EUMEDGRID

Grid Computing in Malta and the Mediterranean

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ABSTRACT

In this paper we introduce EUMEDGRID, an EU-funded project with the objectives of building the first high performance computing grid extending across the Mediterranean, and fostering national grid initiatives in the Mediterranean region. Grid computing is an emerging technology which has generated significant global interest due to its potential to usher in a new era in computing: the provision of computing as a service on demand, akin to a utility such as the electricity grid. Grid computing aims to provide transparent access to computing and storage facilities distributed over a wide area. The European Commission sees grid computing as a crucial component in improving collaboration across the European Research Area. It is branded a key technology in the European Information Society 2010 initiative, whose aim is to maximize economic growth and social inclusion, thus making the EU "the most competitive, knowledge-based economy in the world by the year 2010" [29]. A brief overview of grid computing, applications, standards and architecture opens the paper. This is followed by an account of EUMEDGRID's objectives and activities, and a discussion of Malta's participation in grid initiatives. Finally, we consider the future of grids in Malta and the Mediterranean.

Keywords

Parallel and Cluster Computing, Grid Computing, Networking, Collaborative Systems, e-Infrastructures, e-Science, Human Factors, Standardisation.

1. INTRODUCTION

EUMEDGRID [9] is an initiative funded through the European Commission's 6th Framework programme which aims to build the first high performance computing grid extending across the Mediterranean region. EUMEDGRID is currently in its pilot phase, and will eventually form part of EGEE, the European e-Science grid [6].

EUMEDGRID kicked off in 2006 with a meeting in Malta [28] and to date has secured EU funding to operate until December 2007. The project is coordinated by INFN (Italian National Institute for Nuclear Physics), and the project partners besides the University of Malta are

- GRNET (Greek Research and Technology Network),
- CERN (The European Organisation for Nuclear Research),
- DANTE (Delivery of Advanced Network Technology to Europe, UK),
- Consortium GARR (Italian Academic and Research Network),
- CYNET (Cyprus Research and Academic Network),
- RED.ES (Entitad Publica Empresarial, Spain),
- CERIST (Centre De Recherche sur l'Information Scientifique et Technique, Algeria),
- CNRST (Centre National Pour la Recherche Scientifique et Technique, Morocco),
- EUN (Egyptian Universities Network),
- HIAST (Higher Institute of Applied Sciences and Technology, Syria),
- MSRTDC (Ministry of Scientific Research, Technology and Competency Development, Tunisia),
- TUBITAK (Scientific and Technological Research Council, Turkey).

Additionally, a number of third parties from Greece, Italy, Israel (IUCC), Jordan (JUNET), Palestine (PADI2), Tunisia, and Turkey are participating.

2. GRID COMPUTING

Grid computing is an emerging technology which has generated significant global attention. This is because grids have the potential to usher in a new era in computing: the age of computing and storage resources on demand, somewhat similar to a utility model such as the electricity grid. From a researcher's viewpoint, grid computing enables remote interactive access to

specialised and exclusive scientific equipment, large scale computing facilities and repositories of experimental data, as well as collaboration with geographically dispersed research groups. This can revolutionise the way research is conducted and empower researchers in remote areas with limited facilities.

The European Commission sees grid computing as a crucial component in improving collaboration across the European Research Area. It is branded a key technology in the European Information Society 2010 initiative, whose aim is to maximize economic growth and social inclusion, thus making the EU "the most competitive, knowledge-based economy in the world by the year 2010" [29].

2.1 Grid Architecture

The concept of the Grid is driven by the need for "coordinated resource sharing and problem solving in dynamic, multi-institutional virtual organisations" [16]. This includes direct access to computers, software, data and other resources. Clear constraints on what resources may be shared and who can utilise them are defined by dynamic virtual organisations constituted by multiple individuals or institutions.

Grid technologies complement existing distributed technologies, rather than replacing them, by extending the distribution across organisational boundaries. Since interoperability is key to sharing, The Grid architecture must be open standards-based, defining protocols through which virtual organisation members and resources flexibly and dynamically negotiate, manage and utilise sharing relationships. These protocols govern interaction between components rather than their implementation, hence existing structures within institutions may be preserved.

