MINISTRY OF ECONOMY & FINANCE

Special Secretariat for Information Society

Hellas Grid Task Force for the Development of Distributed Grid Computing in Information Society

Strategy Paper

17th November 2003

This issue summarizes the work of *Hellas Grid Task Force for the development of distributed grid computing in Information* Society set up by means of decision Ref.No.151.036/IS 300 as of 22/01/03 of the Special Secretary for Information Society of the Ministry of Economy & Finance.

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0 Summary

0.1 The New Environment of Electronic Infrastructures

The revolution in computer and telecommunications technology that reached its peak provides for the first time the background to develop Knowledge / Information Societies / Economies.

The continuously developing information intensive applications and demand for access to Information at any geographic point regardless of the means, stress the need to interconnect distributed resources and infrastructures with electronic networks and special middleware enabling easy and friendly access to users, concealing heterogeneous technological implementations of resources.

This distributed environment enabling sharing and common use of computing, storage and other resources (e.g. sensors), aided by middleware, is called Computing Grid or just Grid. The integration of networks and middleware into one single infrastructure aimed at distributed but homogeneous access to Grid resources is referred to as eInfrastructures. In the USA the respective infrastructure is called cyberinfrastructure.

E-Infrastructures developing worldwide will provide researchers and economy a common market of electronic resources, accessible on a 24-hour basis, regardless of the place, and a unique tool for the development of collaborating applications.

0.2 Goals and Applications of Distributed eInfrastructures

The goal of Electronic Infrastructures is the uninterrupted, quick, secure and friendly access of millions of Internet users, not only to information sources, but to internationally distributed sources and services (eServices) implementing the Information/ Knowledge Society: Software and digital hardware for the implementation of shared production tools for the design and simulation of complex technological problems, analysis of a large volume of micro and macroeconomic standards, promotion of virtual education and medical telediagnosis environments, processing, analysis and storage of digital images-high resolution videos, access to and processing of huge biology, biotechnology scientific-research, computational chemistry, meteorology, physics, astronomy, geoinformatics databases, etc.

The above recording of shared use of eInfrastructures mainly relates to scientific and technological applications, with pioneer research- academic communities forming the critical mass required for the development and dissemination of necessary architectures, as was the case with Internet technologies. The relevant technologies are adopted by the greater Information/ Knowledge Society community at a growing rate.

Application edges relate to the analysis, processing and forecast of banking and financial standards, e-Government services, tools related to e-Business, image storage and processing platforms in the area of medical services, entertainment and advertising, design and simulation of complex technological systems (engineering, radio-electrical, aeronautical, chemical processing, statics-dynamic structures, architectural and urban planning, etc).

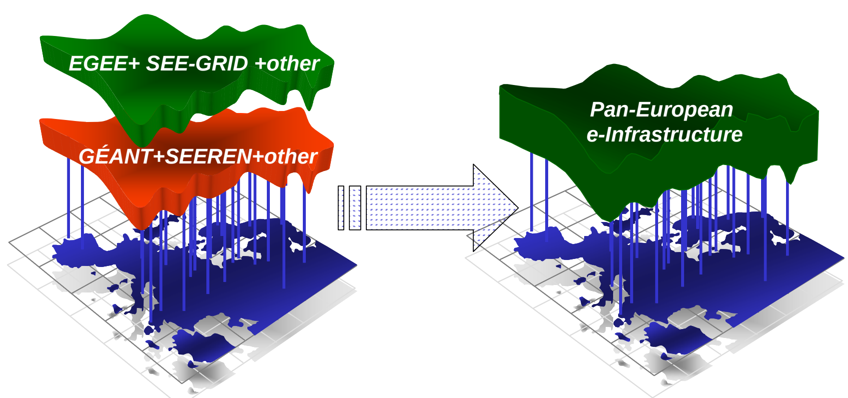
0.3 Grid characteristics

Grids integrate through electronic networks computing, storage and other resources (e.g. sensors) distributed at local, national and international scale, scaling the potential of Information/ Knowledge Society, like power grids were the catalysts to the Industrial Revolution respectively.

Grids can be distinguished as follows:

1. They permit sharing of resources to multiple users in different communities with heterogeneous application fields and geographic allocation. A grid may be based on a campus LAN, a MAN, a national WAN and or national coverage network such as the European Research Network GEANT and Abilene, depending on the requirements of applications and existing network infrastructures.
2. They require secure access through middleware with global emphasis on open source software (e.g. GLOBUS). Grids expand the open software concept to open computer systems, imposing restrictions only as regards security and availability of resources to meet certain needs.
3. They are highly scalable, with particularly limited initial investment. Grid architectures may constitute an important tool to bridge the digital gap in the world, in a continent, in a county (centre-region), in an organization - campus.
4. They integrate, through Internet / Intranet, computer, storage and other electronic installations with heterogeneous technological implementations, aiming at the provision of integrated eServices. Integration is implemented with the use of an additional middleware layer undertaking to share resources over the network with the above characteristics.

It is obvious that eInfrastructures are led by Research and Academic Communities, which greatly contribute to the standardization of relevant technologies and enable greater dissemination to other areas (e-business, e-government, etc).



Network and middleware integration into one single eInfrastructure

Depending on characteristics of individual applications, historic particularities of user communities and areas, and the current technical-financial criteria, there are grids connecting:

a) PCs, benefiting from current potential, especially when under-operated (in this case referred to as desktop or scanverging grids, SETI@HOME being the first application).

b) Completely parallel clusters provided that applications are suitable and users have the required expertise.

c) Large computer centres with distributed memory systems– Beowulf Clusters and symmetric multiprocessing – (SMP), which will coexist as long as there as application so demanding and Computer Centres providing services with appropriate equipment and customer support.

0.4 The Research- Academic Community and the International Grid

Grid technologies are the main constituent to the development of Electronic Infrastructures and natural consequence of broadband electronic networks and new generation Internet. Their significance is stressed by financing initiatives in the USA, Canada, Japan and the European Union, where, as in all great initiatives (e.g. Internet), research and academic communities act as a catalyst. There are already numerous examples of dissemination of the relevant expertise to the greater production section and automation of Public Administration processes. eScience, the United Kingdom initiative which finances the development of Grids and eInfrastructures of the national academic-research community in general, with the increasing participation of the private sector and public administration structures, stands as an example of the great expectations of national governments.

The abstract from a speech of the UK Prime Minister Tony Blair on "*e-Government and the Grid*" is an illustrative example:

> ***'[The Grid] intends to make access to computing power, scientific data repositories and experimental facilities as easy as the Web makes access to information.'***
>
> ***UK Prime Minister, 2002***

0.5 The Greek Initiative HellasGrid Task Force

Financing of eInfrastructures benefits Greece compared to other countries of Western and Central Europe, since it starts from low cost solutions, with unlimited scalability. The start of the Hellenic Grid is based on the long experience of the Greek Research- Academic Community in edge technologies and the successful operation of the high-requirement Greek Research and Technology Network GRNET. This occasion is even more beneficial thanks to the great success of the European Research Network GEANT and the focus of the European Union in the development of operating grid infrastructures in the single and expanded European research area. HellasGrid Task Force acts as an accelerator for the

Information Society of the Ministry of Economy & Finance, in collaboration with the General Secretariat for Research and Technology of the Ministry of Development.

The link to the Greek initiative is the Greek Research and Technology Network (**GRNET**) of the General Secretariat for Research and Technology, while the main research-development gears are the Aristotle University of Thessaloniki (**AUTH**), the Hellenic National Meteorological Service (**HNMS**), the National Observatory of Athens (**NOA**), the Centre for Research and Technology Hellas (**CERTH**), the National Technical University of Athens (**NTUA**), **NCSR Demokritos**, the Research Academic Computer Technology Institute (**RACTI**), the Institute of Communication and Computer Systems (**ICCS**), the Foundation for Research and Technology (**FORTH**), the Institute of Accelerating Systems and Applications (**IASA**), the Centre for the Application of Communication and Information Technologies (**KETEP**), the Athens University of Economics and Business (**AUEB**), the **University of the Aegean, the University of Athens, the University of Ioannina, the University of Crete, the University of Macedonia, the University of Patras and University of Piraeus**.

Those Institutes whose members participate in HellasGrid Task Force have signed Memoranda of Agreement and Mutual Understanding, stressing the need for common development and management of a national grid, using the ultra-high speed GRNET2 services and computer systems operating in Institutes. The national infrastructure should be directly supported with equipment and the development of relevant know-how, so that distributed eInfrastructures are put to practice in Greece and mainly that increasing needs of users in the territory are met. The current focus on research- academic use is the precursor for the dissemination of applications to the greater production and public administration.

0.6 European Initiatives – the Role of Greece

The Task Force participates, through GRNET, in strategic European Programmes for the development of transnational grids, led by the European Organization for Nuclear Research CERN, and in initiatives for the completion of south-eastern Europe eInfrastructures. All members of the Task Force are or have been involved in actions related to the grid, either as advanced users or members of European groups for Research & Technological Development of relevant technologies and software. The operation of the HellasGrid Task Force implements, at a national level, the general European Union policy on the development of national initiatives for the coordination of actions related to eInfrastructures and Grids.

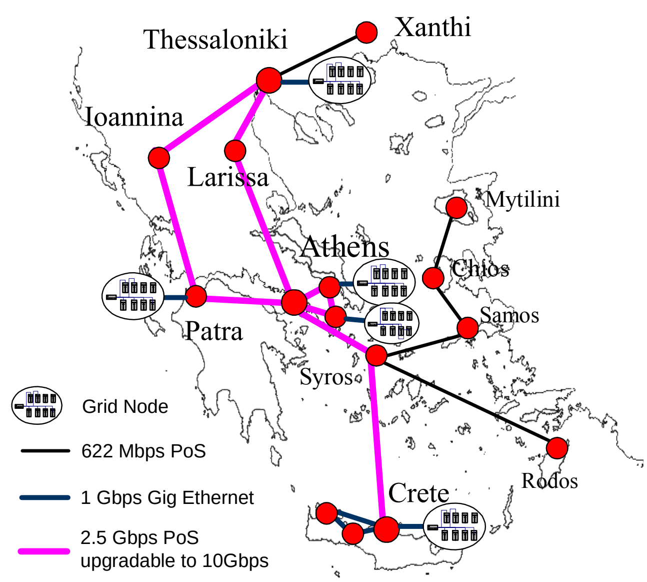
The relevant policy is based on and expands the particularly successful model of National Research and Education Networks (NREN) and the European Research Network GEANT, interconnecting 33 national networks (NRENs) and serving over 3.900 European Universities and Research Centres at high speeds. To this end, the European Union primarily finances the operating support of European grid infrastructures interconnecting coordinated national infrastructures. Greece took action earlier than other countries of the European Union and is in the position to contribute to the greater effort since it has the required broadband NREN (GRNET), the experience and know-how of research teams set up in HellasGrid Task Force, while financing requirements for computing infrastructure are within the national potential.

0.7 Recommendations of HellasGrid Task Force

The Task Force was set up with the aim of analyzing the international background and prepare the suggestion of any necessary actions to the Information Society. As a result of the works of the committee, it is recommended that a national investment be promptly made in the initial development of a Greek Grid to be the first involvement of Greece in a high technology sector.

The Task Force recommends the development of a Hellasgrid pilot project, to include among other things the development of a number of computer and storage clusters, hierarchically interconnected over an ultra-high speed network of GRNET2, the creation of operation and support teams, the improvement of middleware, and the customization of new applications (e.g. meteorology) on the grid, with obvious benefits for citizens.

The Task Force recommends the development of a Hellasgrid pilot project, to include among other things the development of a number of computer and storage clusters, hierarchically interconnected over a Gigabit network of GRNET2, the creation of operation and support teams, the improvement of middleware, and the customization of new applications (e.g. meteorology) on the grid, with obvious benefits for citizens.



