

e-Infrastructures across the Mediterranean



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Foreword



A vision that bore results: our dream has come true

It is my pleasure to introduce this booklet, published during the European Year of Intercultural Dialogue. We ourselves are actively working to improve the levels of collaboration that are already uniting scientists on both shores of the Mediterranean.

Global partnerships of researchers are crucial if we are to address global scientific challenges, particularly those that have high societal and economic impact. Such partnerships form a strategic part of the European Commission's policy to develop a European Research Area (ERA).

ICT based Infrastructures, commonly known as e-Infrastructures, play a crucial role in the development of collaboration amongst scientists. Advanced communication infrastructures like the world-leading pan-European research network GÉANT, and the Grids of computing power that this supports - enable new ways of collaborating and sharing resources. On-line repositories of scientific data provide increased productivity and the ability to collaborate on research independently of geographical location. These e-Infrastructures are the key drivers for virtual research communities now emerging around the world.

Seven years ago the European Commission set out to extend European e-Infrastructures to other regions of the world. The first step was to connect our North African and Middle-Eastern neighbours to GÉANT. Thanks to the strong support of both political and scientific communities on both sides of the Mediterranean, a regional research and education network called EUMEDCONNECT was linked up to GÉANT. Rapidly building on this basic infrastructure came EUMEDGRID, an initiative enhancing cooperation in a very diverse range of research fields from Archaeology to Robotics. These initiatives are now embodied in the national and regional strategies for economic development.

The success of these two pioneering initiatives have lead us to replicate the model very successfully in other world regions such as Latin America, Asia-Pacific, Balkans, Sub-Saharan Africa.

Our efforts in the Mediterranean region have brought yesterday's vision to reality today. E-Infrastructures are bringing real, and very practical benefits to scientific research, supporting collaboration wherever there is a mutual interest, bridging technological and scientific gaps and reducing such phenomena as brain drain.

It is these success stories, and the prospects for future developments in the region that are presented together here in one publication. I would like to thank the EUMEDGRID project for their initiative to prepare this, and hope you will all be inspired by what you read.

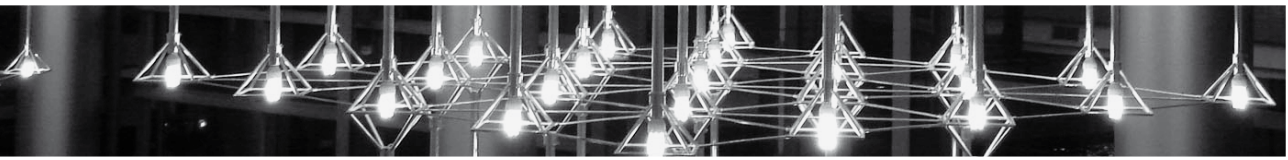
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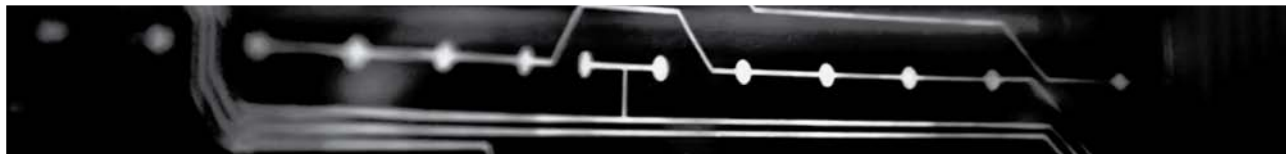


1. About this document



This booklet was written thanks to the contribution of EUMEDCONNECT and EUMEDGRID projects and the Development Activity of GÉANT2. It addresses European and Mediterranean decision makers in the ICT and Research domain (politicians, civil servants, Directors of large research organizations and facilities, senior ICT consultants to Ministers in the Euro-Mediterranean area, as well as relevant International organization and agencies and Private Companies) with the single aim of drawing their attention on the status and perspectives of e-Infrastructures in the Mediterranean. We will hereby provide an overview of the progresses and lessons learned in the framework of European projects and experiences of regional scope, as well as the open issues. We will highlight the importance to bring these progresses further and will propose a roadmap for future initiatives and actions. Furthermore, experts from the world of research, education and industry will provide their insights.

2. Introduction



In the last few years, the scenario of international collaboration in Research and beyond has swiftly evolved with the gradual but impressive deployment of large bandwidth networks.

A number of advanced services and applications have been using these networks, enabling new ways of remote collaboration. The environment resulting from the integration of networking and other resources, such as computing, storage, instruments and related systems is also known as e-Infrastructure. In the most advanced economies, knowledge is nowadays one of the major elements of progress and economic welfare and e-Infrastructures are, in turn, one of the major enablers of development in a knowledge economy.

On the other hand, this menaces to widen the digital gap between developing economies and the most advanced ones, where knowledge is a commodity and an important share of the budget of companies and governments is allocated on R&D and on Education: the latter gets, as a return of their conspicuous investments, more and more advanced infrastructures and techniques that enable in turn new developments, while the former, taken off late and with less resources and urged by more fundamental needs, seem incapable to reduce the gap.

At a first glance, developing countries have much more compelling priorities to fund than building e-Infrastructures. Nevertheless, it is important to understand the role of e-Infrastructures in breaking the loop of mere subsistence. Science is at the basis of long-term innovation in production activities, and digital in-

frastructures are in turn necessary to allow researches to participate to frontier scientific activities, to share competences and experiences with their counterparts all around the world, thus being up with the most recent tools and methods.

2.1 The e-Science vision

E-Infrastructure is a term that is mainly used in the research and development context. It designates the new generation of integrated ICT-based infrastructures.

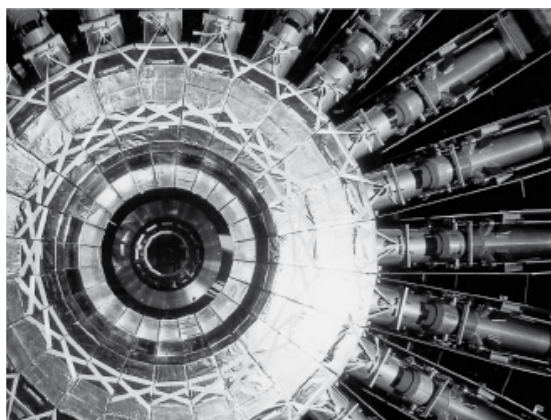
E-Infrastructures exploit several separate components and layers, such as networks, supercomputers and other computing resources, storage, remote resources and instrumentation i.e. sensors. Such elements are seamlessly inter-connected and can be accessed by users all around the world, regardless of their geographical location.

E-Infrastructures are widely considered a key enabler for scientific and social development; their widespread use is rapidly changing the landscape of science and represents an effective answer to problems such as the digital divide and brain drain.

The networking infrastructure delivers the physical connections for the e-Infrastructure. It is the basic layer supporting communication and collaboration among researchers all across Europe and neighbouring countries, as well as specific uses and applications.

In the domain of research and education, networking infrastructures are primarily deployed and managed by the National Research and Education Networks (NRENs) [1] of different countries which interconnect national institutions. NRENs are interconnected with international backbones such as the GÉANT2 [2] pan-European network and the EUMEDCONNECT network [3], which is dedicated to the Mediterranean region.

E-Infrastructures are thus recognised to play a paramount role in future scientific and social development. However their availability, quality and accessibility may vary depending on several factors, such as the national and regional telecom infrastructures and their openness to research institutions, telecommunications markets, and regulations at national and international level. The creation of a network like EUMEDCONNECT in the Mediterranean basin also had some very positive effects on the telecommunications market.



The use of e-Infrastructures is rapidly changing the landscape of science. Remote access to computing services, instrumentation and resources in general, creates new opportunities for researchers to bring existing applications to higher levels of usability and performance. Additionally, it enables researchers to deploy new strategies in approaching scientific problems with simulation tools and intensive applications.

Another benefit of e-Infrastructures is that they stimulate the creation of new scientific communities, uniting researchers who are working on similar challenges and are willing to share resources and reach new levels of collaboration. Researchers can gain access to scientific data and unique instruments located in top level laboratories around the world without the need to travel. They can use very high bandwidth infrastructures with the quality of service requested for their collaborations or applications.