The service abstraction is central to grid operations, and a number of standard services are defined to provide computation, data, resource discovery and other functionality that virtual organisation members may provide and utilise, while abstracting away the internal heterogeneity within specific resources. It is worth noting that web services are being utilised for this purpose in next generation Grid implementations.

Finally, programming interfaces must be built on top of grid services to enable developers to create applications for this dynamic environment.

The Grid architecture as specified in [16] contains the following layers, moving upwards:

- The **Fabric Layer** exposes the local resources which will be shared across the Grid. In general, more sophisticated actions on existing resources, such as advance reservation, will involve more work in the fabric layer in order to extend the resources' existing (possibly limited) functionality. Enquiry (to establish current state, capabilities and structure) and management mechanisms are required at the very least. The types of resources exposed by the fabric layer may include computational resources, storage resources, network resources and databases.
- The **Connectivity Layer** provides communication and authentication protocols to enable the controlled sharing of resources in the fabric layer. Standard Internet protocols for networking and security are generally used. Authentication for virtual organisations should enable single sign-on, delegation of permissions (the ability of a program to perform actions on a user's behalf), user-based trust (combined use of resources from multiple locations without further administrator intervention, provided usage permissions for the individual resources are set), and integration with existing local security mechanisms.
- The **Resource Layer** builds on the connectivity layer to provide sharing of individual resources. This layer defines protocols and programming interfaces for negotiation, initiation, monitoring, control and accounting for the sharing of a resource. The resource layer also utilises the local fabric layer to provide shared access to local resources. Resource layer protocols may be classified into information and management protocols. The problem of synchronisation between multiple resources is left to the following layer.
- The **Collective Layer** deals with the coordination of multiple resources by providing protocols, services and programming interfaces for directories, resource allocation, scheduling and brokering, monitoring and diagnostics, data replication, workload management and collaboration, software discovery and accounting, amongst others. Some collective layer services may be specific to a particular virtual organisation. Persistence of state is a key issue in this layer.
- The **Application Layer** consists of the applications that execute within a virtual organisation, and make use of services at any underlying layer, which are exposed through well-defined protocols.

2.2 Grid Applications

While the most widely publicised applications for grids to date are in high energy physics (HEP) and bioinformatics, any application requiring substantial computational power, storage resources, and/or cooperation between users across geographically dispersed locations is a valid candidate.

In this section we will focus on a selection of applications running on the European e-Science Grid (EGEE and EGEE-II [6]), due to the close association of EUMEDGRID with these activities. The applications mentioned here are treated in further detail in [7].

- **High Energy Physics** was an initial pilot area for grid applications. One of the main tasks of European research grids will be to handle the processing of vast amounts of data that will be generated by the Large Hadron Collider experiments (ATLAS, CMS, ALICE, LHCb) at CERN. Other HEP experiments, such as BaBar, CDF, DØ, H1 and ZEUS are currently making use of the EGEE infrastructure.
- **Biomedical Applications.** The biomedical community was also involved in initial grid pilots from the outset. At this stage, several applications are running on the EGEE infrastructure. Amongst these are GPS@ and WISDOM. GPS@ is a bioinformatics portal providing protein sequence similarity searches, sites and signatures detection, multiple alignment, secondary structure prediction and primary structure analysis. The WISDOM Drug Discovery application aims to speed up the process of finding new drugs against malaria, H5N1 and other diseases.
- **Astrophysics Applications.** The European Space Agency is utilising EGEE e-infrastructure to simulate the forthcoming Planck satellite mission and test the data pipelines, thus

providing input to the mission's hardware requirements. The EGEE e-infrastructure is also processing data from MAGIC, an imaging atmospheric telescope located on the Canary Islands that is used for astro-particle physics research.