In particular, the Task Force initially suggests the development of 4 Hellasgrid level 1 nodes in Athens, Thessaloniki, Patras and Heraklion, which, in collaboration with the GRNET level 0 central node under development, will form the main computing-storage grid infrastructure for the Research and Academic Community.

To use these resources, cooperation policies and regulations on the use of the resources should be determined, following an appropriate study, upon consultation with user groups to run the relevant applications. After the completion of the central infrastructure, it is recommended that studies are made on the integration of further computer systems into the HellasGrid backbone, such as advanced computing nodes (e.g. symmetric multiprocessing systems- SMP) and the exploitation of excess resources of online PCs- desktop Grid (e.g. PCs of Universities and the Pan-Hellenic school network).

It is also recommended to set up an administrative and technical HellasGrid team for policy making and support of actions, to support interface with respective actions in Europe.

It should be noted, though, that it takes more than supplies in computers and mass storage units (Storage Area Networks – SAN). The success of HellasGrid will be judged from the potential to permanent financing of skilled staff, ensuring continuous operation of systems and planning the upgrading of infrastructures at local, regional and national level.

The integration of Grid actions (infrastructures, middleware and applications) with the broadband research and technology network of GRNET2 into a standard e-Infrastructures system is the best possible exploitation of advanced network resources and services of GRNET which can serve the new e-Science generation and will attract the greater users community of the Information Society to the mass adoption of advanced services provided by Grid architectures.

The text below presents international and national initiatives of eInfrastructures, describes the needs of various user communities and proposes national actions to the development of Grid infrastructure and services in Greece.

1 Grid Technologies and Development Models

1.1 Introduction

Worldwide scientific activity has already entered the phase of globalizing efforts, methods, infrastructure and management, and the processing of final results. In all scientific fields, international cooperation is now standard and shared use of available resources common practice. It could not be otherwise, given that in most cases, the cost is very high for a single organization or country. In such a partnership model, individual partners contribute to the creation and operation of a shared infrastructure used by everyone, with the final goal of exporting useful knowledge, solving specific problems and promoting science and technology in favour of the entire society.

The large development of the Internet, the technological development of PCs and the development of the appropriate middleware and applications has given new potential to the classic meaning of the term "computing environment". The combination of the above enables geographically distributed sharing of resources such as computational power, storage area, digital content and other scientific instruments (e.g. sensors, telescopes, etc). In practice, researchers continuously connected to the Internet may, using the appropriate software, share the power of their computers, storage area and other resources of their labs with thousands other researchers all over the world. This sharing may be uniform, secure and distributed worldwide. These new methods, known as Grid technologies, are the edge technology at international level as regards meeting high requirements (among other things) in computational power and data storage area. The term Grid will from this point on refer to a grid of various types of resources and not necessarily computing or storage. Nevertheless, the most disseminated and common use corresponds to the above and at several instances in this document, Grid will be identified with this use.

The Grid is based on cluster computing, and expands geographically with national and international high-speed networks. Illustrative is the example of Macintosh G5 personal computers cluster (the Big Mac)[1], the third more powerful supercomputer in the world. Big Mac was made easily, quickly, much cheaper than a supercomputer, while extension potential is theoretically unlimited. Grids are promoted, due to their low and scalable cost to specialized communities of advanced users with requirements for mass data processing and simulation, such as research teams of High Energy Physics, Meteorology, Bioinformatics, Computational Chemistry, Astronomy, Satellite Teledetection, etc.

Based on the above, and given that GRNET already provides the required internet platform to research –academic units in Greece, with a Gigabit connection to the European Research Network GEANT, the research community must take coordinated initiatives. These initiatives aim at promoting Grid technology and applications in Greece in the framework of the 3rd CSF- OP Information Society, and participating in competitive initiatives of the European Union -6th Framework Programme on Research & Technological Development, Integrating European Research/ Priority Thematic Area Information Society Technologies & Structuring the European Research Area / Research Infrastructures. It is obvious that efforts will start from the research community (**eScience**) and will expand to businesses (**eBusiness)** and the public administration (**eGovernment**).

[1] http://news.zdnet.co.uk/hardware/emergingtech/0,39020357,39117536,00.htm

1.1.1 HellasGrid Task Force

For the investigation of national and European prospects, the Special Secretariat for the Information Society of the Ministry of Economy & Finance has set up the HellasGrid Task Force http://www.hellasgrid.gr, for the development of Grid Computing in Information Society for Grid Technologies (HellasGrid Task Force) http://www.hellasgrid.gr, aiming at developing a national strategy and coordinating user groups for the dissemination of the above technologies. Under the standards of the Broadband Task Force http://www.broad-band.gr 2 levels are provided, as follows:

• The Task Force level led by the Special Secretary for Information Society and representatives of the main research-academic groups operating in the area of supercomputers and computer clusters, parallel systems, middleware and applications, and GRNET. The Task Force undertakes policy-making at national, community and regional level.

• The Scientific Committee level, supporting the work of the Task Force in all issues and recommending technical and organization solutions.

The most significant points for which HellasGrid Task Force was set up are:

- The promotion of distributed grid computing to a primary element for the development of national and interstate research and cooperation between researchers in Information Society

- The guidelines of the 6th Framework Programme of the European Union regarding the development of distributed grid computing in Information Society and directions of community initiatives e-Europe 2002 and 2005 on Grid Computing and World Wide Grid.

- The significance of strategic planning and coordination of Grid actions which can be financed by the OP Information Society in various fields, e.g. research and education at national and European level, combined with Greece's presidency of the European Union for the first half-year in 2003.

HellasGrid task force has already made a Memorandum of Understanding, specifying the partnership framework between its members for the implementation of a national grid infrastructure, and the operating framework of this infrastructure. The MoU has already been signed by all agencies whose members participate in the task force.

The mission of this task force is:

Coordinating and submitting opinions to the Managing Authority of the OP Information Society on the relevant actions on all priorities of the Operational Programme (Priority 1. "Education and Culture", Priority 2. "Citizen and Quality of Life", Priority 3. "Development and Employment", Priority 4. "Communications".

Submitting specific proposals for the inclusion of actions in the OP of IS which promote the development of distributed grid computing on a regional basis, in fields such as high energy physics, astronomy, computational chemistry, meteorology, bioinformatics and distributed teleworking and virtual reality applications (in general high standard e-Science and e-Learning applications).

Supporting **international representation** of the country and the collection and processing of best practices at international level

Planning and proposing **awareness-raising actions** at various levels with parallel operation of the relevant information site (www.hellasgrid.gr)

Making suggestions and giving guidelines to all research and education agencies as regards available standards, main trends in architecture and implementation and in general international practice as this derives among other things from the Global Grid Forum (GGF) http://www.ggf.org, aiming at the creation of a basic platform of distributed grid computing.

Preparing and submitting to the leadership of competent Ministries (Ministry of Development undertaking national policy making and implementation on research and development, Ministry of National Education and Religious Affairs undertaking the inclusion of information and communication technologies in learning, Ministry of Economy and Finance competent for the Operational Programme Information Society, Ministry of Transport and Communications acting as the agency of broadband access networks) **strategy papers** related to the development of Grid Services.

1.2 Grid definition

In recent years, the rapid expansion of the Internet, combined with the availability of high speed backbone networks and the technological development of computers and software have given new potential to the classic meaning of the term “computing environment”. At his phase, a significant number of computer resources, including computational power, data, services, software tools, scientific instruments, etc, are distributed worldwide, creating the need for secure, uniform, reliable and remote access via networks, in order to satisfactorily make use of the potential provided.

Grids are an approach for the creation of dynamically structured environments using computer resources both geographically and organizationally. The term “Grid” was introduced in the early 1990s to describe a proposed distributed computing infrastructure for advanced sciences and applied mechanics[2]. Ever since, important steps were taken to that direction, which brought us before the challenge of creating grid infrastructures at national level, with the participation of a wide range of groups from all scientific communities.

The exact problem leading to the development of the grid as a meaning is the controlled and coordinated sharing and use of resources to solve problems in the context of dynamic multi-institutional Virtual Organizations (**VOs**). Such groups may be scientists participating in High Energy Physics experiments, such as CERN experiments, or groups of astronomers studying distributed images of various observatories and telescopes all over the world, bioinformatics experiments, etc. It should be noted that virtual organizations may operate

[2] Ian Foster, Carl Kesselman (Editors), The Grid: Blueprint for a New Computing Infrastructure, Eds. Morgan Kaufmann

by experiment even in the case of the same user communities, e.g. there may be 4 VOs for the 4 physics experiments of CERN.

This sharing relates not only to data exchange but also to the direct access to computer units, services, software, data and other resources, as required by a wide range of associations for problem solving and management of shared resources arising in science, industry and public life. This sharing should be regulated, with providers and users of resources following protocols clearly specify what should be shared, who may share and which are the conditions of this sharing.

It is obvious from the above that the term Grid includes all infrastructure, hardware and software, suitably interconnected via high –speed networks, and the necessary services for the development of a single supercomputing environment, which, although geographically scattered, appears transparent to all users. This is a single set of computing resources, a consistent- although distributed- computing platform. The grid interconnects heterogeneous computing environments with a similar or different concept and services, also creating new sets of services with increased computing potential and new ways to exploit the various resources shared.

1.2.1 **Grid generations**

According to Charlie Catlett, GGF Chairman, the 1st Generation Grids or **1G Grids** in practice consisted of local **metacomputers** with main operations such as distributed file system, site-wide single sign on, namely the only point where the user provides personal information (e.g. username/ password), over which new distributed applications were built with customized network protocols. The implementation of Gigabit test-beds led to the expansion of 1G Grids and an effort was made to create **metacenters**, which explored issues of integration between different centres. In general, 1st generation Grids were completely customized to the particular experiments and were proofs-of-concept.

2G Grids started with programmes such as Condor, I-WAY (the start of Globus) and Legion (the start of Avaki), where new middleware and communication protocol services formed the base to develop distributed applications and services. 2nd generation Grids provided the basic structural elements, but their use required significant customization and various works to cover large gaps. These independent efforts to use 2nd generation systems, which contained many custom software extensions, caused problems to interoperability.

Taking into account both previous experience from the first two generations and the technologies of the very successful web services, efforts are made for the 3rd generation Grids (**3G Grids**), based on the Open Grid Services Architecture (**OGSA**), where a set of specifications of common and open interfaces support interoperability of independently developed services. The recently published specification **Open Grid Services Infrastructure (OGSI**) is the corner stone of the above architecture. With the introduction of standardized technical specifications, the 3rd generation grid will accelerate competition and achieve interoperability, not only between applications and toolkits, but mainly between different implementations of basic grid services. *"When you can mix and match different structural elements and services effectively, you know there is a commodity"*, says Charlie Catlett. *"However, this takes hard work to set standards"*, which has been undertaken by the Global Grid Forum.

GGF "Grid Connections" Fall Issue - On Line:
http://www.ggf.org/L_News/Newsletter/Grid Connections/grid_connections_fall_03.pdf

1.2.2 Grid to PowerGrid ratio

The term Grid derives from the term Power Grid, meaning the American power generation and distribution network.

Power grids were placed among the technological achievements of the 20th century, connecting a large number of geographically distributed power generating centres to a distribution and use system providing power to billions of devices effectively, reliably and at low cost. One of the main characteristics of a power network is inability to store large amounts of power. Therefore, there is a need to distribute excess power in real time. To do this, coordination and collaboration is required both within a country and between neighbouring countries, given the interconnection of the power networks of these countries.

The above show the operating similarities of network grids with the respective power grids from which they were inspired. Similarly, excess computational power, storage area or any other resource that may be shared will be used within the grid. The vision for the development and operation of the grid is to constitute a computing service provided as a utility, like electricity or telephony. At the conference IST 2003, http://europa.eu.int/information_society/istevent/2003 John Taylor, Director General of the Research Councils, Office of Science and Technology, characterized the Grid as the 3rd wave of the Internet and an information utility.

http://europa.eu.int/information_society/istevent/2003/cf/vieweventdetail.cfm?ses_id=255&eventType=session

1.3 Grid classes

Grid classes are defined based on their operations as follows:

Computational Grids: these are the collection of distributed computing infrastructures operating as a single processor or virtual supercomputer. The benefit is highly demanding processing faster, more effectively, at low cost and using existing infrastructures. Such processing is performed both in the scientific field (modelling) and the industry (industrial design).