One of the most significant news in the outline of global e-Infrastructures is the so-called “grid paradigm”, a revolutionary distributed environment for sharing computing and storage resources, allowing new methods of global collaborative research. In the future, the global network of computers will become a resource that anyone may access on demand: users will exploit the power of an enormous supercomputer simply by connecting from their PC or, eventually, by any kind of consumer electronic device (portable phone, Multimedia, iPod, etc.).

A number of scientific applications that demand high levels of computing power and data processing are already exploiting grid technology, which enables different computing centres, wherever located, to collaborate on the same computation as though all their CPUs were in the same room.

2.2 What are e-Infrastructures and how can they be a trigger for development?

Research and Education Networks and Grids contribute to the development of technologies by requesting state of the art performance and services to the providers of telecommunications and computer manufacturers.

The rapid development of e-infrastructures will be accompanied by the appearance of new and pervasive services in other fields such as business, banking and government. However, across different countries there is still unevenness in availability, quality and accessibility of services, with gaps existing even within countries.

In order to ensure equal opportunities for researchers, narrowing the gap is of the utmost importance. Several initiatives in the European Union and neighbouring countries aim at this objective. GN2, the project that

provides funding for the GÉANT2 network, includes an activity to support the development of research and education networking in less advanced regions in and around Europe. In the past few years this “Development Support” activity has devoted significant effort to the Mediterranean region.

For emerging countries, the creation of e-Infrastructures represents something more than the mere adoption of a new technology developed by someone else. Indeed, it appears that the grid paradigm is especially useful for those countries that have scarce, often scattered in a wide territory, IT resources at their disposal. The implementation and coordination of a grid infrastructure at a National (or larger) level can be regarded, especially in developing countries, as an opportunity to optimize the usage of existing, limited storage and computing resources and to enhance their accessibility for all research groups. These Grid Infrastructures could, as well, become the seed for further investments in larger facilities and/or in High Performance Computing, once a sufficiently large request has emerged from the scientific community.

Many research fields have indeed very demanding needs in term of computing power and storage capacity, which normally are provided by large computing systems or supercomputing centres. Furthermore, sophisticated instruments may be needed to perform specific studies. Such resources pose different problems to developing economies: they are expensive, they need to be geographically situated in a specific place and – this is the case especially for those countries where the larger part of researcher is forced to emigrate in richer countries to continue their work in research – they could not reach a critical mass of users, because, for example, they are very specific and interest only a small community of researchers, or small communities scattered across the country. Thanks to the creation of a virtual distributed environment, all these drawbacks



can be overcome. Through an appropriate access policy, different user groups can use resources wherever they disperse according to their availability. Furthermore, geographically dispersed communities working at the same problem can collaborate in real time on the same study or experiment, thus optimizing not only hardware and software resources, but also human efforts.

2.3 Added value of the international approach

The international dimension is a key aspect in perspective of the so-called “Lisbon strategy”: “Research infrastructures top the list of areas where a European approach is called for, given the levels of funding involved and the need for them to be given the means to ensure they are able to provide services on a European scale. Issues related to major infrastructures cannot be dealt with effectively at national level. Needs in this area must be defined and decisions taken at European level.” [4]

In the last years, the EC posed a special attention in connecting “neighbouring” countries and recommended the “Exploration of the scope for using Article 169 to establish regional cooperation between countries participating in the Framework Programme which are geographically near to each other and are linked by historical ties or by common problems, such as EU countries and, where appropriate, associated Candidate Countries in the Mediterranean or Baltic regions” [5]. Instances of this strategy and its results are a number of initiatives co-funded so far by the EC in the Baltic, the Balkans and the Mediterranean itself.

The creation and support of a common platform enabling daily cooperation for European and Neighbour scientists is then twofold strategic: on one hand, it tries to speed-up the catch-up process of less advanced

countries giving them the opportunities of using leading-edge technologies and state of the art resources; on the other, it allows the extension of the European Research Area to the South-Mediterranean and middle-East countries with the opportunities of accessing unique facilities and a large number of brilliant brains which will actively and productively collaborate in the challenging research activities currently held in Europe and World-wide.

2.4 International Scenario & European initiatives

At the world scale, a large number of international Grid projects are on going, with different purposes and concerning a very large variety of categories of users and applications. Essentially, all the major countries in the world are, either directly or indirectly, involved in large scale Grid projects and national Grid initiatives. In the USA, the major projects are the Open Science Grid, and TeraGrid.

The Open Science Grid [6] is supported by the National Science Foundation (NSF) and the Department of Energy, and it is aimed at providing computing power and storage capacity to American researchers through the set up of a distributed Grid infrastructure and the deployment of the Virtual Data Toolkit middleware.

TeraGrid [7] is supported by the NSF and 11 partners in the USA. Its goals are to enable powerful Grid computing capacities, storage, integration of different data sources for the scientific community; its key indicator numbers are very relevant: 750 Teraflops of computing capability and more than 30 Petabytes of online and archival data storage, with rapid access and retrieval over high-performance networks. Researchers can also access, through TeraGrid, more than 100 discipline-specific databases.

Very relevant Grid projects are also on-going in Japan (NAREGI [8]), in China (China National Grid [9]) and India (GARUDA [10]).

The European scenario is outstandingly represented by the EGEE project, by far the largest and most important EU funded Grid infrastructure project. EGEE (Enabling Grids for E-SciencE [11]) is a collaboration from 90 partners in 32 countries, organized in 13 Federations. The associated Grid production infrastructure is comprised of more than 240 sites across 45 countries offering around 45,000 CPUs, and more than 5 Petabytes of storage. The infrastructure is available to users 24 hours a day, 7 days a week, achieving a sustained workload of approximately 30,000 jobs/day. A trusted federation of Certification Authorities (Eu-GridPMA [12]) grants the issuing of credentials to the EGEE users, and this federation belongs to a world-

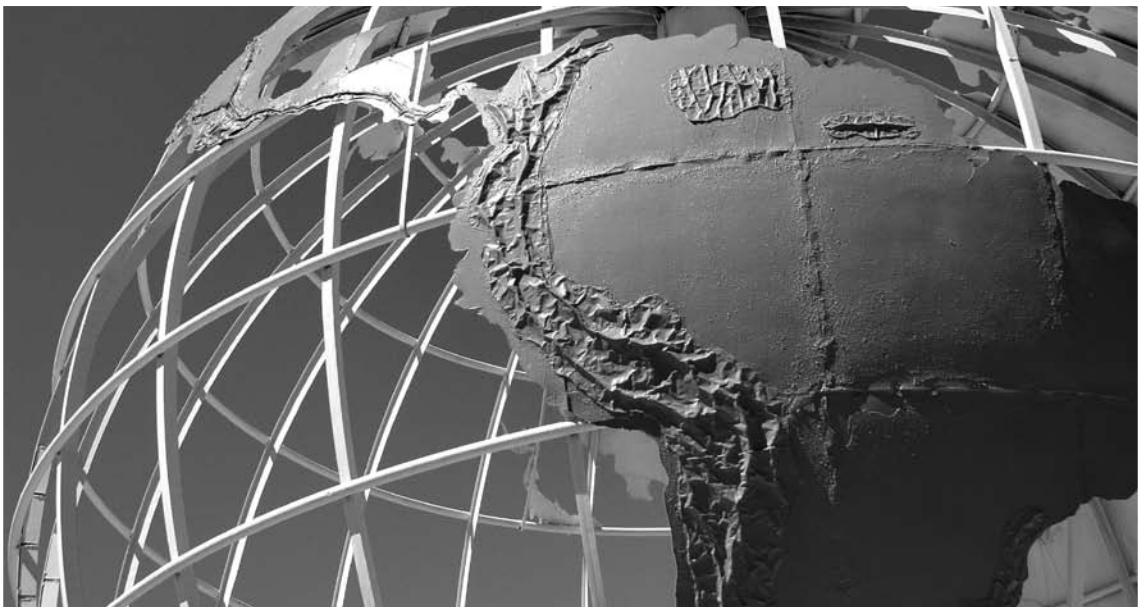


wide network of trust called International Grid Trust Federation (IGTF [13]). IGTF provides the basis for a world-wide interoperable Grid infrastructure. EGEE is actively involved in the Open Grid Forum (OGF [14]) promoting the adoption of common standards in the Grid domain, and above all being involved in the GIN working group (Grid Interoperability Now).