- **Earth Science and Geophysics Applications.** The Grid is being used to analyse ozone profiles from the GOME satellite and oil spill data from the ERS/SAR satellite, facilitating data sharing within the earth observation community. Earthquake simulations using 3D geological models, and Montecarlo simulations for seawater intrusion in a coastal aquifer of the Mediterranean basin are also being carried out. In addition, a flood forecasting application has been ported for grid execution. Finally, GeoCluster, a seismic processing solution, is the first industrial application running on the EGEE production service.
- **Computational Chemistry.** A number of applications have been deployed under the computational chemistry virtual organisation. The GEMS and DI-Poly applications are running on EGEE to simulate the reaction dynamics of complex chemical systems. RWAVEP computes chemical reactive quantum probabilities. COLOMBUS performs *ab initio* molecular electronic structure calculations, while GAMESS calculates SCF wave functions for molecular quantum chemistry.
- Other areas such as **Financial and Economic Research**, **Digital Libraries**, **Fusion Research**.

3. THE EUMEDGRID PROJECT

3.1 European and Mediterranean Scenarios

Recent developments in European Research Infrastructures have led to the creation of a pan-EU high-speed research network with full administrative and operational support. This network has paved the way for the development of an overlying European Grid infrastructure in order to enable the sharing of distributed computing power and storage across geographical and administrative domains. This e-infrastructure provides a platform for new methods of global collaborative research: e-science. The leading initiatives in European e-infrastructures are the GÉANT /GÉANT2 [18][19] and EGEE/EGEE-II [6] projects.

The e-Infrastructure is bound to broaden in the next few years, as a result of a number of initiatives taken in this area between Europe and developing countries all around the world. Implementing a Grid-enabled infrastructure would be of strategic relevance to foster collaboration between researchers from Europe and other countries and to contribute towards bridging the digital divide among areas with different levels of technological development.

The EUMEDCONNECT project [8] has succeeded in establishing a Mediterranean research network (see Figure 1). At this very moment, several non-EU Mediterranean countries are taking the first steps towards adopting Grid computing and a number of cooperative research projects exist thanks to the collaboration between scientists from the Mediterranean and Europe. These projects would strongly benefit from the availability of a stable regional Grid-enabled infrastructure.

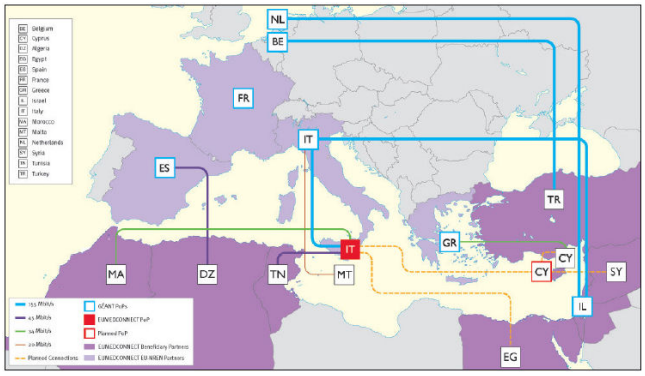

Figure 1. The EUMEDCONNECT network, a basis for EUMEDGRID

3.2 The Objectives of EUMEDGRID

The objective of the EUMEDGRID project is to bring the less experienced and less resourced countries of the Mediterranean region to the level of European developments with regards to e-infrastructures [26]. With the Mediterranean networking infrastructure reaching stability through the EUMEDCONNECT project, the focus of the EUMEDGRID will be on Grid infrastructure and related e-science applications. The objectives of EUMEDGRID are focused on two main areas:

- creating a human network in e-science, assessing its needs and transferring Grid expertise to the constituent communities; and
- driving the technological developments that will enable the commencement of Grid operations in the region.

A broad range of activities will focus on dissemination and outreach, hands-on workshops and close collaboration with related projects such as EUMEDCONNECT, GÉANT, EGEE and SEE-GRID [27]. Furthermore, a pilot Grid infrastructure will be created, including Grid cluster deployment and the development and enforcement of operational and organisational schemes. Finally, a range of regional e-science applications will be investigated, with candidate applications deployed on the regional infrastructure.