Data Grids: these provide secure access to data. Data grids allow users and applications to easily and effectively manage information from databases located on distributed platforms. As in the case of computational grids, data grids are also software-based for secure access and use. Data grids eliminate the need to transfer, copy and collect data at a central point, thus reducing cost. Already, original data grids serve collaborating research communities. Software companies and large enterprises currently examine data grid solutions and services for commercial applications, while data grids will constitute a significant element to the further development of Internet applications.

Service Grids: these are the collaboration Grids aiming at real time processing. They require data collection from physically distributed labs, analysis, visualization and management. This would enable remote control of equipment, gauges, thus creating a virtual observatory or a virtual laboratory.

1.3.1 **Grid vs Clusters**

A computational Grid usually consists of independent, geographically distributed clusters, which in turn consist of computational systems (PCs to supercomputers) concentrated in the same physical area or close enough enabling interconnection over a Local Area Network (LAN). Also, the resources of a cluster are known, reliable and usually uniform in configuration. Grids are different from clusters because they share system resources scattered over large geographic areas. Obviously, the interconnection of geographically scattered clusters is a grid. In general, a Grid consists of resources interconnected with any manner of network (Local-, Metropolitan-, Wide-Area-Networks or LAN, MAN, WAN) with huge expansion, and consequently performance, potential via the Internet. What remains to be verified in the near future is grid expandability, but also the ability both of local clusters and distributed grids to resolve various complex computational and other problems. It is certain, though, that the grid development model is easier, cheaper and scalable for Greece, since the country cannot invest huge amounts in supercomputers and multiple expensive clusters.

Finally, it should be mentioned that a grid does not necessarily comprise of computers only. On the contrary, there are many examples of special components (e.g. grids of sensors, telescopes and other scientific monitoring and recording instruments).

1.3.2 **Grids and human networks**

Grids develop and operate in proportion to human networks. Similarities are numerous and important. Human networks consist of people with common goals and methodology in dealing with common problems-questions. In nature these are geographically scattered, based on mutual assistance and dependence. They use accumulated experience and know-how on promoting knowledge. Grid operation is similar, supplementing human networks at the level of computational infrastructure and services. In fact, one could say that a grid is a different expression of the same main concept.

1.4 Main components of a grid infrastructure

The term Grid refers to a set of structural elements, from computational resources to user applications. The basic layers of a Grid Infrastructure are the following from top to bottom.

A. The network layer, containing physical interconnections and the respective network equipment (routers, switches, etc)

B. The resource layer, where resources may be computational, storage or other (e.g. sensors, telescopes, etc) focusing on the former and various implementations (supercomputers, PC or server clusters, etc)

C. The middleware layer, which includes all necessary services of communication, scheduling and access to resources, security emphasizing on authentication and authorization, and accounting and statistics.

D. The Application & Serviceware Layer where various applications (calculations, simulations, etc) of different scientific fields and services to be provided are finally connected.

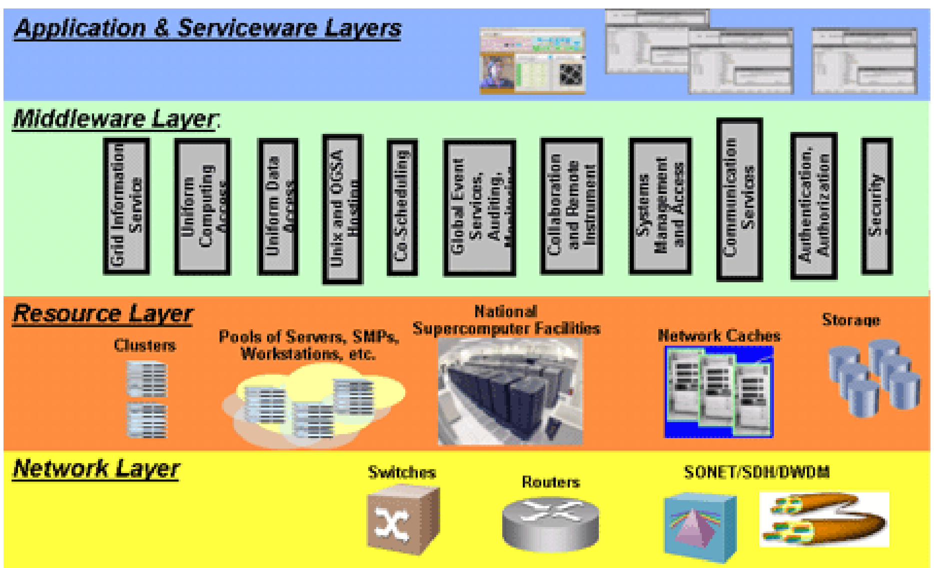


Figure 1,1: Main components of a grid infrastructure

The following paragraphs approach the implementation of Grid Infrastructures, starting from the simple case of an organization which wants to fully exploit available resources (**IntraGrid**). We will then examine the case in which more than one organizations enter into partnerships with a mutual offer and use of resources (**ExtraGrids**). Finally, we will conclude with the analysis of the wider sense of Grid Infrastructures, the creation of **Inter-Grids** and finally a World Wide Grid (**WWG**).

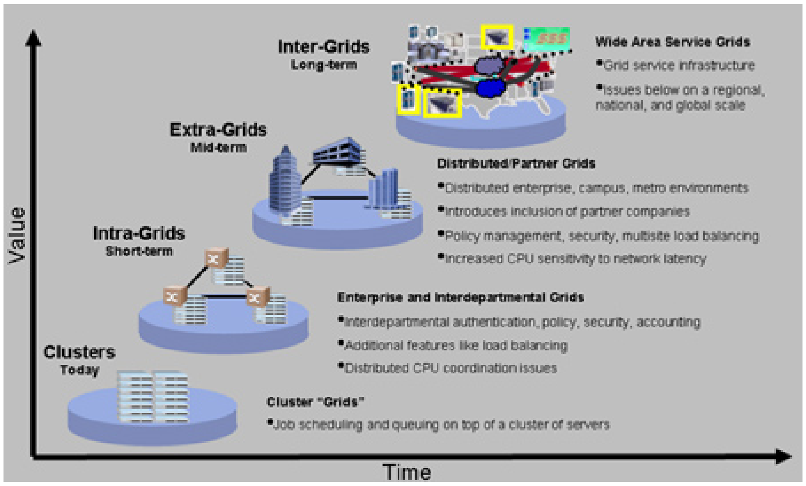


Figure 1,2: Grid Infrastructure Scaling

1.5 Grid infrastructure development models

1.5.1 **Hierarchical vs Peer to Peer**

In the last decade, National Research and Education Networks-NRENs have adopted the hierarchical development and operation model. There are three **hierarchy levels**, starting from the local network of each laboratory or institution, proceeding with the national research and educational network of each country, and finally completing the infrastructure on GEANT. In many cases, there is also a regional level, e.g. Scandinavia (NORDUNET) or South-Eastern Europe (SEEREN).

On the contrary, the prevalent interconnection model in the United States is **Peer to Peer (P2P)**, under which there is not central network infrastructure, but interconnection between two institutions is negotiated by the institutions themselves. This model provides great autonomy and flexibility to end users, against high cost and the creation of infrastructures complex in management.

Most current middleware versions (Globus, Legion, CCS, Apples, NetSolve, Ninf), require hierarchical infrastructures with central control. EGEE also moves to the same direction, following the successful model of GEANT, recommending Regional and National Centres, which will create an organizational pyramid whose coordinator will be CERN.

The hierarchical model is ideal in the case where the hierarchy extremes cannot exist autonomously, mainly due to financial and often political difficulties. Especially in Greece, it will be difficult to see research institutions operating autonomously and talk about direct interconnection of a researcher's lab with another lab with optic fibres or wavelength (lambda). In the long term, the effort to implement peer to peer infrastructures would result in widening the digital gap.

If end users can be autonomous, then the basic element to the development of infrastructures would be their requirements, thus leading to the creation of complex Peer to Peer user-oriented infrastructures.

It is only natural to expect that the development of infrastructures under the hierarchical model, having the potential of concentrating large funds, leads to the creation of high quality infrastructures. In deed, taking the example of GEANT and comparing it with the respective infrastructures in the USA, one can easily confirm the superiority of the former.

Given the conditions all over Europe and especially in Greece, the ideal model to be followed in the research field is GEANT, focusing on serving common users, enabling in parallel service of demanding scientific communities.

The high requirements of Grid Infrastructures demand L1, L2 and L3 provisioning which can enable high speed and quality connections between research centres. The connection between CNAF and CERN is an illustrative example.

1.5.2 **Infrastructure and services development models**

In parallel to the creation of large infrastructures dedicated to computational Grids (**Dedicated Grids**), a significant number of research programmes are already under way, aiming at exploiting already existing computational infrastructures (**Desktop or Scavenger Grids**). Illustrative is the example of **Hungary**, which has started a similar programme, aiming at interconnecting 99 clusters to a Grid infrastructure. Each cluster consists of ~20 computers, used for educational purposes during the day and converted into a computational Grid at night. By the end of 2003 it is expected to integrate 2,079 computers.

Being a country with less developed infrastructures, Greece should add value to the existing computational infrastructures, following similar models. The **Pan-Hellenic School Network** would be ideal, and **computer islands**, scattered at universities and research centres. In both cases, computers are mainly used during the day, which leaves a huge amount of computational power unexploited. Also, the case of large enterprises-organizations falls under this class.

This manner of actions may not replace grid-dedicated computational infrastructures. On the contrary, Desktop Grids will operate ancillary to the central infrastructures, adding more value at minimum cost.

The Grid as a computational power generation and distribution model

Power Generation and Distribution Networks have been studied both in technical and financial terms. The second aspect is particularly important in our case, because it provides the methodology tools to the determination and sustainability study of a national grid infrastructure, primarily for research and education. Assuming the national grid infrastructure as a Computational Power Generation and Distribution Network and in the near future a computational power and services network, this can be distinguished in the following basic parts:

(a) Generation units. Generation units mean supercomputing systems, clusters, local networks, storage units, representation units, etc. A generation unit contains both the hardware and the software required for the provision of a complete service. The set of generation units could also include the provision of applications or even integrated services. The basic element is that a generation unit is regarded by the national grid infrastructure as a unique system with a specific interface.

(b) Distribution network. The existing GRNET network is already being used for multiple applications for research and development. It is obvious that GRNET2 broadband network with backbone capacity at 2.5 Gbps and access for institutions at 1.25 Gbps has been designed to meet demanding grid applications. Nevertheless, distributed calculation experiment must be performed, requiring collaboration of remote generation units, in order to evaluate the intercommunication cost on the network and sufficient capacity. Distributed calculations require a significant communication charge, both during, before (data distribution), and possibly after calculations (collection of results, system clearance). It is certain than many applications have not been implemented so as to run effectively in such an environment and it remains to be seen whether intervention and change of the source code is required.

(c) Management nodes. These have a picture of the condition of base units and the network. In addition, they have a picture of service use demands submitted at consumption points (characteristics of each application, necessary data, etc).

(d) Consumption points. These are the front-end with end users. They will possibly have the form of a web site guaranteeing users the necessary operability for recording, submitting task and data, checking progress, collecting results, communicating with persons in charge, consulting, documentation, other information, etc.

1.6 Requirements

1.6.1 **Reliability and high availability**

Several attempts were made recently to create computational centres within research institutes, without, though, the desirable results. The main reason for the failure of most attempts was the lack of confidence in the provided services, which led the largest percentage of researchers turn to the use of foreign infrastructures, which met the requirements for high quality provision of services.