The EGEE Applications community is represented by around 250 registered virtual organizations, covering a variety of different disciplines like Bioinformatics, Chemistry, High Energy Physics, Fusion Physics, Health Science and Medicine, Life Science, Astrophysics, Earth Science, Earth Observation, Computational Fluid Dynamics, Computer Science. The EGEE infrastructure is also used by the WLCG project, the World Wide LCG Computing Grid [15]. EGEE provides a distributed computing infrastructure for the data analysis of the huge amount of data provided by the Large Hadron Collider at CERN, the European Laboratory for Particle Physics. EGEE also indirectly supports a number of related projects, such as geographical expansions to areas around Europe, such as SEE-GRID in South Eastern Europe, BalticGrid in the Baltics and Eumedgrid in the Mediterranean basin. In addition, its middleware is used by different application projects such as DILIGENT (Digital Libraries) and BionfoGRID (Bioinformatics). There are also a lot of support projects with which EGEE has special collaboration, such as ICEA-GE (dealing with Grid education) and ETICS [16], a software management quality project, on which the EGEE middleware (gLite) is integrated, built, quality assessed and released.

The Nordic European Countries are federated in two major Grid projects: The Nordic DataGrid Facility [17] and NorduGrid [18].

In essentially all European countries, parallel to the national contribution to EGEE and other international Grid project, the National Grid Initiatives (NGI) are relevant actors to coordinate at the national level the development and deployment of Grid middleware and infrastructures. NGIs will be coordinated for the establishment of a long-living permanent European Grid Initiative, whose scope is much longer than the short-living projects on Grids. EGI [19] will therefore take over at the end of phase three of EGEE, which is starting in spring 2008 and lasting until spring 2010, to implement a permanent European Grid infrastructure, allowing interoperability among the NGIs and the existing deployed middleware distributions, coordinating the national efforts on Grid computing.



3. E-Infrastructure experiences in the Mediterranean



3.1 Seven years of cooperation

The adventure of Euro-Mediterranean cooperation in e-Infrastructures started in the framework of the EUMEDIS programme [20]. Funded by the European Commission's EuropeAid directorate, whose main aim is a series of cooperation activities with emerging regions worldwide, EUMEDIS frames a number of interventions aiming at speeding up the establishment of the Information Society in the Mediterranean. Different levels of actions were foreseen, including the implementation of a regional IP-based communication network devoted to Research and Education. Thus, EUMEDCONNECT was born 7 years ago. From that moment on, the e-Infrastructure community has grown in size and activeness and a number of results were reached.

3.2 GÉANT2 - NA4 Activities

The Development Support activity of GÉANT2 aims to lower the gap between different countries in Europe and its neighbouring countries by helping the development of research and education networking. The geographic range of this activity encompasses the countries represented by partners in GÉANT2, as well as the countries in southern and Eastern Europe and the Mediterranean region, which are currently participating in the SEEREN2 [21] and EUMEDCONNECT projects.

The activity is addressing in particular knowledge transfer in technical, managerial and policy areas. Detailed

country assessments are an important element in deciding the nature of aid to be provided by the project, and in advising actors at the national and local level about actions that they can undertake themselves to promote the development of research networking in their regions.

Since the start of the activity, support has been provided for the following countries in the Mediterranean region, with experts of the NREN community visiting high level people in relevant ministries and key stakeholders in the country. Those visits lead to country needs assessments, and the organisation of workshops. See the list hereunder:

- May 2005, Country Needs Assessment of research and education networking in Morocco;
- October 2006, Country Needs Assessment of research and education networking in Malta;
- January 2007, Workshop on eduroam in Nicosia, Cyprus;
- April 2007, Workshop on eduroam in Gökova, Turkey;
- June 2007, Workshops on eduroam and identity management in Rabat, Morocco;
- October 2007, EU-MED Event in Brussels, Belgium.

The Development Support Activity is lead by TERENA, the Trans-European Research and Education Networking Association [22]. TERENA staff members are assisted in their work by a Development Support Advisory Panel; the panel currently includes senior representatives from the following NRENs: CYNET (Cyprus) [23], SigmaNet (Latvia) [24], PSNC (Poland) [25], RENATER (France) [26].

3.3 The network: EUMEDCONNECT

The EUMEDCONNECT project is a pioneering initiative to establish an IP-based network that serves the research and education communities of the Mediterranean region and is linked to the pan-European GÉANT network. With the help of the project, national research centres and institutions in the Mediterranean region now have dedicated connectivity to the European research and education community via GÉANT2, and to other research communities worldwide. Countries in the Mediterranean region connected to the EUME-



DCONNECT network either directly or via GÉANT2 are Algeria, Cyprus, Egypt, Israel, Jordan, Malta, Morocco, Palestine, Syria, Tunisia and Turkey. The European Commission's EUMEDIS programme was instrumental in establishing the network and provided 80% of project costs up to the end of 2007 when this funding support ceased. The network is continuing temporarily using the funding reserves of partners but this can only be a temporary stopgap measure, and further EC funding is sought to allow the benefits to be maintained for the long term.

The project started in 2001 and the network entered service in 2004. EUMEDCONNECT was the first non-EU regional networking programme supported by Europe. Thanks to its success the approach has also been used to regional R&E programmes for Latin America (ALICE) [27] and Asia (TEIN2) [28].

In each country, the EUMEDCONNECT network connects to the National Research and Education Network. The Mediterranean partners form an Internet community using a combination of direct physical links and virtual pathways via the GÉANT2 network. And the EUMEDCONNECT project also helped training Mediterranean NRENs as some dedicated actions and budget were devoted to training. Topics covered by the EUMEDCONNECT trainings have included BGP,

Multicast, security, and NOC (Network Operation Centre) management.

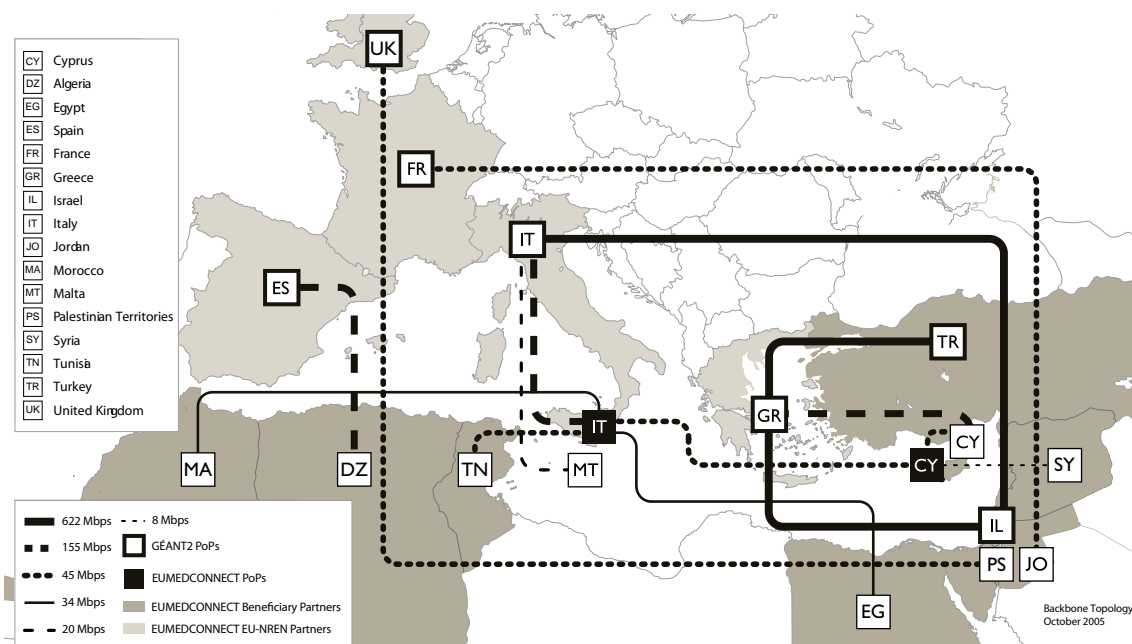
In addition to networking the Mediterranean countries together, the links to GÉANT2 also provide connections to major Research and Education in Europe and worldwide as well as access to the commercial Internet.