This approach will help bridge the digital divide between Mediterranean countries and the EU and will facilitate the participation of these countries in European and worldwide e-infrastructures and e-science activities, thus expanding and supporting the European Research Area (ERA).

EUMEDGRID will pave the way towards the provision of a transparent and ubiquitous common market of computing resources to the various research communities in the region. Integration of EUMEDGRID into the wider European e-infrastructure will provide the research and education community of the region with access to a much larger pool of storage and computing resources than currently available.

EUMEDGRID will utilise the networks built through the EUMEDCONNECT and GÉANT projects, as well as through strong liaisons with the EGEE project and the experience of other regional initiatives such as SEE-GRID.

We now provide a detailed list of specific objectives for EUMEDGRID as specified in the project proposal's technical

annex. The first set of objectives focus on soft actions, with the overall aim of creating a human network in the area of Grids, e-science and e-infrastructures in the Mediterranean, and promoting regional and international cooperation:

O1 Stimulate the formation of national Grid infrastructures (NGIs) in the Mediterranean countries, thus contributing to the creation of a "virtual Grid-based research space".

O2 Promote awareness in the region regarding Grid developments through the organization of a number of dissemination and outreach events, which will promote the project results to the private and public sector, ultimately reaching the general public.

O3 Establish a dialogue regarding policy developments for research and education networking and provide input to the agenda of national funding bodies and if possible governments.

The second set of objectives focus the technical aspects and are intended to support, on the basis of an in-deep analysis of local requirements, the implementation of a pilot Grid infrastructure across the Mediterranean and the deployment of a set of test applications on it:

O4 Capture local e-science user requirements in terms of resources needed, Grid services, and application software.

O5 Provide guidelines and technical cookbooks to guide regional integration in the Euro-Mediterranean infrastructures

O6 Support the establishment of pilot Grid resource centres at each country in the region, and adapt and implement operational and organisational management procedures, bringing the region up to speed with production-level operations. Pilot Grid resource centres are intended to be the major vehicle of this process, becoming the seeds of national Grid infrastructures in the Mediterranean countries.

O7 Build upon and exploit the network infrastructure provided by GÉANT and EUMEDCONNECT in the region. The amalgamation of national grid initiatives into a Mediterranean infrastructure will take advantage of the existing human network created within the EUMEDCONNECT project. It is envisaged that this human network will trigger the creation of a physical backbone connecting directly all EUMEDGRID actors, to maximize the effectiveness of the pilot grid infrastructure.

O8 As a proof of principle, support the deployment of EGEE applications (high energy physics, biomed) and other Grid applications of regional interest on the pilot infrastructure, with the involvement of local user community. New user communities will be actively encouraged to join the EUMEDGRID community and deploy their own applications on the pilot infrastructure.

3.3 Expected Impact of EUMEDGRID

This section outlines the expected strategic impact of the EUMEDGRID project, focusing on standards and policy.

3.3.1 Standards

One of the key objectives of EUMEDGRID is to enable the implementation of a pilot Grid interoperable with wider European (EGEE) and worldwide Grids, thus ensuring a smooth integration on the infrastructure, core middleware and service levels. This will in turn enable resource and service access and sharing between the Mediterranean region and rest of Europe and the world, allowing the local user communities to access resources and collaborate with partners across Europe and the world.

In this context, an inherent activity within EUMEDGRID will be active use of the middleware developed by EGEE, its validation and certification, and feedback regarding its functionality and performance, based on its use. In this way, EUMEDGRID will actively participate in requirements capture and feedback on the middleware, standards and protocols, but also Grid management tools. Via this feedback through EGEE, EUMEDGRID will indirectly contribute to international standards bodies such as the Open Grid Forum (OGF) [25].

3.3.2 Policy

The Barcelona Euro-Mediterranean Conference of 27-28 November 1995 [14] stressed that support for the development of the Mediterranean scientific and technological community, together with the upgrading and modernisation of local telecommunications infrastructure, are two pivotal elements for the success of the Euro-Mediterranean partnership.