The operation of computational centres requires the existence of modern installations which will ensure continuous **availability**. More specifically, installations must ensure uninterrupted power supply, proper cooling of the area, protection of the area from invaders and, most important, they must be staffed with adequate, specialized technical personnel. In parallel, there must be support and promotion services which will aim at informing, educating and supporting users.

It should also be ensured that needs and requirements of different groups of applications and users are properly met. To this direction, a number of questionnaires should be implemented to all potentially interested scientific communities in Greece to record their requirements. **A first effort was taken by Hellasgrid task force http://www.hellasgrid.gr/results to be analyzed in a subsequent chapter. In fact, it is necessary to set up quality assurance groups to represent numerous scientific groups and feedback heads of computational and operation centres of Grid infrastructures.**

1.6.2 **Broadband Networks**

The development of high quality and speed networks, from the local network to connection to the Internet, is of major importance for the implementation of Grid Infrastructures.

Starting from local networks of organizations (companies, entities, institutes), we recommend the option of Gigabit Ethernet. In case where the organization has more than one local networks, it is recommended to implement broadband links for interconnection.

In the field of education, GRNET has proceeded, within the framework of the programme GRNET2, to the total upgrade of the Greek research network to a new generation optic Wavelength Division Multiplexing network, enabling interconnection via a backbone network at 2.5 Gbps. This GRNET action is taken in parallel to respective actions in western European countries. GRNET2 will enable single broadband access for end-users in the country's higher education institutions and research centres through their institutions' local networks (speed 10-100-1000 Mbps) with broadband access (1 Gbps) to the national backbone (2.5 Gbps) as well as to the GTRN (Global Terabit Research Networking) new generation international research network at 5 Gbps (2*2.5 Gbps) through the European network GEANT.

At the level of international connections, great importance should be placed to the implementation of multiple broadband links which will enable Greece to play the role of a central node for the entire area of the Eastern Mediterranean and the Balkans.

In an environment of multiple management entities, it is important to have **bandwidth commitment** models with **service quality** characteristics and respective **service level agreements**. Experiments should be typically performed for various types of calculations (the use of relevant benchmarks might help), in order to assess the bandwidth which must be committed in each case. It is possible to create certain basic models to enable a forecast of the bandwidth commitment required by type of calculation. Also, the achievement of certain network end-to-end characteristics should be considered, taking into account not only technical issues of interoperability, but also management-political issues. Obviously, there is also the simple model of overprovisioning, where no care is taken to the commitment of bandwidth or other quality characteristics, and the new network upgrade is just seen to.

The strategy paper prepared by the task force on broadband networks (http://www.broadband.gr), meets requirements to the development of grid infrastructures to a great extent. Finally, it is recommended to develop a partnership between the **Broadband** and **HellasGrid** task forces with the potential of a horizontal action between all IS task forces with similar objectives.

1.6.3 Security

Security in the grid enables users to perform controlled actions, ensuring proper use of resources and preventing abuse. The sense of security includes protection of assets from unauthorized access, keeping information from unauthorized change and ensuring continuous availability of resources, enabling users to enjoy secure use of resources.

With conventional computational infrastructures, having an account on a given machine or cluster, the user may take certain protection actions. The sense of protection lies at the level of computational resources and the system administrator usually knows the persons using the installations and privileges to be given.

In the case of grid infrastructures, the user may use a number of resources, and the person managing such resources is likely to never contact the user. Therefore, it is necessary to have those infrastructures to enable authentication, authorization and accounting **(AAA**) of users via other methods.

The ideal solution to the problem of authentication is the implementation and use of Public Key Infrastructures **(PKI**). PKI infrastructures have a central entity, the Certification Authority (**CA**), which performs user identification and authentication procedures. Therefore, resource managers may, relying on the certification authority, authenticate user identity without contacting the users themselves.

Key to the operation of public key infrastructures is confidence between the certification authority and consumers-resource providers. In order to ensure this relation of confidence, it is necessary that the CA has a clearly specified operation policy, to be consistently followed.

The coordination of CAs in a widely distributed area such as Grids should be reviewed in detail, both in the context of research efforts and in the context of commercial and other efforts. Further analysis on this issue is presented in the chapter of Greek reality, where current efforts and Greek participation are presented.

1.6.4 **Mobility**

The term Grid is frequently used to characterize a new generation of high performance supercomputing infrastructures. Despite that the grid comes to provide solutions to the increasing needs for computational power, it only constitutes one of the parts of the picture. Grids are open systems on which users, software and resources and dynamically interconnected. These infrastructures must be flexible in order to meet the needs of current and future users who demand continuous availability of the system and the services provided, regardless of the area where they work or the means used. The above reflect the concept of mobility. In parallel, the increased demand of users for new services will result in the ongoing development of new ‘smart services’ which will inform the infrastructure at real time about availability.

To achieve the above, it is necessary to develop ‘smart services’ which may inform the infrastructure about availability at real time.

1.6.5 **Time scheduling and exploitation of resources**

The issues of **time scheduling and exploitation of resources** are also important, so that the requirements of scientific groups and end users are met. In this aspect and taking into account previous experience from electrical networks, it is necessary that the following are provided for:

(1) **Time allocation** of demand on a daily, annual and long-term basis. It is obvious that analysis requires a sufficient model to forecast demand for computational power and other resources. Such a model could arise from a questionnaire, with adequate collection of information and analysis margin. Based on such a model, generation units may be distinguished into:

-Base units, namely units of continuous operation meeting permanent demand in computational power.
-Peak units, namely units meeting urgent forecast peak demand.

-Backup units, namely units meeting unforeseen demand peaks or other extraordinary situations, such as operation interruptions.

(2) Proper use and **exploitation** of generation units. Based on a model of long-term demand and given the investments made by various state agencies, one could justify (or otherwise) the appropriate investments in generation units, study depreciation, rate of investments, etc. For example, a medium-sized university makes annual investments in workstations standing at about 300-500 thousand euros. Average use of computers is lower than 50% and systems are depreciated in about three years. Therefore there is a significant margin for better exploitation of public investments.

(3) Organized **system withdrawal** model. Alternatives for the withdrawal of a large number of systems should be considered from a technical and financial point of view. Withdrawals have already started and in a few years the problem will be particularly intense. Alternatives are related to the development of thin-client network-centric applications, the development of recycled clustered servers, and the financially and ecologically beneficial withdrawal of systems.

(4) Calculation of demand **geographic allocation**. Such a study enables reduction of the cost for transporting computational power and charge on the distribution network, since it is clear that large and permanent consumers must also be availed of respective generation units. On the other hand, peak demand may be served from other units with diversified geographic allocation. Of course its should be taken into account that part of the computational power is necessarily scattered (e.g. to schools) but this is rather small.

(5) Demand **characteristics**. Computational power may be specialized e.g. numeric, representative, real time, data storage calculations, etc. Such a study will enable diversity in the supply of basic and other units.

(6) Resource management systems development. For the proper coordination of the exploitation and monitoring of resources state-of-the-art cluster management systems should be studied and possibly developed, and in general grid infrastructure management tools, etc. The goal is to avoid turn-key solutions which are obviously easier but on the long run commit the entire system to specific technologies.

2 The grid strategic importance internationally

2.1 The importance of Grid for the Society

2.1.1 Introduction

The consequences of Grid on the daily life of citizens are quite important. Citizens will have access to resources and services from the **scientific** and **research** islands of the country and **private** agencies. The use of computational power, software and data will be open, resulting to an economy of scale at a personal level. Citizens will have access to upgraded services of the p**ublic sector**, which will result in better and faster service. The impact from the use of the grid by public administration agencies will be directly interpreted to better quality of life for citizens, who will have access to high quality, reliability and availability services.

2.1.2 The importance for the scientific community - eScience

In a particularly competitive environment, the international scientific community has already acknowledged the specific importance and significance of the Grid. The partnership model on which the grid is based considers the particularities of individual scientific groups and fields, but at the same time acknowledges that successful approach and dealing with complex scientific problems is only feasible through wide range partnerships. International partnerships are now established and a practice of the scientific community.

With the grid this partnership obtains a new meaning. Computational resources are shared based on specific protocols and policies to users needing them at that particular moment. Thus, the needs for computational infrastructure may be met by excess found in other geographically scattered areas. This way, an **economy of scale** is created at levels not yet reached. The resources are available to anyone who needs them any time. Also, with the dissemination of the grid, scientists at remote research centres and universities or branches may now actively participate in the experiments and efforts of central and large universities of the country in various sciences. The same is the case at a European and global level where small countries participate in international experiments and partnerships led by large countries. Thus the grid enhances the efforts of small- remote institutes- countries and **promotes greater participation and equal opportunities**.

The scientific community has taken significant initiatives aimed at exploiting grid computational model. Led by scientific fields which traditionally need large computational power, storage area and other resources such as **high energy physics, astronomy, meteorology, chemistry, biomedical sciences & bioinformatics, teledetection, etc**, associations and partnerships are created beyond national borders, financing limits, boundaries of specific individual scientific fields. Therefore, there is the potential to deal with problems which were extremely difficult to deal with in the past.

Research institutes of the country will have the ability to use computational power by far greater than their current infrastructure, thus significantly improving their work.

Grid potential may cause that different scientific fields communicate and collaborate, with the ultimate goal of common benefit. Such a collaboration requires changes to the sociological approach to the meaning of available resources and infrastructures, which the scientific community tries to understand. Common sharing of these resources is probably the most significant change to the way of thinking and acting of involved parties.

2.1.3 The importance for the private sector - eBusiness

In the private sector, the Grid comes to meet equally important needs. Companies may actually benefit both as hardware, middleware and applications-services providers, but also as users of Grid technologies for respective activities (simulations in various sectors such as ship building, creation and analysis of digital material for advertisements, films, etc, using **rendering** technologies, sharing **storage and computational resources** and high standard **tele-partnership** between multiple company branches, etc).

Geographic allocation of branches of specific companies means that they highly benefit from the creation of intra-grids in proportion to existing intranets. Thus they can remotely exploit resources located at central points, only supplied with fast interconnection through networks.

The grid is a significant field of development for new applications and tools, the creation of new services, and thus a good opportunity to create a new market for products and services operating with grid concept and protocols. One of the most significant developments in the area of Grids is the adoption of the **Grid Services** concept based on **Web Services** of the **World Wide Web Consortium (**http://www.w3.org) and Open Grid Services Architecture (**OGSA**) recently announced by the **Global Grid Forum (**http://www.ggf.org) and studied in the framework of the relevant Task Force http://www.ggf.org/ogsa-wg/, while it will be supported by the most common open software platform Globus http://www.globus.org/ogsa/. The existence of an open but also standard middleware may be considered as the necessary basis on which respective applications may be built and companies may provide respective grid services. This is proved by the interest and participation of large companies such as IBM and SUN, in all these task forces, and the adoption of technologies and architectures in their products. The aforementioned architecture allows the relatively easy creation of a number of new services based on programme interaction (autonomous agents) with the grid. A large part thereof can have a commercial application, such as stock market proposals to all stock exchanges of the world. The vision of companies can be summarized as follows: If we assume that Grid is the new Internet, and World Wide Grid the new World Wide Web, then Grid services will be similar to Web and internet services which have taken over several market and public life sectors.

2.1.4 The importance for eGovernment

Grid applications cover a huge range in all fields of life. Public administration may benefit the most from a general use of the grid computational model. The sharing of resources and data to various fields of public administration, new conditions may arise in the effectiveness of operation of the State.

Remote access to data will facilitate the operation of public services and significantly reduce bureaucracy. The services will be dealt with consistently as regards recording and processing of information required, while at the same time they may access information which was not available to date. In parallel, the way is open to the homogenization of software and services used, while dispersion and dissemination of computer technology is facilitated where it remains at low levels.