The project has also stimulated the development of national research and education networks in the partner countries. In most countries the national networks have been significantly upgraded during the EUMEDCONNECT project term.

The first EUMEDCONNECT hub was established at the University of Catania in Sicily. This is not only in a geographically central position but also, importantly, a major landing point for the fibre-optic cable systems serving the Mediterranean region.

The second EUMEDCONNECT PoP (Point of Presence) in Nicosia, Cyprus, came into service in January 2005. The EUMEDCONNECT network is now well established. The map below shows the current status of the network.

Mediterranean NRENs are aware of the importance of international connectivity for Research and Education and are therefore actively pursuing measures to ensure its continuation beyond the end of EUMEDCONNECT.¹ Efforts in this direction led to the Rome Declaration



¹ Recently, several actions have been carried out at the policy level to identify alternative sources of funding as well as to influence national governments and institutional bodies in supporting network connectivity for research. The EU-MED event, which was held in Brussels on the 23 and 24 October 2007, was a dedicated high-policy event to promote the follow-up of Grid and Research and Education networks in the area.

and in a number of letters and contacts with national-level politicians in order to ensure the largest possible support to the continuation of EUMEDCONNECT.^[29] The coordinator of the project is presently negotiating a replacement regional network project EUMEDCONNECT2 to follow on from EUMEDCONNECT in the framework of the new European Neighbourhood Programme. Provided EC funding can be secured, the plan is for regional networking to continue seamlessly and further evolve the existing regional network infrastructure for the further benefit of the user community which consists of over 1.4M researchers and educators in over 400 academic and research centres.

With the aim of complementing the EUMEDCONNECT efforts and in the view of achieving long term sustainability, a very interesting study has been conducted by Ministry of ICT of Jordan. The outcome of the study is illustrated in the picture below and it is based on the possibility of usage by the research and education community of a fibre network across the Mediterranean (MED-BELT) based on power lines.

The estimated costs were: CAPEX 34-44M USD (depending on actual technology), OPEX: 3M USD per year in the two cases of acquiring the fibres or renting respectively. The plans were completed in November 2005, but have not yet been taken forward. If the MED-BELT project does take place it could give much higher and cost effective capacity, and the EUMEDCONNECT2 programme has already indicated that it would work in a co-operative and co-ordinated way

with this new infrastructure.

Following this study, many efforts and actions were taken towards the creation of a stable Mediterranean network for Research and Education. The representatives of Institutions of Arab Mediterranean countries (Morocco, Algeria, Egypt, Palestine, Jordan and Syria) interested in R&E networks, signed the Rome Declaration in September 2006. Tunisia, Libya and Lebanon have also been invited to join the consortium.

The signing countries declared that they will:

- promote and support the establishment of NRENs in their home countries;
- lead the efforts towards the creation of a sustainable regional network;
- actively promote in their countries the usage of research e-infrastructures.

In a longer-term perspective, most Mediterranean NRENs are currently interested pursuing the creation of an association or a legally established consortium (CAMREN – Consortium of Arab Mediterranean Research and Education Networks) with the mission of improving the current networking situation. Such organization could be a major actor in proposing and steering further regional projects and initiatives in the field and could easily widen its mission to e-Infrastructures in general, thus proposing itself as a privileged party at an international level.

The consortium agreement is bound to be signed in the next few months. The consortium will work closely with European Commission and especially with the



projects related to research and research e-Infrastructures. One of the main activities of the consortium, in the near term, will be securing the funds needed to build the regional network and to promote the use of networks and e-Infrastructures in research and education in these countries.

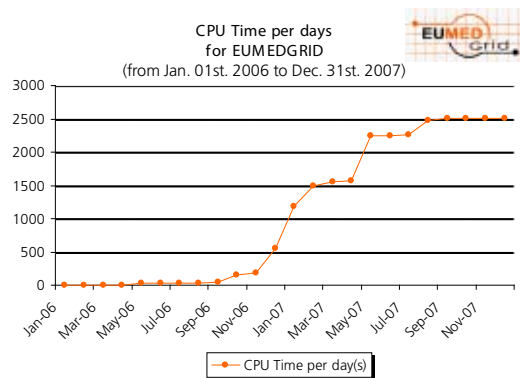
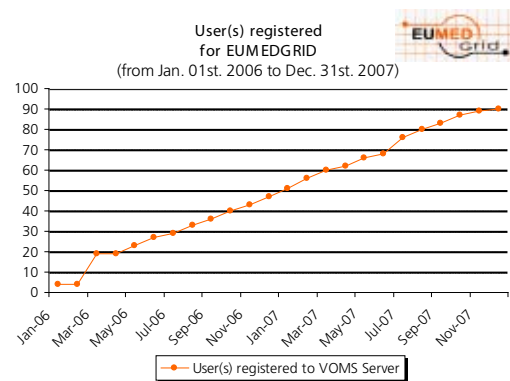
3.4 The Grid: EUMEDGRID

The EUMEDGRID Project started on the 1st of January 2006 with a 26 months duration. [30] Scientific and technological organizations from 14 different Countries (Algeria, Cyprus, Egypt, Greece, Israel, Italy, Jordan, Malta, Morocco, Palestine, Syria, Switzerland, Tunisia, Turkey, U.K.) collaborate as partners and third parties in the initiative. Cooperation among all participants has been demonstrated by the enthusiastic participation to common workshops and meetings (Rome, Marrakech, Amman, Algiers, Damascus and Tunis) organized during the year and the good progress made towards the creation of stable national Certification Authorities (CA) and Grid initiatives. Impressive results were also obtained in the training events on Grid Technology, delivered in all participant countries for about 700 trained people including researchers, application developers, system administrators and university students. The 1st EUMEDGRID Grid School (EGSAP1 [31]) was definitely the biggest and most important training event organized during the lifetime of the project. It was organized in Cairo (Egypt) in collaboration with the EUN University [32] due to its strategic geographical position in the Mediterranean region. During the 1st EUMEDGRID Grid School Several research groups had the opportunity to port their own applications into the EUMEDGRID e-Infrastructure. Moreover, the EGSAP-1 event gave to the EUMEDGRID project a very high level of visibility coming from Egyptian decision makers up to local and international media.

At the root of project is the challenge to create a pilot infrastructure capable of triggering the cooperation between European and Mediterranean scientists. The infrastructure was bound to eventually become part of EGEE and be integrated with analogous initiatives worldwide. As several countries in the area started (almost) from scratch, the project had also an ambitious plan for raising grid awareness and creating new skills among the researchers operating in the Mediterranean. After almost two years, we can affirm that the strategy proved to be very effective and led to a number of results beyond technical achievements. As of today, a pilot Grid infrastructure including 14 sites from all partner countries has successfully been established. Other sites are currently in the process of joining, while some of the initial ones are taking steps to reach

production quality. Many pilot applications, selected for their strategic impact in the region and belonging to several fields of research such as Archaeology, Hydrology, Physics, Biology, Engineering, Robotics, and Cognitive Sciences, have been deployed and are currently available on the pilot e-Infrastructure.

The EUMEDGRID e-Infrastructure is actually receiving a very good feedback from both users and application developers. Statistics taken from grid accounting services shows that from January 01st 2006 to December 31st 2007 the e-Infrastructure have counted about 90 different users registered and a total of almost 2500 CPU Time per days.



The esteems reported above show the importance of the e-Infrastructure as a test-bed to improve and speed up the technical development of the Mediterranean Countries.