The EC has since approved initiatives for the development of the EUro-MEDiterranean Information Society (EUMEDIS) specifically designed to reduce the region's informational and technological gap as compared to the neighbouring countries. The Programme is also complementary to a regional telecom regulatory framework project, New Approaches to Telecom Policy, launched around the same time. In coming years it is foreseen that all current financial assistance instruments will be integrated into the framework of the new European Neighbourhood Policy.

The European Neighbourhood Policy (ENP) [15] is an overall policy aiming to share the benefits of the EU's enlargement with neighbouring countries in strengthening stability, security and welfare, in order to prevent the emergence of new dividing lines between the enlarged EU and its neighbours. Amongst the ENP's key issues are the integration of infrastructures, and scientific and cultural cooperation.

The EUMEDGRID project will contribute to policy developments via a number of its activities:

- Enhance collaboration between scientific communities, both within the region and with the rest of Europe and the world, thus paving the way for educational, scientific and cultural exchanges, initiatives and projects across borders.
- Stimulate the sharing of the know-how in terms of Grid computing within the region and between the region and the rest of Europe and the world.
- Stimulate the use of the regional networking infrastructure (GÉANT, EUMEDCONNECT) and trigger the connection of the Mediterranean national research and education networks with each other in order to create a powerful regional backbone.
- Become a catalyst for the development of a common computing and storage infrastructure, thus paving the way for a unified regional e-Infrastructure.

- Facilitate research activities over a number of scientific sectors, by providing access to the nascent e-Infrastructures to a wide spectrum of applications.
- Encourage the interaction of research communities and governmental bodies in the region with the aim of gaining long-term support for e-infrastructures and e-science.
- Foster dialogue on common policies among governments by means of a targeted communication strategy, including the organization of a dedicated Policy workshop.
- Take advantage of the experience of the e-Infrastructure Reflection Group [4], involve in it actors from Mediterranean and propose its model at a regional level. EUMEDGRID aims to trigger these actions by involving the countries of the region in latest developments and e-infrastructure practices in networking, computing and e-science. e-Europe aims to accelerate the development of the information society in Europe and ensure its availability to all citizens. In this context, the impact of the project will hopefully be beyond the immediate scientific community, building towards an all-inclusive knowledge society.

The project is expected to improve the following knowledge-based society indicators along three distinct lines:

1. Providing cheaper, faster, secure and immediate access to resources;
2. Investing in people and skills;
3. Exploiting the network infrastructures provided by GÉANT and EUMEDCONNECT.

These are seen as directly linked to economic development of the region.

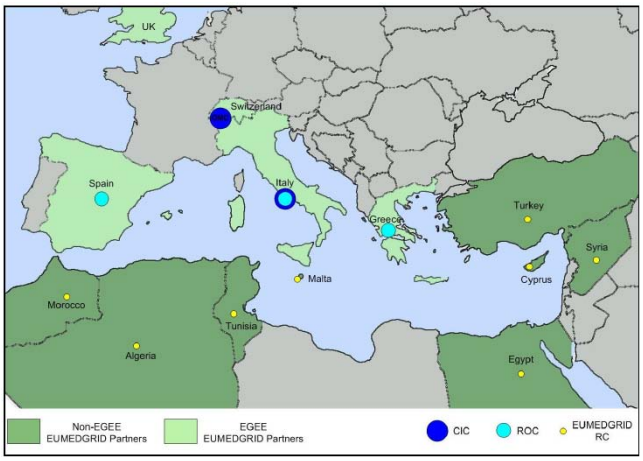

Figure 2. The strategic impact of EUMEDGRID on the Mediterranean region

Figure 2 depicts the strategic impact of EUMEDGRID on the Mediterranean region. A distinction is made between European EGEE countries and the less-resourced Mediterranean countries: the EGEE countries already operate Grid management structures such as Regional Operations Centres (ROCs) and Core Infrastructure Centres (CICs), which will help launch and operate the Grid Resource Centres (RCs) in the Mediterranean countries thus creating a unified Grid infrastructure across the region.