The introduction of grid with distributed computing, storage and other machinery to computerization and management systems of insurance funds, tax offices, public utilities and local authorities is illustrative. The single, transparent and homogeneous way of access will lead to simpler financial and administrative transactions with the state, with a parallel reduction in time, cost, errors and increase of productivity, while ensuring easy and direct information for all interested parties.

In all sectors of Public Administration and Government, the Grid may provide substantial assistance to provided services. The list of potential applications is practically inexhaustible.

2.1.5 Importance for citizens

The wide expansion of the Grid will have a direct and positive impact on the daily lives of citizens, upgrading a number of general utility services, both at the level of provided services and at the level of immediate and substantial information for citizens.

An illustrative example is civil protection, where direct information, recording and dealing with events involving a large number of independent agencies and services is required.

The exact forecast of weather conditions requiring the existence of significant computational power may greatly benefit from an environment with an extremely large amount of available resources. At the same time , calculations may be improved, resulting in better provided services by national agencies involved in these issues.

Education is the primary sector to benefit from the new potential provided by the Grid. The field of use of digital technology is extended beyond the limits of each educational organization and data accessed. The way opens to development and the use of educational software systems currently beyond the potential of the existing infrastructure.

Health is another sector where the Grid is expected to have a direct and substantial contribution. The use of Grid technologies will enable access to remote diagnosis tools and resources, easy and direct exchange of medical data, homogenization of emergency services, effective dealing with events using the know-how and experience obtained in geographically dispersed areas in the country and abroad, see **eHealth -** www.ehealthInitiative.org, **HealthGrid -** www.HealthGrid.org. Naturally, care should be taken as regards the protection of personal data, and medical secrecy.

2.2 International initiatives

2.2.1 eScience

It is already known that the European Union, in collaboration with research and educational networks in Europe, has promoted and implemented the European research network **GEANT** (http://www.dante.net/server.php?show=nav.007). GEANT is co-financed by the European Commission (DG INFO) and managed by DANTE UK, (http://www.dante.net), a company incorporated by national research networks in Europe. It provides high quality and speed services to the European educational and research community and is one of the most important parts of the global Internet as the agency interconnecting all national research networks of the countries in the European Union, Central-Eastern Europe, Israel and Cyprus. The global interconnection of GRNET through GEANT is made at 2x622 Mbps, while it is soon expected to be upgraded at 2x2,5 Gbps.

The European Union, given the operation of GEANT throughout Europe, wants to promote the creation of an additional middleware layer, aiming at achieving Grid infrastructures which will enable distributed sharing of resources to all researchers and students all over Europe. The concept actually promoted is related to the integration of the two layers into one single **eInfrastructure** to operate on a 24hour basis (24x7 or 24 hours a day– 7 days a week) at the service of researchers. For this reason, the European Union has made an invitation to tenders, under the 6th Framework Programme in the area of research infrastructures, on Communication Network Development – Grids and a budget standing at **50 million euros**.

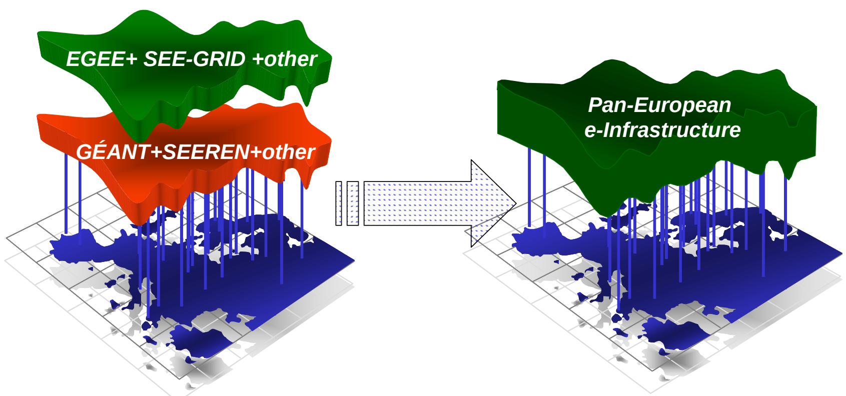


Figure 2.1 – The vision of the European research infrastructure (eInfrastructure)

Already in Europe and America programmes and initiatives for the creation of grid infrastructures are under way. Both the European Union and the USA strategically invest in grid services, which is obvious from the number and size of these initiatives. We indicatively mention the pilot programmes Datagrid (www.eu-datagrid.org) and CrossGrid (www.eu-crossgrid.org) with the collaboration of and led by CERN, aimed at developing services and applications in scientific fields such as high energy physics, biology, meteorology, etc.

The programme **EGEE – Enabling Grids for E-Science in Europe** (www.cern.ch/egee), being the natural consequence of pilot programmes DataGrid and CrossGrid, expected to be financed under the 6th Framework Programme with about **32 mio Euros (**out of 50 mio Euros), aims at developing and supporting grid services at production level. EGEE coordinated by CERN will be based on hardware infrastructures (mainly of PCs) deriving from national efforts of participating countries and will only finance specialized staff (not the purchase of hardware).

In fact, central and regional centres for the operation and support of infrastructures and grid services on a 24-hour basis will be staffed and operate, aiming at the provision of secure, reliable and uninterrupted services to the research and educational community.

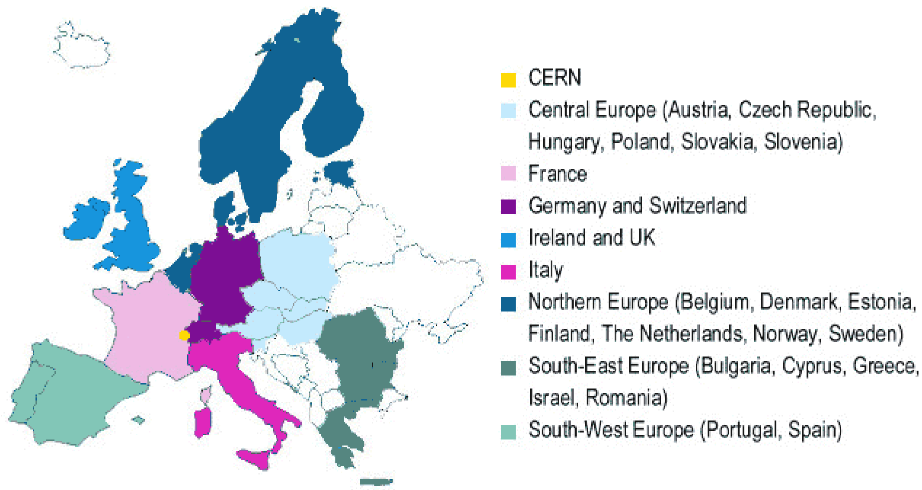


Figure 2.2 – Geographic coverage and regional organization of EGEE

In the same area (of research infrastructures) it is expected to obtain approval for the programme **DEISA** (Distributed European Infrastructure for Supercomputing Applications - www.deisa.org) constituting the mutual effort of leading supercomputing centres in Europe to create and operate a distributed supercomputing infrastructure in Europe. The most important supercomputer centres in Europe are expected to be interconnected with 10 Gbps telecommunication lines. DEISA, expected to be financed with about **14 mio euros**, is supplementary to EGEE, since it focuses on the interconnection of supercomputers, as opposed to the new model for grid development with cheap PCs. DEISA wants to constitute the European **TerraGrid** www.teragrid.org of the National Science Foundation (NSF) www.nsf.gov, financed with **53 million dollars**!

The third programme financed in the same area is **SEE-GRID** (South East European Grid eInfrastructure Development – www.see-grid.org) coordinated by GRNET. The programme aims at creating a human network in south-eastern Europe to promote grid technologies. SEE-GRID will implement grid testbeds in all countries of the area, focusing on the western Balkans, seeing to gradual accession to European infrastructures, in close collaboration with EGEE. SEE-GRID continuous the effort made with **SEEREN** – South East European Research & Education Networking, www.seeren.net for the reduction of the digital gap, developing a network for research and development in the same area.

At the same time, efforts and initiatives are in progress and constantly upgraded for the creation of common standards in the Grid through GGF (www.ggf.org) being the global forum for exchange of views and ideals on the Grid, as well as efforts for a common attitude towards challenges appearing with the Grid through the development of homogeneous and open middleware systems such as Globus. It is noted that Globus www.globus.org started as an American initiative in parallel to the Globus Project and was considered to be the most appropriate package of open software for the development of infrastructures and services of computational grids. Recently, the Globus Project was expanded with the participation of European partners, such as the University of Edinburgh and the Swedish centre of parallel computers, and was renamed into **Globus Alliance**. It is obvious that Globus Alliance may lead to the creation of a reliable and functional software package and having obtained a European character, it is more likely to prevail compared to other competitive efforts such as the Unicore.

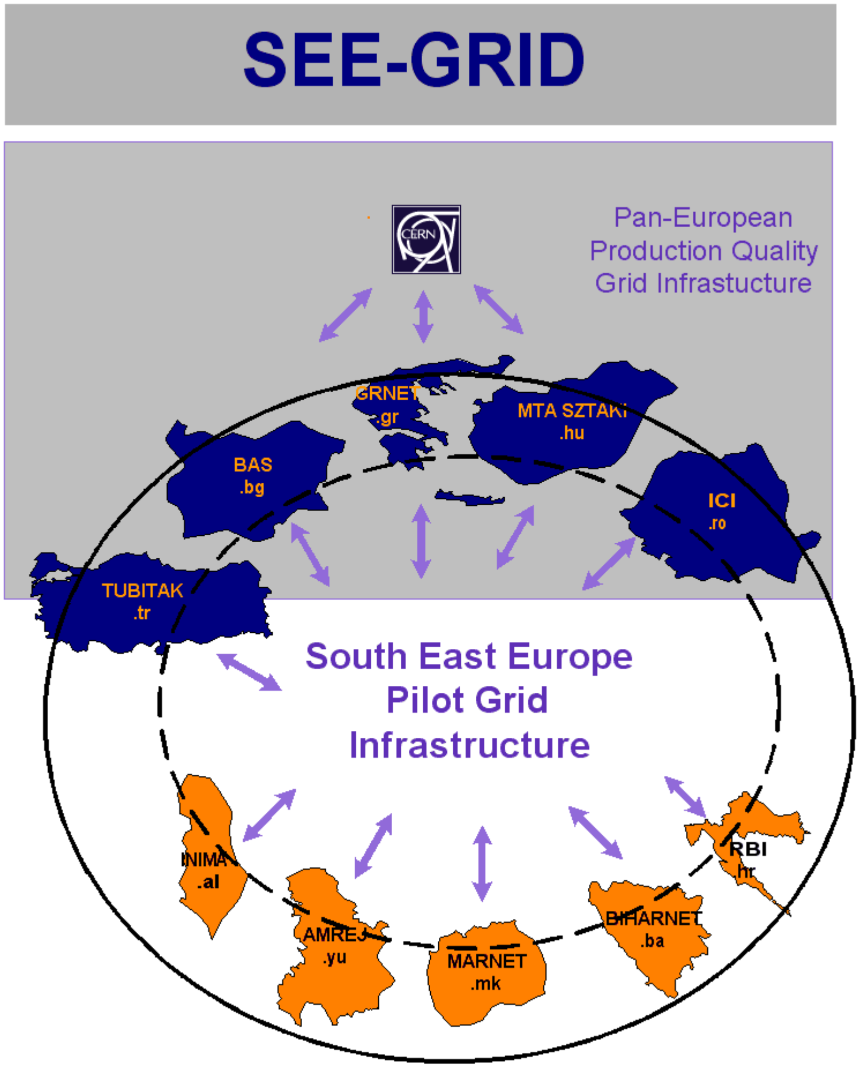


Figure 2.3 – Geographic coverage of SEE-GRID and interconnection to EGEE

Based on the above, and in particular on the guidelines of the 6th Framework Programme of the European Union related to the development of distributed Grid services and research infrastructures, but also to IST, and the guidelines of the community initiatives e-Europe 2002 and 2005 on Grid Computing and "World Wide Grid" (the new WWW-World Wide Web), the Greek research community, with initiatives taken by GRNET, in collaboration with Hellasgrid Task Force, has taken actions aimed at promoting grid technology and applications in the greater research community, and the partnership with international initiatives in the context of European Union structures, as shown below:

- At European level, participation in **EGEE** aimed at creating a utility for resource sharing for all European researchers and students over GEANT. As already mentioned, EGEE aims at integrating all existing national and regional initiatives and the creation of Operation and Support Centres for Grid users under the standards of network management systems. GRNET represents before the Executive Committee the area of south-eastern Europe and actually tries to ensure connection of this effort to the respecting regional (SEE-GRID) and national (GRNET- HellasGrid Task Force) ones, in order to provide access to the entire research and educational community to the European and global grid via the high speed network **- GRNET2 http://www.grnet.gr/edet2.**

-At regional level (Balkans), coordination of **SEE-GRID** for the creation of a human network in south-eastern Europe, focusing on the promotion of Grid technologies in the western Balkans.