In most of the Mediterranean countries, scientists do not have the opportunity to run programs in parallel how much time do these programs consume. The EUMEDGRID infrastructure gives the chance to those users to run their applications from their institutes. EUMEDGRID allows, as well, EU scientists

to work with Mediterranean scientists remotely on projects and research points of interest instead of bearing the cost of travel and accommodation of MED scientists and charging this cost on the projects.

Most of MED countries do not have enough budget to acquire up to date labs in different fields of specializations and even if they have labs they are sometimes not accessible for all scientists in the country and hence those labs do not serve the entire community in the same country.

The sharing of resources helps scientists to proceed further and faster in their researches and inventions. It activates, as well, a human network among different people in the same field of specialization not limited to a country but widened to the EUMED region leading to a friendly and peaceful cooperation environment.

3.5 Applications

Several applications were selected to be deployed on the EUMEDGRID e-Infrastructure spanning several fields of interests: High Energy Physics, Biology and BioMedical, Hydrology, Archaeology, Seismology Vulcanology and Finance. Many of them were selected thanks to a large survey delivered to scientific groups working in the region, while some other have been chosen taking into account their regional relevance (ArchaeoGRID and CODESA-3D) and by selecting them amongst a set of candidates proposed by local research groups interested in exploiting grid technology in their work.

All the applications selected during the project's lifetime have been deployed on the official pilot e-Infrastructure with the support of a pool of grid experts who provided all the technical know-how and experiences in order to grid-enable user's application. The valuable work performed so far by WP4 helped

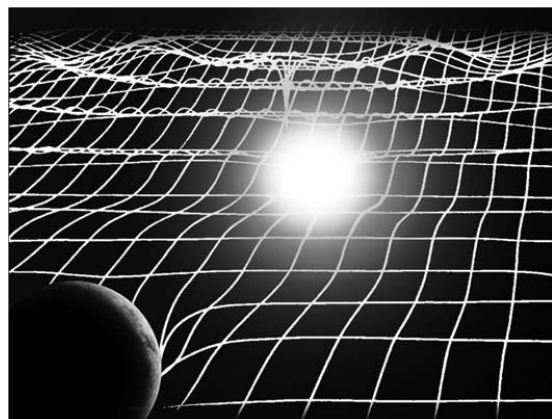


scientists, coming from different scientific domains, to embrace the grid paradigm for research activities changing the way to make research. Grid paradigm provide scientists a new means for collaborative research by facilitating the sharing of computational and data resources at an unprecedented scale.

The following table depicts the applications successfully deployed on the official e-Infrastructure:

Application	Country	Institute
ARCHAEOGRID	Italy	University of Florence
CODESA-3D	Italy - Tunisia	CRS4
GROGET	Morocco	Faculté des Sciences de Meknes
HERO	Egypt	Helwan University
HuM2S	Turkey	Bogazici Univerisy
JP2_GRID	Tunisia	ESSTT
MINSP	Syria	HIAST
PAREL	Tunisia	ESSTT
SACATRIGA	Morocco	UAE/FST Laboratory of Radiation & Nuclear Systems
SimCommsys	Malta	University of Malta
Grid Taxation	Greece	University of Macedonia

In order to highlight the benefits introduced by the grid paradigm and use the established e-Infrastructure as dissemination tool, we can report the experience gained by some other projects such as MedGeNet (Euro-Mediterranean Network for Genetic Services) [33]. The MedGeNet project, founded by European Community in the 6th Framework Programme, aims to expand the human expertise in clinical genetics and cancer genetics through the transfer of knowledge and technology in the Mediterranean area, which share a common burden of genetic diseases. The expanding of this knowledge between Mediterranean countries and Europe can be achieved at a reasonable cost exploiting the pilot Infrastructure established so far during the EUMEDGRID project.



4. A Roadmap for the future



E-Infrastructures, and Grid Technologies in particular, can be considered the forefront of a more general and large change in the interaction between ICT and human resources. They seem to announce a new and more pervasive way of using technologies to disseminate knowledge and accelerate processes related, not only to the Scientific Research, but also to Business, Industry and fundamental domains like health and climate.

Despite the large number of examples already available, none really knows how these future will look like and how long it will take to turn this vision into reality.

A discussion regarding the short term opportunities, however, can certainly be done. Long term visions and possible objectives of future actions are, as well, domain of present speculation.

4.1 A challenging vision: objectives & open issues

It is not very clear yet, which will be the name of the next generation ICT revolution (see the interview to F. Gagliardi in the following) although a number of candidates appeared on the scene in the last decade (Grid, Web Services, Cloud Computing). On the other hand, the vision behind them is very similar: exploit completely the opportunities of a growing pervasive availability of ICT resources.



This vision needs to be enabled by advanced networking infrastructures and easy-to-deploy-and-use middleware. The challenges for developing countries are then related to the possibilities to eliminate all the obstacles that prevent the realisation of these e-infrastructures, such as: Digital Divide and Brain Drain.

4.2 Networking

The EUMEDCONNECT project has demonstrated the value of a high capacity network infrastructure dedicated to research and education purposes, and has stimulated the development of national infrastructures and collaborative applications. For the first time the diverse countries of the Mediterranean are connected to each other and to the European research community via the interconnection of EUMEDCONNECT and GÉANT2 networks. The primary challenge is to maintain the infrastructure to provide a long term platform that the national NRENs and their user communities can rely on and can plan further collaborative programmes. In addition there is the desire to increase network capacities: typically EUMEDCONNECT access circuits are 34 or 45 Mbps speeds today: the aim would be to increase these to at least 155 Mbps and in time to gigabit speeds to cater for a larger number and more bandwidth intensive applications. To achieve this vision, it is essential that long term funding and organisational structures are established that can sustain the network layer. Over time it is also hoped that markets will become more competitive and open; these changes have been slow during the EUMEDCONNECT period, but there are some signs indicating a greater competitiveness and a growing awareness of the importance of non-commercial research and education among the telecommunications suppliers of the region.

Through CAMREN, the Arab Mediterranean Countries will push towards extending the EUMEDCONNECT and the EUMEDGRID projects, and at the same time will work on building a sustainable regional research network and support the national research network at each country. CAMREN is not legally established yet, it started the activities of promoting the concept of research networks and collaborative approach in doing research among the Arab Mediterranean Countries, it was introduced to the research communities in Mo-

rocco, Algeria, Jordan, Syria, Libya, Tunis and Egypt. The concept was also introduced and discussed with the Arab League ICT Policy Committee meeting in Amman (28-30 Sept 2007) and it was welcomed and to be adopted in the General Arab Strategy for Communication and Information Technology. The CAMREN approach makes a step forward from bilateral agreements to the vision of peaceful cooperation in the Mediterranean Area and in the Middle-East.



One of the major networking activities in the region is the utilisation of the Arab States Network Access Point (NAP) which consists of four NAPs for the Arab Region these NAPs will be located in Morocco, Egypt, Jordan and Arab Emirates, where each NAP will connect the neighbouring countries and then these four NAPs will be interconnected together and to the Internet. This project is managed by the ITU office in Cairo. CAMREN started to explore the opportunity of building the Research network along with this project. Although the NAP project is considered as commercial project it was accepted by the ITU to include the research network requirements in the study and the implementation plan.

CAMREN is also exploring the funding opportunities and some discussions have already started with possible donors, mainly the EC. CAMREN needs to capitalize on the political support in the different Arab States to build a sustainable network and to assure political blessing for the cooperation between the different research institutes in the different countries.

A project to investigate the opportunities of connecting Jordan, Palestine and Syria to Cyprus was appro-

ved by the EC (LinkSCEEM) and the study will be conducted by GRNET in the first half of 2008.

