9]. DORII partners have established a research group inside standardization body - Open Grid Forum, which exactly focus on topics related with the project, i.e. RISGE - Remote Instrumentation Services in a Grid Environment. The main goals of the group as well as the scope have been defined within OGF charter [18]: "RISGE-RG explores issues related to the exploitation of Grid technologies for conducting and monitoring measurement tasks and experiments on complex remote scientific equipment. The main purpose of this research group is to bring together various existing approaches in defining remote access interfaces to sophisticated laboratory equipment, and to come up with use cases that can dictate the requirements for integrating scientific instruments with the Grid. As such, it mostly concerns the steering and monitoring of instrument resources, although more typical problems such as user access and authorization are also in scope. The advances of Grid technologies in areas such as interactivity, visualization, and Quality of Service provisioning play an important role in accessing remote devices; therefore, the description of suitable service-level terms is highly relevant."

Work of this group is focusing on providing an overview of existing solutions as well as on indicating some requirements and future directions of e-Infrastructure functionality development to facilitate access to instruments.

This group gathers people that are involved in the field of remote instrumentation and Grid, in order to document experiences, present best practices and work on an informational document that would describe different use cases and would define

"model use cases". Such document could be later used by other Working Groups(WG), that are taking care of some aspects of use cases. Depending on the results, the group will take into account the possibility of establishing new WG to standardize the relevant capabilities.

8 Concluding Remarks

A combination of the existing European infrastructure with the unique environmental instrumentation will make a new kind of e-Infrastructure, equipped with sensor networks (earthquake and environmental instrumentation), synchrotron and free electron lasers, high bandwidth networks (GEANT2 and national networks for endpoint connections), computational, visualisation resources and data storage systems. Remote control of scientific facilities with usage of virtual laboratories and solutions proposed by DORII has the potential of revolutionizing the mode of operation and the degree of exploitation of scientific instruments. Grid technologies will be used to integrate operations with computing farms where complex models and computing coming from instruments could run, but also for storing large amount of data. Grid will handle issues related with authorization, resource management, data transfer and storing. Network infrastructure will be used with the available mechanism for QoS handling. The leading role of consortium partners in reflection groups and standardization bodies for the integration of instruments within the Grid, will increase sustainability of the proposed solutions.

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