The above clearly demonstrate the international initiatives of the research and educational community for the development of uninterrupted, secure and functional services aimed at meeting the needs of e-science. Also, as will be analyzed in the next chapter, Greece follows developments closely and participates in these basic efforts financed by the European Union.

Finally, a list follows with programmes related to Grids *(source Globus Alliance)* all over the world, confirming the belief on new generation Internet and World Wide Grid and demonstrates strategic investments of the USA, Europe and other countries.

Programme	**Site & Financing**	**Goal**
Access Grid	www.mcs.anl.gov/FL/accessgrid, DOE, NSF	Development & promotion of partnership systems of task forces with the use of existing technologies.
BlueGrid	IBM	IBM pilot
DISCOM	www.cs.sandia.gov/discom DOE Defense Programs	Creation of Grid infrastructure aimed at easy access to resources of U.S. DOE labs
Earth System Grid (ESG)	www.earthsystemgrid.org DOE Office of Science	Analysis of climatological models
European Union (EU) DataGrid	www.eu-datagrid.org European Union	Creation of grid infrastructure with applications in high energy physics, bioinformatics & environmental sciences.

EuroGrid, Grid Interoperability (GRIP)	www.eurogrid.org European Union	Development of technologies for remote access to supercomputers.
Fusion Collaboratory	www.fusiongrid.org DOE Off. Science	Creation of grid infrastructure for research of nuclear fusion technologies
Globus Project	www.globus.org DARPA, DOE, NSF, NASA, Msoft	Research & Development of GRID technologies
GridLab	www.gridlab.org European Union	Test and evaluation of GRID technologies
GridPP	www.gridpp.ac.uk U.K. eScience	Creation and application of grid infrastructure for research in the area of particle physics.
Grid Research Integration Dev. & Support Centre	www.grids-center.org NSF	Integration & Operation and support of the NSF Middleware infrastructure for research and education.
Grid Physics Network	www.griphyn.org NSF	Technology R&D for data analysis in physics expts: ATLAS, CMS, LIGO, SDSS
Information Power Grid	ipg.nasa.gov NASA	Creation & application of grid infrastructure for aeronautical engineering and other NASA missions.
Network for Earthquake Eng. Simulation Grid	www.neesgrid.org NSF	Creation & development of grid infrastructure for seismology
TeraGrid	www.teragrid.org NSF	Interconnection of 4 supercomputer centres at 40 Gb/s
UK Grid Support Centre	grid-support.ac.uk U.K. eScience	Programmes supporting Grid applications and infrastructures in the UK

Unicore	www.unicore.de	Integrated distributed Grid platform with particular safety features, ideal to go through firewalls.

2.2.2 eBusiness

The grid is already a significant part of international corporate efforts, both at a level of use and services and infrastructure. Already, large companies manufacturing computers develop computational platforms based on Grid. Companies such as IBM[3], SUN[4] , ORACLE[5] use the Grid, but also develop hardware and software for the provision of services through the Grid. Therefore, the grid is promoted to an important tool for the exploitation of available computational resources, and an important gear for the development of the respective industry producing hardware and software with respective benefits on the labour market.

2.2.3 eGovernment

Significant are the operations undertaken in the area of electronic government in advanced countries such as the USA, the UK, Japan and Canada. The potential of storing and managing a huge amount of data, geographically and functionally distributed, apply to several aspects of e-government related to tax, insurance, army, census issues, and applications of police, immigration and customs authorities and the land registry.

2.3 Summary of "e-Science Gap Analysis"

In a detailed study [GAP], G. Fox and D. Walker of the Universities of Indiana and Cardiff, stress and analyze the gaps (which led to the term **Gap Analysis**) in the current condition of programmes, initiatives and implementation of Grids aimed at their gradual elimination and the application of technologies for mass use (as a commodity or utility). The initiatives contained in the study mainly fall under e-Science, but certain implementations in e-Business are also contained. The initiatives examined are geographically focused mainly on the UK and Europe.

The **scientific fields** covering **e-Science** initiatives and programmes contain high energy and elementary particles physics (*European DataGrid-EDG, Grid Particle Physics-GridPP and Large Haudron Collider Computing Grid project, LHC Grid or LCG*), Bioinformatics (*DiscoveryNet, myGrid and EBI*), Chemistry, Science of Materials, Astronomy and Environmental Science (*Comb-e-Chem, Reality Grid, AstroGrid, NERC Data Grid, GODIVA*).

The Grids related to business and industrial applications (**eBusiness-eIndustry**) include Peer-to-peer environments for distribution of multimedia material to the radio station *Capital Radio*, *DAME*, a Grid in which Rolls Royce participates and which is involved in problem diagnosis and maintenance of aircrafts at real time, and *Geodise* on which

[3] http://www-1.ibm.com/grid/index.shtml

[4] http://wwws.sun.com/software/gridware/

[5] http://otn.oracle.com/products/oracle9i/grid_computing/index.html)

calculations and improvements are made for aeronautical environments with a large participation from the relevant industry.

The study also approaches other areas which are particularly crucial for the development of business grids, such as workflow applications, financial, stock exchange and other applications, and models for managing the cost of grid services and exploration of cost effective grid services, without, though, including data from actual implementations in these fields.

Initiative gaps are presented based on different entity analyses. Such different entities are grid organization levels, used technologies and the type, operability or method of collaboration. Based on each one of these entities, the study identifies the important points on grids under review.

In organization levels, the study defines six levels. Web services are assigned to the first level, based on the exchange of messages and description through metadata languages. Component services of Grids are assigned to level 2, as these are defined under OGSI. Grid operation policies and principles are assigned to level 3, while functionalities and services which, under the OGSA, must be supported on all grids are assigned to levels 4 and 5. Finally, applications ready to be performed in grid environments are assigned to level 6.

As regards used technologies, the study includes both component technologies such as Web services implementation environments (CORBA, Enterprise Java Beans-EJB, JAVA/JINI, JXTA, Microsoft .NET etc), and complete Grids suites, such as Globus Toolkit and Unicore. Emphasis is also placed on meta-languages where the semantics of various services forming a grid is expressed.

The type-functionality entity includes computational power grids (standard in physics and in general e-Science), Grids using office computers (standard in Grids applications over the Internet such as seti@HOME), information Grids based on the integration of distributed stores of information, complexity Grids (integration between computational power and information Grids) and large institutes corporate Grids. Moreover, the same entity method distinguishes different methods of collaboration between grid systems into semantic, peer-to-peer or autonomic Grids.

The conclusions of the study include, among other things, the following:

- Technology significantly affects other parameters such as the type, functionality and method of collaboration.
- There is a distance between W3C, GGF and OGSI standards. It is important that these converge, mainly in order to achieve integration of current technologies in Grid environments.
- Middleware technology is important, while significant is the role of a potential messaging, alert, management, etc subsystem.
- The composition of Grid services through Workflow applications is important, but such Workflow systems will be more complex than the respective ones of Web services.
- The existence of metadata environments is crucial for interoperability between different Grids. Tools such as UDDI, MDS and RGMA must be further developed.
- Complexity in the composition of various structural elements of grids remains a suspending factor for rapid development to all operations of Information Society. For this reason, the gap between programmes with technological potential and the need for infrastructures, software and properly operating services must be covered.

[GAP] Fox, Geoffrey and David Walker, "*e-Science Gap Analysis*"

3 Greek reality and development prospects

3.1 International research initiatives with Greek participation

It is beyond doubt that recently strong efforts have been made in Greece to follow European and international developments in grid technologies. Despite the objective difficulties, the technological gap with more advanced countries in these issues is no longer prohibiting for collaborating and participating in initiatives organized.

Especially the research and scientific community express their great interest in grid services. This interest can be seen from the participation of research groups (and companies) from Greece in international initiatives directly (Crossgrid, GridLab, Gria, EGEE) and or indirectly aiming at Grid technologies (Open Source).

In particular, in the context of **Crossgrid** (http://www.crossgrid.org), the Aristotle University of Thessaloniki (AUTh) and NCSR Demokritos actively participate in high energy physics applications, including the company Algosystems (http://www.algosystems.gr) operating in the area of IT and Telecommunications.

GridLab (http://www.gridlab.org) is an initiative focusing on the implementation of a general framework for the development of applications in Grid environment. It has been realized that the Grid should address end users developing applications, without being involved in the complexity contained in the grid infrastructure. The National Technical University of Athens (NTUA) participates in this programme.

GRIA (http://www.gria.org) focuses on the use of Grid in an industrial environment at the level of applications such as production and processing of digital films or structural analysis. Therefore, in focuses on QoS, the adoption of standards and security, incorporating GridLab experience. The NTUA and KINO (http://www.kino.gr), mainly operating in the production of advertising films, are the Greek partners in this effort.

EGEE, (http://egee-ei.web.cern.ch) is the European framework for the development of computational grid technologies. EGEE includes national or regional efforts for the development of Grid technologies. Hellasgrid is represented via GRNET, participating as a partner, with the participation of the entire task force, and has shown increased mobility in this area.

SEE-GRID (http://www.see-grid.org), coordinated by GRNET, aims at creating a human network in south-eastern Europe for the promotion of Grid technologies. SEE-GRID will implement Grid testbeds in all countries of the area, focusing on the western Balkans, seeing to gradual accession to European infrastructures, in close collaboration with EGEE.

3.2 Greek Initiatives

The adoption of the respective Open Source software, namely a software for which the source code is provided without limitations in use) is also based on a node. And this is because the relevant cost to acquire the software is eliminated on the one hand and on the other hand a know-how dissemination core is created which can enhance research in relevant technologies in Greece and meet the potential need for limited and application-oriented customization. In Greece, the open code move has been well received, with a recent example being the operation of a relevant site (http://www.open-source.gr & http://www.ellak.gr) under the GRNET.

The involvement of scientific groups from Greece at various levels on the grid – information about international initiatives, collaboration with respective partners from abroad and user of experimental Grids- arose from international trends in calculation practice in the respective research fields.

In several cases, the Grid is seen as an evolution benchmark following calculation at local cluster computing level. In this sense, in Greece there is adequate know-how from this previous calculation model. Students in Greek Universities attend, either at graduate or post-graduate level, subjects focusing on this model. At research level, the development of applications and the use of clusters is very common. Therefore, the adoption and incorporation in daily practice of the relevant Grid technologies, especially in an educational and research environment, appears extremely smooth.

Naturally, difficulties are several and in some cases are related to issues which are not directly faced.

Despite recent development, as detailed below, the fast backbone network is a reality only for research and educational networks. Broadband access is gradually developed and therefore isolated users and Greek regions cannot enjoy its fruits in the near future.

There is a dispersion of computational infrastructures in research centres and universities in Greece. Beyond the level of geographic allocation, dispersion lies in the lack of a national framework to govern collaborating operation. Their integration, therefore, as promised by the grid concept, will definitely relate to the dissemination and acceptance of a re-determined role.