3.4 EUMEDGRID Activities

There are four support activities within EUMEDGRID, dealing with requirements capture and analysis (work package 2), Grid middleware and establishment and operations of the regional pilot Grid infrastructure (work package 3), supporting applications deployment (work package 4), and outreach and dissemination (work package 5). Project administration and technical management is encapsulated a separate work package. We will provide a brief overview of the activities within each work package, as outlined in the project proposal [26].

3.4.1 Requirements capture and analysis (WP2)

This work package, under the management of the University of Malta, is responsible for the gathering and analysis of participant information through various sources, and the formulation of a strategy and technological roadmap for the implementation of the EUMEDGRID initiatives on the basis of this analysis.

A questionnaire was designed to establish the status in each of the participant countries as regards grid technology awareness, current use of computing or grid facilities, current and future grid application requirements, and existing hardware infrastructure (computing power, storage capacity, connectivity). A system for the online submission of questionnaire responses was developed and deployed [12]. In total, ninety-six questionnaire responses were gathered from researchers and institutions in eleven participant countries and analysed, though we are still accepting responses at this stage. Furthermore, the current state of play in the IT and telecommunications areas including research and academic network initiatives in each of the participant countries was established through various sources. The information collected was analysed and a detailed report on the findings presented in a project deliverable document [10], which has provided EUMEDGRID with a clear view of the state of the current Mediterranean grid computing, IT and telecommunications landscape.

The second activity of this work package, coordinated by CERN, utilised as its principal input the above-mentioned results to formulate a strategy and a technical roadmap for EUMEDGRID. A model for the promulgation of Grid technologies to the Mediterranean region was established to guide the formation of sustainable National Grid Initiatives and the development of regional infrastructure for integration purposes. Technical solutions were proposed, taking into consideration the middleware and hardware infrastructure requirements. Additionally, a regional deployment strategy starting from site installation to operations was developed, giving due consideration to the regional perspective in terms of financial, political, technical, managerial, and time-scale concerns. The experience gained in other European projects for the promotion of regional Grid initiatives, such as SEE-GRID, was a primary guiding force in this activity. The strategy and technical roadmap was also documented in a project deliverable [11], and serves as a guide for the infrastructure and operations activities in work package 3.

This work package was formally completed in summer 2006, though the questionnaire is still open for further responses from interested researchers and institutions.

3.4.2 Infrastructure and operations (WP3)

Taking as input the regional requirements and technical roadmap produced by work package 2, this work package, coordinated by

GRNET, is currently supporting the successful deployment and operation of the regional pilot Grid infrastructure. This involves the selection and adaptation of middleware solutions produced by the leading Grid projects, with special focus on the latest EGEE middleware based on web services.

The aim during the first year of the project is to ensure the establishment of one stable pilot cluster in each beneficiary country, and to achieve interoperability of the pilot infrastructure. This task is already in an advanced state of completion, with clusters forming part of EUMEDGRID in various Mediterranean countries including Malta. A catch-all Certification Authority (CA) for the region, to issue user and machine certificates to entities in the countries which do not have an established CA, has been established. In the meantime, related CA and Registration Authority guidelines are being established. By the end of the first project year, all the participant countries should have gained some hands-on experience with Grid middleware and clusters.

As the regional teams gain experience, studies will be carried out to determine the operational requirements for the pilot infrastructure. Solutions for the operations centres will be proposed, with the special emphasis on the relationship with EGEE production-level operations and operational structures such as existing Regional Operations Centres (ROCs) and Core Infrastructure Centres (CICs). GRNET will lead this effort, benefiting from its experience in running a distributed operations centre in the EGEE and SEE-GRID projects.

Solutions will also be proposed for helpdesks and monitoring. Although the project does not intend to deliver production-level Grid services (with full manageability, robustness, resilience to failure, scalability, 24/7 production operations, etc.), all available effort will be invested to adopt as many practices as possible from EGEE. The second year of the project will focus on this aspect and it is envisaged that at the end of the project most countries will gain enough expertise and experience to be able to support full-fledged production Grid operations.