4.3 Grids infrastructure & resources

The Grid infrastructure provides computational and storage resources to scientific and academic communities allowing them to store, process and share scientific data enabling them perform their research by accessing those resources remotely. The Pan European Grid Infrastructure (EGEE) enables thousands of European users to have access and share a large amount of resources. The EUMEDGRID projects enabled the creation of a similar Grid infrastructure in the countries of the Euro Mediterranean area. The EUMEDGRID, Grid infrastructure comprises of resources distributed among all the participating countries in the EUMEDGRID project. It currently comprises of 20 resource centres offering more than 1850 CPUs and 33 TBs of storage available to researchers and scientists in the area. At least one resource centre is created in all countries of the Euro-Mediterranean area that participates in the EUMEDGRID project. Users of the region access the infrastructure by using digital certificates issued by the catch-all certification authority as well as form some of the national Certification Authorities that have been created in the countries of the area. This network of certification authorities provides seamless access to resources to all the members of the scientific communities of the Mediterranean countries. More important, a human network of administrators, resource centre managers, operations personnel and user support teams has been created among the participating countries that already have the expertise



to operate, maintain and make available the infrastructure to its users.

4.4 Applications

A group of new EUMEDGRID e-Infrastructure adopters will be created to contact the promoters of the applications that haven't been yet selected but were considered as promising in the evaluation phase. Feasibility studies will be started so as to port them in the Grid environment.

One of the most recent requests coming from the Tunisian partner is to open the e-Infrastructure to other Grid environments, exploring the new universe of Interoperability with other infrastructures, with a particular attention to the new P2P environments.

Another key aspect in broadening the user community is the opportunity to attract new EUMEDGRID users and especially newcomers, allowing them to use the e-Infrastructure through the MS Windows operating system. It is important to target this community of users, since most of the Mediterranean people are more confident with MS Windows. This can be done by exploiting already available Linux software packages and building upon the results of success projects that are currently integrating Grid services onto Windows machines thanks to emulation layers.

4.5 Multiplying competences

Thanks to the big number of tutorials organized by the project, and in addition to the EUMEDCONNECT trainings, at this stage EUMEDGRID can rely on a expert group of local tutors that can help speeding-up the integration process of regional applications over different scientific disciplines. These tutors can be also exploited to further disseminate the e-Infrastructure paradigm, thus widening the number of new EUMEDGRID users. This should start a human exchange chain reaction in order to multiply the competences involving

new user communities and informing decision makers about the results of such activities, thus promoting the long term sustainability of the infrastructure.



4.6 Getting involved with industry and other partners

Despite the lack of resources that can generally be allocated by developing countries an enormous enthusiasm towards collaboration with industries is characterising the community of researchers and Universities. Technical and applied researches are, as well, among the main drivers of such collaborations, but it's not unusual to find programs, funded by industries, that aim at larger scopes and tend to strengthen the link with High Education and Universities in several countries of Africa and Middle-East.

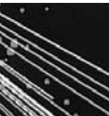
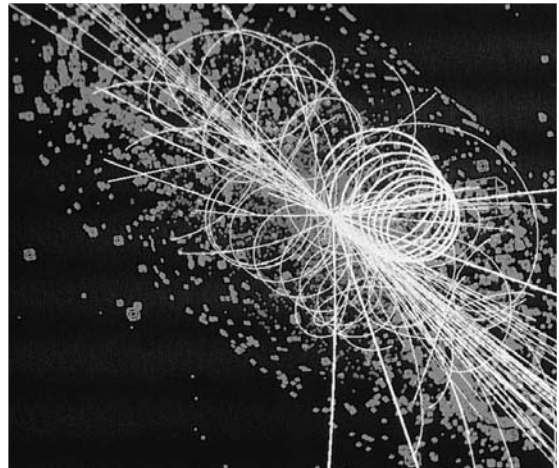
In many cases such broader scope programs are developed with the patronage of relevant not for profit International Organisations like UNESCO [34].

An example of these kind of programs is the HP's project with UNESCO to counteract the "brain drain" in Africa launched in 2006. Skilled professionals, scientists, academics and researchers are estimated to be leaving the continent at a rate of 20,000 per year, depriving many African countries of the human and intellectual capital they need to develop. This project, "Piloting Solutions for Reversing Brain Drain into Brain Gain for Africa", will provide grid computing techno-




logy to universities in Algeria, Ghana, Nigeria, Senegal and Zimbabwe to help re-establish links between researchers who have stayed in their native countries and those that have left, and to connect scientists to international colleagues, research networks and funding opportunities. Faculties and students will also be able to work on major collaborative research projects with other institutions around the world. The project follows a similar successful joint HP-UNESCO initiative to address brain drain in South Eastern Europe.

Several industries provide software and hardware products and solutions that are used in the Grid environments. Discounted licensing and Academic programs are frequently offered to facilitate the adoption of such hardware/software solutions in the developing countries.



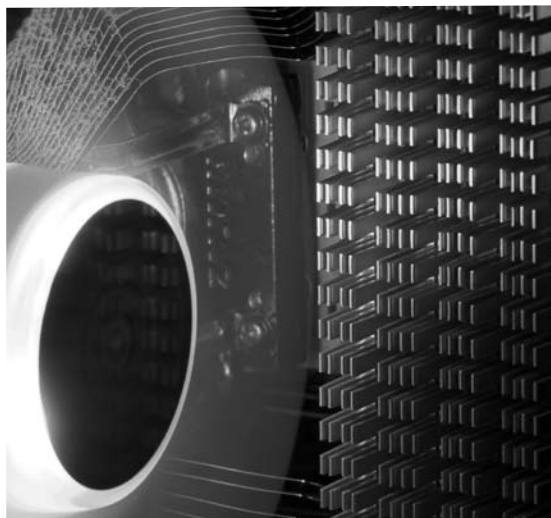
5. Conclusions & Recommendations



Experiences as EUMEDCONNECT and EUMEDGRID are having deep impact in the development of e-Infrastructures in the Mediterranean, thus contributing to reduce the digital divide between the two sides of the Mediterranean.

In seven years of cooperation in this field, lots has been done, and not only from a merely technical point of view. Awareness of new ways of doing (e-)Science is raising not only amongst the scientific community, and in particular amongst young researchers, but also at a Policy level; this has brought to first endorsement of stable initiatives concerning e-Infrastructures in several Mediterranean countries, as well as to dedicated investment, thus putting the seed for a long term sustainability of e-Infrastructures in the Region.

The results achieved so far need however to be consolidated, both on the technical and organizational side; furthermore, they will be widely advertised to decision makers in order to gain their support.² The core of the approach carried out so far is to set off the existing human network in the e-Science area, transforming a pioneering community in a critical mass of users and managers capable of driving the uptake and further evolution of e-Infrastructures in their countries. This outcome only will enable a real, effective and equal collaboration between Europe and its neighbouring countries.

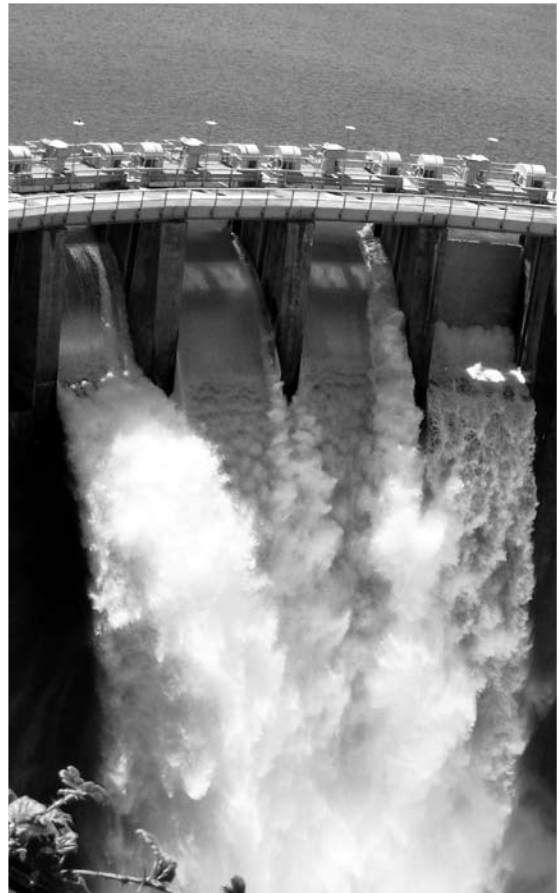


The following are a few recommendations born from the experience gained so far by a number of partners and intended to guide further evolutions of the e-Infrastructures in the Mediterranean.