Greece is a small market for grid services. Thus, in sectors outside educational institutes, demand for this type of technologies is low. Besides, the majority of enterprises in Greece do not have the research and development departments which could suggest a possible scenario for the exploitation of grid services within operations. Namely there is a deficiency at know-how level, strengthened by the limited needs of the domestic market.

HellasGrid, with its national range, comes to organize and link the first efforts made by the research community, mainly on eScience, but also provide guidelines both to Greek companies on eBusiness and the public administration on the service of citizens and eGovernment. In this effort, the human network and infrastructures meet and are organized in a node of direct communication with the respective efforts made abroad.

3.3 Greek reality review - Questionnaire results

In the context of the need to collect and process demands of users to record Greek reality, the **HellasGrid** scientific board prepared a questionnaire in order to explore various components of the activity taken in Greece as regards Grid technologies.

Specifically, the type of resources required by Greek users was recorded, including computational power, storage areas and network resources, the existing infrastructure in networks, middleware and applications, and development plans.

After the preparation of the questionnaire, the interested communities were identified and a table of eligible ones was made, which included both research and educational institutes (*eScience*) and public organizations (*eGovernment*), but also private agencies (*eBusiness*).

The detailed answers to questionnaires are presented both in a table and a figure in Annex B[6].

From the collection and processing of information as recorded from filled in questionnaires, Greek reality is recorded as follows:

- As regards the type of required resources: The Greek user community uses CPU intensive applications, the time of execution exceeds 24 hours, they are non-time critical in majority, and many of them run on a daily basis. The required storage area corresponds to tens of GB. Needs in security may be characterized as moderate.
- As regards the current infrastructures in network, middleware and applications: Greek users in majority develop software, have used parallel interfaces, especially MPI, while there is small experience in the use of middleware frameworks such as Globus Toolkit and Condor/Condor-G. The current infrastructures include about 20 clusters of 8 to 32 nodes / cluster and a storage area of about half a TB for most agencies. Speeds of local networks stand at 100 Mbps.
- As regards plans to infrastructure upgrade: Plans have been made for the next two years for the installation of at least 10 new clusters (consisting of 700 nodes in total).

In general, initiatives for the penetration of grid technology in Greece were received with great interest by Greek users.

3.4 Currentt Infrastructures & Applications - Development prospects

3.4.1 **Broadband network infrastructures**

The development and dissemination of distributed computational grids greatly depends on the condition and services of broadband networks in Greece. Due to the small number of PC users and low penetration of the Internet on the one hand, and geographic complexity of the country on the other hand, Greece (with the exception of GRNET broadband network for the research and educational community) shows deficiencies compared to other European ones as regards network infrastructure. An effort is made below to analyze the current condition of network infrastructures compared to the services which may be provided to the educational and research community for eScience, the public sector for eGovernment and the private sector for the support of eBusiness applications.

Broadband infrastructures for eScience

To the direction of developing advanced network infrastructures, the Greek and global research and educational communities have played an important role. In Greece, the Greek Research and Technology Network(http://www.grnet.gr) has been providing backbone network services to the Greek educational and research community since 1995. The backbone network of GRNET currently includes nodes in the cities of Athens, Thessaloniki, Patras, Heraklion, Larissa, Ioannina and Xanthi. Connections between Athens, Thessaloniki, Patras and Heraklion are made at a speed of **155 Mbps**, while the GRNET2 MAN already operates in Attica from June 2002 at **2.5 Gbps,** interconnecting the largest institutes in the area of Athens. This network is expected to be expanded covering all the above areas in Greece, with interconnections at 2.5 Gbps. Also, GRNET is interconnected at **1.2 Gbps** with **GEANT**. In early 2004 it is expected to upgrade the

Deleted: http://www.grnet.gr

[6] Annexes are not included in this issue

international connection at **2 * 2,5 Gbps,** which will provide a significant motive to Grid users for collaboration with respective European and international groups in the USA and Canada. It is reminded that GRNET is the international partner of Internet2 (USA) and has access through GEANT.

GRNET also takes initiatives and coordinates regional programmes financed by the European Union, such as SEEREN (South Eastern European Research Networking-www.seeren.org) implementing a research network of medium-low speeds in the area of south-eastern Europe, and countries of the Mediterranean outside the EU, including Turkey, a network implemented under the competitive programme Eumedconnect.

GRNET cooperates with 73 national agencies including all universities and technical institutes of Greece, a large number of research institutes and primary and secondary education schools. In particular, **GUNET** (http://www.gunet.gr) supported the interconnection of 18 Universities and 14 Technical Institutes with high speed lines to GRNET, while it will support the upgrading of the access network for its members and the implementation of telematics and digital content services. Also, the Pan-Hellenic School Network (http://www.sch.gr) is the primary and secondary education network (2nd CSF, EPEAK and 3rd CSF, OP ITS), connected to GRNET at seven main points (Athens, Thessaloniki, Patras, Heraklion, Larissa, Ioannina and Xanthi), has 51 nodes and serves 1,059 primary schools, 3,660 junior high and high schools and 141 Vocational Training Institutes (April 2002). Further collaboration between the school network access network and GRNET backbone for better geographic coverage of Greece and the service of new institutions.

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In the context of the operational programme Information Society and community competitive programmes under the common European policy of e-Europe2000 and e-Europe2005 on research–educational networks, GRNET2 is being developed to provide research centres, universities and technical institutes of the entire country with access to the Internet at **2.5 Gbps** proportionate to GEANT.

Broadband infrastructures for public administration - eGovernment

To the direction of developing network infrastructures in the public sector, we should mention the project SYZEFXIS (http://www.syzefxis.gov.gr) which started operating in 15 agencies of public administration in 2001 (2nd CSF, OP Kleisthenis) as a pilot project. This network provides interconnected users access speeds of 1 Mbps on average, with two agencies at 2 Mbps, one at 4 Mbps and a central one at 34 Mbps. 19 more agencies were interconnected in 2002.

The national public administration network with SYZEFXIS, financed under OP Information Society of the 3rd CSF is expected to interconnect 1,766 agencies of the Greek public administration. This will be a large scale broadband network with access speeds from 2 to 34 Mbps. SYZEFXIS constitutes the necessary infrastructure for the grid implementation in the public sector. Tender procedures have already been proclaimed and the first connections are expected to be delivered by end of 2004.

Changes under way will also relate to non-urban areas, affecting the life of citizens living and working in the province. Specifically, Measure 4.2. of OP Information Society" (Development of Local Access Network Infrastructures) aims, among other things, at developing the appropriate telecommunications network infrastructure for towns and non-urban or remote areas, supporting supervision-protection of these areas from natural disasters (e.g. fire, earthquake, etc) or supporting other environmental protection applications. This measure is more general and relates to all 3 categories of operation (eScience, eGovernment, eBusiness).

Broadband access in Greece (eBusiness)

The development of broadband applications and services is of strategic importance for Greece, since it is expected to significantly boost financial activities and contribute better quality of life for citizens. For this reason, under the OP Information Society, a committee was set up in order to prepare and submit to political leaders of the competent Ministries a strategy paper for the development of broadband access services in Greece (http://www.broad-band.gr). Based on recommendations and actions proposed, it is expected that short and long-term changes will be planned among other things to the development of networks in Greece.

Apart from the action under measure 4.2 aforementioned, **DSL** technologies are expected to contribute to the development of broadband access in the country (also taking into account wide acceptance in other western countries). This would create and or stimulate business activities using the Internet as a means of interaction for eBusiness and give new breath to Grid potential also to/ from end domestic users.

Traditional Internet service providers are expected to evolve into *grid service providers*. This would give new potential and form the ground for business activities hard to imagine. Maybe the selection of a product from a super market shelf might trigger a chain of calculations in the near future (automatic warehouse updating and order for supply of new batch, buyer profile processing based on recent visits, automatic charging of bank account, etc) part of which may be executed on the buyer's home PC!

3.4.2 **Middleware**

Middleware actually allows access of application users to Grid infrastructures mainly implementing the sharing and control of resources and their secure management. On this, interfaces are built to be used by the end user when customizing applications. The production of such of a state-of-the-art software requires concentration of know-how of experts from various countries. The international character of such an effort at a second stage also facilitates the process to promote the product to an industrial standard.

Greece follows the development of various technological solutions, mainly open code, and embraces the guidelines of European efforts in which it participates, at the same time taking into account the existing know-how as recorded in the questionnaire (**MPI, Globus Toolkit, Condor/Condor-G**). Focus on an standard open code software arises from the need for flexibility to custom applications while maintaining compatibility.

The basic middleware infrastructure platform includes primary components such as security and the issue of certificates, index services, etc. Research initiatives have been developed, mainly from the task forces of **TERENA** with the participation of GRNET (see http://www.terena.nl/tech/task-forces/tf-aace/), aiming at encouraging and supporting collaboration between national and educational research networks and other task forces in Europe for the development and implementation of infrastructure interoperability and authentication and authorization services. Among other things, **TERENA** also deals with and issue of Public Key Infrastructure (PKI), as regards the collection of all Root Certification Authorities (CAs) in a practical and efficient manner. A possible solution to be implemented is the use of a procedure for the collection and confirmation of European NREN root-CA certificates, which enables subsequent publication on a reliable site.

Other research initiatives can be found in European research development programmes under the 5th Framework Programme such as the **IST Datagrid** and **IST Crossgrid** www.eu-crossgrid.org. In the context of the latter, the Physics Department of AUTh has developed an infrastructure for the supply of certificates (http://pki.physics.auth.gr), under which it has created the HellasGrid CA, which has been granting certificates for use on grid technologies since mid 2002. Free certificates are provided and the rules regulating operation at all levels have been determined (security rules for the staff, procedure for the issue of certificates, storage of information, obligations of contracting parties, technical specifications of issued certificates, certification policies, etc).

In parallel, the National Telecommunications and Post Commission (EETT) already examines the main accreditation and supervision schemes (Root CA hierarchical model), Distribution of a List, Meshed Cross Certification, Cross Certification with Hub CA and is expected to select one of the above for the creation of a national certification infrastructure.

In the context of the above efforts and considering the suggestions of the new research programme EGEE, the administrative and technical task force Hellasgrid may proceed to the selection of a suitable identity authentication and authorization scheme to support grid technologies.

For consistent dealing with the issue both in Greece and in Europe, and internationally, the intention to create **Middleware institutes** has been expressed. The first efforts have already been reported in America **(Open Middleware Institute Initiative –OMII)** and England. This proposal was submitted to the one-day meeting co-organized by the European Commission, the General Secretariat for Research and Technology and the Greek Research and Technology Network (GRNET) in collaboration with the National Documentation Centre (NDC), under the title **eInfrastructures**. http://www.cordis.lu/ist/events.htm. The Greek Middleware Institute could consistently deal with the issue of middleware and coordinate European- American efforts with that made in Greece. Such a proposal could be submitted also under the OP ITS. For the latter to be achieved, changes should be proposed to the OP ITS after consultation with the agencies represented in HellasGrid and the appropriate procedures.

3.4.3 Applications

The Grid concept was born from increased requirements for computational power, storage area and other resources with some wide range scientific applications (**eScience**). This also relates to communities without an educational orientation (eBusiness, e.g. entertainment, production of digital films), but at least at this primary stage it easier to identify applications in scientific research.

This is even more true in Greece, where the lack of expertise in the limited business environment aggravates adoption. Examples of companies like KINO and Algosystems having presented operations in grids must be considered as individual. On the contrary, in education, grid applications are a reality. Some basic application examples follow, where significant operations are undertaken in the field of grids.

In high energy physics, Greece participates in **CERN**, the cradle of grid technologies. What is interesting here is the distributed processing of a huge volume of data to be produced by large scale experiments to be performed in next years.