This work package aims to integrate the existing and nascent National Grid Initiatives through enabling an interoperable infrastructure. Moreover, by promoting the deployment of standard solutions, this infrastructure will aim to be interoperable with wider European and worldwide Grid services. Finally, this work package is responsible for providing network support and co-ordinating this activity with corresponding network projects such as EUMEDCONNECT and GÉANT.

3.4.3 Application selection and deployment (WP4)

Three application classes will be considered for deployment on the EUMEDGRID infrastructure under this work package which is coordinated by INFN:

- **A well-established set of Grid applications, such as the EGEE applications**, which will be used to verify the effectiveness of the pilot infrastructure. The application areas (and associated user communities) in this class are:
    - LHC (Large Hadron Collider) experiments in the field of High Energy Physics. Experiments at LHC, currently under development at CERN, will start taking data in 2007 and groups of Mediterranean scientists are actively participating in these experiments. The data collected by each experiment will be of the order of 100 Mbytes per second and will be widely available to all the collaborators in Europe and worldwide, provided that good connectivity and a compatible grid infrastructure is available.
    - Biomedicine applications, as this is the second pilot scientific field in EGEE. EUMEDGRID is currently contributing resources to the WISDOM Data Challenge [4], which is utilising Grid technology to assist in drug design.
    - Earth sciences applications, which are emerging as the third-level scientific field in EGEE. A typical application that could be deployed is SPECFEM3D, numerical simulation of earthquakes in complex three-dimensional geological models.
- **A set of applications to be chosen between the Mediterranean partners of the project as regional pilot applications**. The selected applications will be a sample of those most demanding in terms of producing and processing large quantities of data. The GILDA test bed will be used to validate and integrate candidate applications.
- **Applications intended to attract new communities**. A preliminary segmentation of the user base, obtained in collaboration with the Mediterranean partners, will identify this audience, and a number of public relations activities will be undertaken in order to contact the new potential users and facilitate their participation in the EUMEDGRID community. The intention is to support to the communities contacted as part of the dissemination by illustrating the benefits of Grid computing and providing them with an opportunity to use the Grid infrastructure for their research activities.

An applications questionnaire is currently being hosted at the University of Malta [13], and potential grid users in the Mediterranean region are encouraged to submit their responses in order to indicate their Grid application requirements.

3.4.4 Dissemination and outreach (WP5)

Dissemination and outreach activities are a crucial component of EUMEDGRID's strategy to introduce state of the art grid technologies to users from a broad range of disciplines in the Mediterranean region. The aims of this work package, coordinated by GARR, are to:

- disseminate knowledge to communities who have already expressed an interest in grids through the requirements analysis questionnaire or other means.
- disseminate information about the benefits of grid technology to a wider audience, in order to attract new communities which have not yet evaluated this technology. This includes not just researchers, but parties who could potentially support further development in this field, such as governments, funding bodies and private industry.
- create a human network in the Mediterranean to spread both Grid awareness and know-how among researchers.

The tools at EUMEDGRID's disposal to achieve these aims include the project web site, press releases to general and specialist media, bulletins, and events organised for general and specialist audiences. A number of events have already been organised, such as the February 2006 kick-off meeting and

information event in Malta, the September 2006 conference in Rome and various Grid computing tutorials across the Mediterranean. Over the past few months EUMEDGRID has been the focus of a number of media reports in the region. Additionally, through this work package, EUMEDGRID is liaising with a number of other projects such as EGEE and SEE-GRID and ensuring that information on EUMEDGRID is disseminated at related events.

Training events are being hosted at a steady rate in a number of participant countries, including Greece, Turkey and Morocco. Training sessions ensure that users understand the characteristics of the offered grid services and that they have enough technical knowledge to properly use the infrastructure. Besides the basic induction training, two other complementary training services will be offered, covering the needs of advanced users who require deeper technical knowledge, and regular updates to keep the users informed about new services and functionalities.

Specialised training is also provided to persons involved in the technical aspects of the project. These include developers, virtual organisation managers, resource centre administrators, resource centre security managers and other support personnel. The INFN GILDA grid computing infrastructure for dissemination and training [17] will be an enabler and a key tool for the transmission of advanced knowledge and will allow new users to gain first-hand, on-the-job experience of a real grid infrastructure, including typical services and applications.