- The academic and research community in the Mediterranean region should count on a regional infrastructure for data communication to improve cooperation in the area of academic research and investigation and education within the region and globally. Such objective should be pursued within the scope of a regional consortium, capable of supporting applications and e-services that assist research, education and learning in these countries.
- Existing Mediterranean NRENs should cooperate in the development and consolidation of national research and education networks in those countries in the Mediterranean region, where they do not yet exist or where they have recently been founded.
- Network and grid infrastructures, wherever they exist, should be dependable, extended and improved in the whole Mediterranean Region as much as possible.
- The non-European countries of the Mediterranean Area at large should profit extensively from the collaboration and cooperation with European Institutions and Research Programmes to build the basis for the long term sustainability of both network and grid infrastructures in the area.
- Grid computing scientists and professionals of non European countries should devote reasonable effort to foster the creation of a national demand for deploying computational grids in applications that need high performance computing in all sectors of their countries. They should as well raise awareness of decision makers in their countries, informing them on the strategic potential of such e-Infrastructures and soliciting clear plans on the deployment of supercomputing capabilities through distributed computing models such as grids. Grid scientists in the Mediterranean region should be sponsored to disseminate grid and parallel computing knowledge among the scientists of the their country. They should be incentivised to promote the sharing of resources using the grid infrastructure built by EUMEDGRID during the last couple of years and to increase and maintain this infrastructure open

to all the countries in the region and to the largest possible number of Virtual Organisations (VO).

- National Grid Initiatives should be sponsored by the governments and ministries to reach an adequate level of shared resources among scientists in the same country and in the EUMED area, hence minimizing resources costs and implementing a more productive team work in the area.
- The creation of curricula relating to e-Infrastructures, such as networking, grid computing architectures, operating systems, middleware, and applications should be encouraged in the Mediterranean Countries, as well as the registration of related master and doctoral degrees. New research fields such as the utilization of agent-oriented technology in computational grids, service-oriented architectures over grids, should be proposed and pursued.
- Synergies and regional collaboration should be pursued as much as possible and decision makers should be contacted by groups of high-visibility persons in the various countries.
- Regional e-Infrastructures such as EUMEDCONNECT and EUMEDGRID (and their future successors) should be considered as the most important incubator in the Mediterranean Region for the establishment of inter/multi-disciplinary (e-)scientific collaborations.
- It is instrumental to have a regional network based on optical fibre to connect the non-European Mediterranean Countries among themselves and also to the other Regional research networks; mainly GÉANT.



² The work towards this objective started within the framework of the EUMEDGRID activities and led to the organization of dedicated events at a national and international level. See as a reference the EU-MED Event, which was organised in collaboration with EUMEDCONNECT and the GÉANT2 Development Support Activity: <http://www.terena.org/eumedevent>.

6. Insights



E-Infrastructures: a strategic view



Prof M. Najib Abdul-Wahed,

is Deputy Minister of Higher Education of Syrian Arab Republic and from several years actively promotes the necessity of building e-Infrastructures in Syria and the rest of the Mediterranean Region.

The experiences of EUMEDCONNECT, EUMEDGRID and GÉANT2, e-infrastructures fostered by our European partners in the Mediterranean region, witness about an open and friendly scientific dialogue between both sides of the Mediterranean, which is a great result in itself. After several years of such a fruitful collaboration, it seems only too appropriate to draw some reflection as to the expected role, results and impact of e-infrastructures, as well as the critical role played by our EU partners in the creation of endogenous research and development capabilities in the Mediterranean Countries.

As a matter of fact, e-Infrastructures are not only a prerequisite for development, but the enabling tool for its uptake, for several reasons.

First, e-Infrastructures represent a way of leapfrogging in technology: my country, like other developing countries, needs a big leap in order to catch-up with most advanced countries, and ICT represent the perfect catalyst for this.

Second, as they are the platform to exchange knowledge, which is in turn a virus that transmits innovation, e-Infrastructure enhance a country's potential for innovation.

Third, e-Infrastructures are the best networking environment, both for institutions and individuals to communicate and collaborate with the rest of the world.

Four, projects such as EUMEDGRID proved that e-Infrastructures are a new opportunity to access more resources more efficiently – a very important point for developing countries which have limited resources.

E-Infrastructures are widely considered as key enablers

for development and for bringing developing countries at the same level of most advanced ones. This view I share, provided of course that there is a real intention in most advanced countries to bring developing country to their very level, regardless of political considerations. Look at the situation in the Middle East and the political tension it brings along: science and technology should be somehow separated from this and collaboration in this field can represent a catalyst for peace, as well. In Syria we have often experienced this virtuous communication in using e-Infrastructures. We are involved in several international initiatives (i.e., for instance, agriculture and the study of earthquakes) that show the benefits of treating problems in a joint endeavour, the enhanced efficiency that the collaboration with European scientists can bring and a concrete appreciation of the potential impact of using e-Infrastructures on the quality of life of the People.

This brings me to highlight what is probably the most important lesson learned with the participation in such initiatives: the fact that although establishing e-infrastructures have proved to be fundamental for triggering technological development, it is not sufficient: e-infrastructures are just an efficient tool to help innovation, but building e-infrastructures without sound policies and a strategic approach to economic and technological development is nonsense. A national policy for Science and Development should be in place to help the process; meanwhile, the implementation of e-infrastructures should be accompanied by building the necessary capacities for managing and sustaining them. This should be a part – and an important part – of a national innovation System.

Of course, if we are to maximise the benefits of e-Infrastructures, we need a regional, or even wider, perspective – that's why the Euro-Mediterranean approach adopted within projects such as EUMEDCONNECT and EUMEDGRID represents a real added-value. If we underestimate this aspect, there is an evident risk of isolation from other countries, while e-infrastructures are all about sharing with the others. We should not forget that this is a game in which more partners you get the more each partner gains. No country will have the slightest interest in building a standalone e-infrastructure (and very few will afford to bear the costs alone).

In the new Knowledge society sharing is important but sharing on a win-win basis: cooperation is replacing competition and this should be especially true at the Regional level, where larger commonalities exist. Both on the Regional and the Euro-Mediterranean level, this means the opportunity to unify efforts to deal with common problems and challenges. On the Regional level, geography can help – we are neighbours. Furthermore, sharing resources and funds is playing a crucial role in carrying out researches that no country alone could afford: so here you can see the added value for each partner.

At the Euro-Mediterranean level, the collaboration with Europe will help us in bridging gaps – in knowledge, technology and development – and limiting brain drain, allowing skilled researchers to stay in their country and yet to collaborate worldwide. But above all it will boost the establishment of a dream: a Euro-Mediterranean shared area of peace, research and development.

E-Infrastructures: the user's side



Michele Bianco,

is the Managing Director of the European Genetics Foundation and the project manager of the MEDGeNet (Euro-Mediterranean Network for Genetic Services) Project, whose main objective is to expand the human expertise in clinical genetics and cancer genetics in Mediterranean Partner Countries (MPC) through the transfer of knowledge and technology between the two rims of

the Mediterranean which share a common burden of genetic diseases. In order to achieve this objective, MEDGeNet exploits the EUMEDCONNECT network and supports its sustainability in a longer term perspective.

One of the missions of the foundation I manage is the advanced training of young geneticists, and we carry out this mission as a residential activity in Italy. What we realised was that first we wanted to widen the possibility of attendance on our courses, and to do this we developed a platform for distance training called PLATONE, in order to open to the Internet the possibility of getting the knowledge transfer we offer. The second thing we realised was that our courses were too expensive for developing countries. Not because they are expensive in absolute terms - as a matter of fact they are not, on the contrary they're very inexpensive for a European, but many MEDA country participants could not afford to come and attend a course. So, for us giving them the opportunity to attend via the Internet at a very low cost is a major advantage and means reaching a much larger audience.

More generally, all the projects that we are presenting to the European Commission at the moment are fully based on the connectivity that is lying underneath, because very important sections of the workplan relate to ICT and without connectivity we could not even present them. Every time we build a project, after we define the concept, we check whether the Country of possible partners is included in one of the EUMEDCONNECT or GÉANT or GÉANT2 maps. If it's not, it is very likely that we do not propose them to join, because they would become partners who are not able to deliver their duties to the project - we call them "phantom partners" because without connectivity you never manage to get the job done.