4. GRID COMPUTING IN MALTA

Malta, through the University's Computing Services Centre, has been involved in e-Infrastructure initiatives such EUMEDCONNECT and GÉANT for several years, with the associated benefit of substantially improved international Internet connectivity for academics and researchers.

The need for a Mediterranean Grid project was discussed amongst EUMEDCONNECT participants in late 2004, and an editorial board consisting of members from Italy, Greece and Malta was appointed to pen a proposal for EU funding. The bid was successful, and EUMEDGRID commenced in January 2006 with INFN, Italy leading the project and Malta's participation coordinated by the University's Computing Services Centre in collaboration with the Department of Computer Science and Artificial Intelligence.

The project kick-off meeting was hosted by Malta in February 2006 [28]. A public information session on Grid computing was organised, at which the Maltese Minister for Education, the Hon. Louis Galea, addressed the audience. A number of interviews with the intention of further raising awareness about Grid computing were aired on Maltese television stations during 2006.

Malta, as overall coordinator of the requirements gathering and analysis work package which ran through project months one to seven, was responsible for devising a Grids requirements questionnaire, deploying an online system for the submission of responses, and liaising with the Mediterranean partners to ensure that the call for questionnaire responses reached the intended target audience in the region. By April 2006, ninety-six responses were received from eleven countries. On the basis of these responses, and further information gathered from the partners and other sources regarding the IT and telecommunications infrastructure in the Mediterranean countries, a requirements analysis document for EUMEDGRID was produced at the University of Malta and submitted to the European Commission in July 2006 [10]. This document served as an input to the technical roadmap prepared by CERN within the same work package [11].

Progress has been also made on the deployment of the Maltese Grid e-Infrastructure. The Department of Computer Science and Artificial Intelligence's compute cluster, hosted in the Computing Building, has been a part of the EUMEDGRID e-Infrastructure since summer 2006, and jobs are being successfully submitted from other countries.

The current effort is focused on identifying Maltese grid computing users and applications. Maltese researchers and academics are being solicited to provide EUMEDGRID with information on their possible applications for Grid technology. We are looking for individuals or teams who:

- would benefit from accessing the existing EGEE applications (High Energy Physics, Biomed, Earth Sciences), or other existing Grid applications that could be made available on EUMEDGRID;
- currently use parallel applications running on clusters (using MPI [23], PVM [1], etc.) and would like to 'gridify' them for vastly improved execution speed and capacity for larger data sets;
- require large amounts of compute and storage resources to solve a research problem, but do not have experience with parallel or Grid computing.

A principal target for Malta by the end of the first EUMEDGRID project is to have a number of local users making use of the newly created e-infrastructure to solve research problems on a pilot basis. This will hopefully lead to the Grid service being offered as a standard computing service to academic and research institutions in Malta in the coming years.

A goal of EUMEDGRID is to stimulate the formation of locally funded National Grid Initiatives. In the Maltese context, this is a long term activity which commences with educating the Maltese public, researchers and policy makers about the Grid philosophy that is considered so crucial in the European context.

5. CONCLUSION

This paper has provided its reader with a brief overview of Grid computing and of the EUMEDGRID project. The objectives of EUMEDGRID were discussed, along with an analysis of the project's strategic impact, and the principal actions that are being carried out within EUMEDGRID. Furthermore, an overview of Malta's involvement in Grid initiatives was provided.

The EUMEDGRID initiative hopes to influence the Mediterranean region from the social as well as the technological perspective. While the Grid deployment process is a necessary component of the EUMEDGRID approach, its value would be severely diluted without a corresponding effort to stimulate the creation and strengthening of human networks in e-science, a thriving user community of researchers spanning the Mediterranean, and indeed, the entire world. The nascent e-infrastructure is purely an enabler for this vision.

EUMEDGRID will formally close at the end of 2007. With the project activities well on track, it is the partners' intention to seek

further funding for the continuation of the project, while developing plans to ensure its long-term sustainability.

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