As to the sustainability in the longer term of initiatives such as the EUMEDCONNECT project, I would

like to express a provocative point of view. My feeling is that connectivity is a primary need; it's like bread, it's like oxygen. You cannot work around an issue like this, talking about sustainability. You cannot struggle every year to find funding for oxygen. No-one could ask a research centre, "well stop breathing for a couple of months, and then we'll see if we can find money for enabling you to breathe again". Connectivity is a must. Governments, the European Commission should simply find a technical way to get the money to fund this activity. One idea could be to co-fund it – every Euro that the EC gives there should be a commitment that the governments give the same amount. And if we can imagine all the commercial money that is spent using the network for other purposes, maybe this is possible.

This matter also gets to the heart of who's responsible primarily for developing and maintaining these kinds of connections.

We should not be considered as customers of connectivity; we are building solutions over the connectivity, the customers are the citizens. So if decision makers do not understand, that we're not asking money for ourselves, we're asking money just as a tool to build houses, it's the same. And for this reason giving money to connectivity means giving money to the people – this is my idea and there is no development without connectivity today.

This doesn't mean that no commitment is required from the countries in the Mediterranean region.

One commitment that the Mediterranean countries should provide is to have attention to this issue and to respond in the best way every time they are involved in projects where connectivity is engaged. But I think there is no need to highlight this to them because they know very well that this is an issue and they are ready to respond to any kind of solicitation on projects like this. Our experience is that we never get turned down every time we try to involve the Mediterranean countries. We have a very good response and very professional attitude from all our friends in the southern rim of the Mediterranean every time we involve them in projects that have a large amount of connectivity underlying the project".

E-Infrastructures: what's next



Fabrizio Gagliardi,

former coordinator of the EGEE project, is EMEA and LATAM Director of the Technical Computing division at Microsoft Research. He was one of the first inspirers of extending the EGEE infrastructure to neighbouring countries and he still follows with interest the progresses of EUMEDGRID as an external advisor.

My first point is that the experience of building Grid infrastructures in Europe and beyond has been a very significant one, both from a scientific and a political point of view.

This is especially true for the Mediterranean region: the uptake of the EUMEDGRID infrastructure gave the Mediterranean countries the opportunity to optimize the usage of limited storage and computing resources at their disposal. Also, the sharing of the computing resources allowed researchers to create a scientific network and for the first time a sufficiently large request of technological facilities emerged, in a coordinated way, from the scientific community of the Mediterranean countries. Still most important, it was an occasion to bring together –physically and virtually– researchers from both shores of the Mediterranean and gave them the opportunity to seamlessly collaborate with each other.

Finally, this pioneering Grid experience has given a strategic visibility to the EU ICT excellence outside the European borders and can be considered a big social and political success for the EU.

My second point, however, is that, although Grids are nowadays a reality - and a reality capable of answering the needs of vast segments of the Research community - they should not be regarded as the *panacea* to every computing need. In my opinion, this can indeed be an easy mistake to do, with all enthusiasm raised by the Grids' uptake in some environments – but nevertheless a big strategic mistake.

Today's Grids will not be "the final solution" for several reasons: the first, and most important, is that the users' requirements swiftly evolve and technologies must keep the pace with them, or give way to something else which is more suited to meet them. This is not yet the case for Grids, as they will continue, in the next few years, to effectively answer the Scientific Community's needs and they will remain a concrete, cost-effective alternative to supercomputing, especial-

ly for developing countries, where big investments in computing clusters are most unlikely to come.

However if we look at this technology in a broader perspective, we can see also a few flaws in this technology that prevent it – as it is – to gain an universal uptake. For one thing, its usability is far from being immediate and, as a consequence, it remains a niche experience because it is not the right solution for an important segment of users.

I'm referring to private users, with a low level of IT knowledge and also to small/medium companies needing "plug-and-play" technologies. This segment (which is by the way interesting from the point of view of software companies) needs transparent provision of resources and doesn't want neither can afford the long training needed to master Grid technologies. So in my view either Grids will evolve or, sooner or later, they will be replaced by a new generation of e-Infrastructures.

That's the next challenge in e-Infrastructures: make the most of the Grid infrastructures and, at the same time, to move on towards new directions. Besides creating the base of the new generation e-Infrastructures, the Grid experience offers an immense capital of technical know-how and the expertise and we should not miss the opportunity to build upon it.

As I mentioned before, e-Infrastructures usually evolve in steps of scientific and industrial applications, thus making it really difficult to foresee their future with so many variables involved; on the other hand, what we know of newer approaches (of which the cloud computing and data centre, are at the moment the most significant examples) are focusing on more usability, more cost effectiveness, lower environmental impact, on demand facilities for the final users and the virtualization of resources. In particular, the virtual computing resources give the opportunity to operate in different computing centres with different hardware/software configurations as they were an homogeneous environment connected to the same local network in a unique computing centre.

As a conclusion, decision makers should be aware that their investments in e-Infrastructures had – and continue to have – revenues, both in terms of improving scientific research and making a step forward in technological development. But they should as well be prepared to commit for further investments – and confident that this will bring these progresses forward, and involve larger layers of the society.

This is always true, even in the cases where a change of technology is involved because what remains is knowledge, one of the most valuable patrimonies in the Information Society, and it is knowledge that allows to wisely drive technology change.

7. Terminology & Glossary



e-Infrastructure

The new generation of integrated ICT-based infrastructure. E-Infrastructures, which exploit and seamlessly interconnect several separate components and layers, such as networks, supercomputers and other computing resources, storage, and other remote resources.

e-Science

An innovative approach to research, thanks to the use of advanced technologies of communication and regardless to geographical location of instruments, resources and last but not least, brains. Today, the paradigm is used in several application fields: Astrophysics, High Energy Physics, Computational Chemistry, Biomedicine, Earth Sciences, Meteorology, Environmental Sciences but also Finance, Cognitive Sciences and Archaeology.

Grid

Grids are a set of services over the Internet, allowing geographically dispersed users to share computer power, data storage capacity and remote instrumentation. Although Grids are still in a prototype phase, experts believe that they will have a dramatic impact, comparable to WWW, in the next few years; but while nowadays everybody knows the www and every day millions of people use it to share information all over the Internet, only a few of them are aware of the potential of Grid technology.

The basic concept is in the very world "grid", usually meaning the electric distribution system in English language countries: electric power is distributed to final users who are not aware how and where it was produced, nor they need to use it. With grid computing, it is just the same for remote resources.

Middleware

A software layer able to manage and allocate resources in an optimal way to all users and applications that need them, just like the Operative System does with programs running on your PC.

NREN – National Research and Education Network

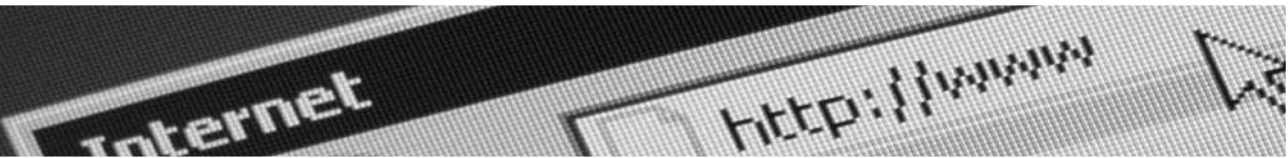
A NREN is a unique organization that plans, manages and operates the IP telecommunication network infrastructure devoted to R&E in a country. They imple-

ment the network requirements of the scientific and academic community and are the privileged partner for dealing with Telecom operators and provider of apparatuses on their behalf. Although there may differences in the different instances at a national level, the model is widely diffused in Europe, the Mediterranean and worldwide as it proved to be cost-effective and flexible.

NGI – National Grid Initiative

An NGI is an organization that coordinates on a national basis the Grid projects and initiative and is entitled to deal with counterparts worldwide on themes such as standardization and interoperability of middleware and procedures. It is the NREN-equivalent at a Grid level.

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e-infrastructure



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