There are research groups in Greece, in the greater fields of meteorology and environmental physics, which have the expertise, but also demanding numeric simulation models, which can be customized to Grid infrastructures. The progress of weather forecast has always been connected to the respective progress in computer science, given the large computational needs and the need to perform the application in corporate time. The active involvement of public agencies such as the Hellenic National Meteorological Service (**HNMS**), the National Observatory of Athens (NOA) and the National Centre for Marine Research (NCMR) is only expected and the benefits to the economy direct. The participation of the civil protection service is also interesting, which could exploit Grid infrastructures to forecast disasters (floods, earthquakes), immediate notification of fires, etc.

In the fields of **Health and Bioinformatics,** Grid applications are of high importance even for simple citizens in Greece. The use of various techniques such as image analysis, artificial intelligence and data mining, some really sensitive for the public applications are proposed, aiming at preventing serious conditions through the processing of digital medical data. The creation of a Health Grid has already been proposed.

Complex problem solving, and new sectors such as Virtual Collaboration Environments with **AccessGrid** services (distributed teleworking, tele-education, traffic of digital content, virtual reality, etc) can benefit from Grid applications, provided they make the appropriate software adaptation to be able to use grid interfaces.

The development of computers is generally connected to progress and technologies based on computational engineering of simulations, such as aeronautical engineering, where such calculation methods are used in the design of aircrafts and motors, dramatically reducing the time of design and increasing the reliability of the product. As an example we mention a motor which was designed in this method, which met the specifications required for a licence to fly and met industrial goals with the first manufactured original. Foreword software enabling the required management and optimization methods has been developed for numerous applications, starting from high technology areas, as the one mentioned above, to current applications, as the ones in the offices of architects and civil engineers. The use of Grid technologies in such high technology applications is expected to reduce the cost of products, increasing quality through the potential optimization provided. Therefore, it increases competitiveness of the enterprise using those means, regardless of the country where it is located and technological level.

Parallel processing with distributed low cost memory computers offers great opportunities with an increasingly higher computational power to have a positive effect, not only on eScience applications and agencies providing services, such as stage agencies (eGovernment). Also, all enterprises, regardless of the available technology, must be able to use all the computational tools available to be competitive. Therefore, the preparation of a strategic plan to raise awareness in enterprises as regards the use of new computational tools to be/ become competitive, will create the necessary R+T space, which will have the necessary infrastructure and will enable support of enterprises and training of staff to the extent required, is necessary. HellasGrid moves to that direction.

3.5 Grid importance for the country

Grid infrastructure development in favour of the Greek community, both in areas of research and technological development with traditional needs of supercomputing systems, such as high energy physics, astronomy, computational chemistry, computational simulation engineering, meteorology, the environment, bioinformatics, and in new fields such as distributed teleworking, telemedicine, teleeducation, traffic of digital content, virtual reality, etc, is a priority for the Information Society in Greece.

It is obvious from the above that the grid may contribute to the improvement of quality of life and communication of citizens, management and services, and the distribution of necessary computational resources to the scientific and research community of the country.

Greece as a central grid node of south-eastern Europe

Greece, at a regional level in the Balkans and the greater area of south-eastern Europe can and must be the central node of services and grid expertise pole for neighbouring countries. This means that Greece should play the role undertaken by Bulgaria from time to time at a power level, since the country has a nuclear generation station.

Our country, having greater experience in European issues and participating and leading European grid initiatives, must attract the other countries in these efforts to reduce the digital gap and on the long run to achieve prosperity, development and stability in the region.

As already mentioned GRNET moves to that direction in the field of eScience with the recommendations of SEEREN and SEE-GRID, aimed at creating eInfrastructures and human networks in the Balkans, and EGEE for equal accession of the region in European efforts. The business world of the country should act similarly, and the Greek State, promoting interstate cooperation in research and development, eScience, e-Business and e-government.

4 The role of the state and possible intervention

4.1 Grid technologies as a challenge of the ITS

The challenge of Information Society for all citizens

In the 21st century, Information Society (ITS) creates new conditions and new opportunities for development, prosperity and quality of life. Its development is based on the rapid evolution of Information and Communication technologies. These technologies are the substantial tool for an open and effective government an the provision of improved services to citizens. In parallel, they create a new economy based on knowledge, upgrading the role of human manpower.

The policy of information society aims at using new technologies for an open and effective government, upgrading conditions for financial development, creating job positions, quality improvement of the educational system, improving quality of life, protecting and promoting Greek culture.

The policy of information society also sees to the equal participation of everyone in the digital era, access for all areas to the global village, the elimination discriminations between those having digital access and those who have not.

Aiming at promoting information society in a consistent and complete method, the Operational Programme for Information Society has been proposed under the current Community Support Framework (2000-2006). It is an innovative horizontal action programme at interministerial scale, which seeks to implement the White Paper of the Greek government "Greece in Information Society" (February 1999), while following the Lisbon implementation strategy and e-Europe 2002 and 2005.

The OP ITS is the main gear to the implementation of the entire national strategy to ITS. Significant institutional actions are taken in parallel and complementary to the OP priorities.

In this occasion, characterized by the accession of Greece in the Economic and Monetary Union and European integration in general, an overall strategy has been shaped for Information Society, with specific goals and application procedures. This strategy is based on some main principles:

- *Innovation and business initiatives*: ITS will develop based on market mechanisms and the institutional framework must facilitate new business initiatives and innovation

- *Democracy and personal freedom*: ITS must strengthen democratic procedures and protect the rights of citizens

- *Equal opportunities and solidarity*: ITS must offer all citizens access to opportunities, knowledge and markets provided by new technologies and support who could not obtain access.

Goals of e-Europe 2005 "Information society for all"

The main goal of e-Europe 2005 is to create an advantageous environment for the development and creation of new job positions, promote productivity, modernize public services to citizens and give all the opportunity to participate in global information society.

eEurope 2005 aims at creating secure services, applications and content to all European citizens, based on a widely available broadband infrastructure network.

The eEurope action plan is based on 2 sets of actions interacting and supporting each other: on the one hand services focusing on e-government applications to citizens and e-business for the development of economy, and on the other hand infrastructures for the above, focusing on broadband networks. In detail, by 2005 the European Union must have:

- modern, electronic services for citizens
- electronic government infrastructures
- e-learning infrastructures
- -health services
- full digital environment for the operation of e-business and infrastructure of the above
- wide dissemination of broadband networking services
- secure access

The action plan includes four tools for the achievement of the above goals:

First, interventions at administrative level for the adaptation of legislation at national and European level. The goal is to ensure that the current legislation does not place any obstacles to the new services of eEurope2005. In addition, competition and interoperability of services at European level should be strengthened.

Some indicative goals (priorities) are:

- Interconnection between public administration, schools, health service providers
- Interoperability between the above poles at a national and European level
- Public e-government services for users, accessible by all.
- Online health services
- Advantageous environment for the development of broadband infrastructures
- Development of an advantageous institutional framework through appropriate legislative interventions and policies to the European development of e-business, stimulation of productiveness and boost to the economy

- Development of a safe environment for information transfer, development and operation of all e-services via broadband networks.

Second, the eEurope framework facilitates the exchange of ideas, views and good practices and demo projects in the above priorities, and the exchange of experience gained from potential failures in the fields above. Pilot projects will be the driving force to the promotion of applications and the exploitation of infrastructures. **Third, e-benchmarking** for the evaluation of the successful implementation of the above. **Fourth,** total **coordination of national initiatives in the above priorities** to promote synergies at European level. Coordination teams will explore national policies aimed at exchanging ideals, approaches and actions in order to align national initiatives with the goals of eEurope2005.

e-Government projects: The goal is services to the citizen

According to the priorities under eEurope 2005, the IDA framework for interoperability between e-government projects and the subsequent IDAbc (Interoperable Delivery of pan-European eGovernment Services to Public Administrations, Businesses and Citizens), the main priority for the implementation of ITS projects must be final e-Services to citizens and the development of infrastructures must serve these services. Already, under the action plan eEurope 2002, and now under eEurope 2005, 20 main services have been distinguished for citizens of Member States, to be provided on the Internet[7].

In a few years, citizens should take the provision of on-line services by public administration for granted, just like today, in a fully competitive financial environment, the provision of integrated on-line services by private companies is taken for granted, e.g. for the purchase of goods (market research- order- payment-home delivery), the organization of a trip (enquiry– booking– payment- receipt), banking transactions (full performance of all transactions) etc. The implementation of online services not only facilitates citizens but also makes easier the way companies perform transactions today with the state, enabling faster, simpler and filly electronic transactions. Services to the business world such as the setup of a new company, the payment of loans, insurance contributions, taxes, debts to the State, participation in procurement and tender procedures, the submission of statistics, the declaration of commodities at customs, the acquisition of operation licences, etc, are some of the standard services.

Besides, e-benchmarking indicators of e-gov projects at European level are now based on the result, evaluating the extent of operation of a service and the number of citizens using it, as indicators of successful implementation or otherwise.

Web Services for e-government projects:

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[7] Source:
1) eEurope2005 action plan ,http://europa.eu.int/information_society/eeurope/2005/index_en.htm
2) eEurope common basic public services,
http://europa.eu.int/information_society/eeurope/2002/action_plan/pdf/basicpublicservices.pdf
3) Linking-up Europe: the importance of interoperability for eGovernment services:
http://europa.eu.int/ISPO/ida/jsps/index.jsp?fuseAction=home

The modern concept for the design of e-Gov projects is now based on the provision of integrated services to citizens. Integrated are those services of implementation level 4, namely those including a full cycle of electronic transactions, completing the procedure, without needing additional actions by the citizens (e.g. at a debt payment service: authentication, decision, notification, delivery and payment, all electronically). It is obvious that e–gov projects are now designed on open architectures and standards, fully supporting interoperability between different agencies and applications, for uninterrupted workflow and information to citizens. Modern e-government projects in countries such as Germany (Bundonline2005[8], www.bundonline2005.de) are based on technologies enabling the original (horizontal development) of basic services as software subsystems which may be reused, constituting the basic structural elements for individual e-Gov services. The distributed concept for the design of e-Gov services requires that each administrative agency offers a suite of basic services on its data (e.g. Ministry of Finance with tax register, Municipalities with rolls, etc) automatically provided to any other agency, thus enabling exploitation of the registry data from other agencies. Illustrative is the example of information from the Information Systems Secretarial General or insurance agencies or local authorities, required for numerous other transactions with the State. The introduction of web service technologies allowing **modular design of applications**, providing open interconnection and exchange of data with other applications, enables the reuse of services (software), leading on the one hand to economies of scale and on the other hand to full interconnection and electronic collaboration of agencies, creating uninterrupted data flow between various administration levels for citizens.

Web Services in Grid environment

The Web Services technology enables interconnection (at data level) and interoperability (at processes level) between computers for the automatic creation of complex e-services. It is a set of modern, open development and operation modular software components on the Internet, based on XML language for WSDL and browsing of services in a distributed list (UDDI), and communication and dispatch of data (SOAP or XML-RPC for XML).

The integration of Web Services in Grids has led to the development of the standard OGSA (Open Grid Services Architecture)[9]. According to the OGSA, the open grid applications standard on the web services concept, every service distributed through grid infrastructures supports a number of open standards allowing it to be known, describe its functionality, call and be called by other services and end users, under the grid access and communication rules, in order to dynamically compose new, complex applications. The adoption of the web services model for the development of applications in the distributed grid environment has resulted in the OGSA. New services are now distributed, dynamically composed through the grid, since each service provider, through open protocols and description languages, states the type of services provided and how an authorized grid user can user them either as end service or structural components for complex services.

E-government services through Grid infrastructures: Integration of standards, applications and services for citizens

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[8] www.bundonline2005.de : Implementation Plan for the E-government Initiative BundOnline 2005

[9] "The Physiology of the Grid: An Open Grid Services Architecture for Distributed Systems Integration," Ian Foster, Carl Kesselman, Jefrfrey Nick, Steven Tuecke, http://www.globus.org/research/papers/ogsa.pdf

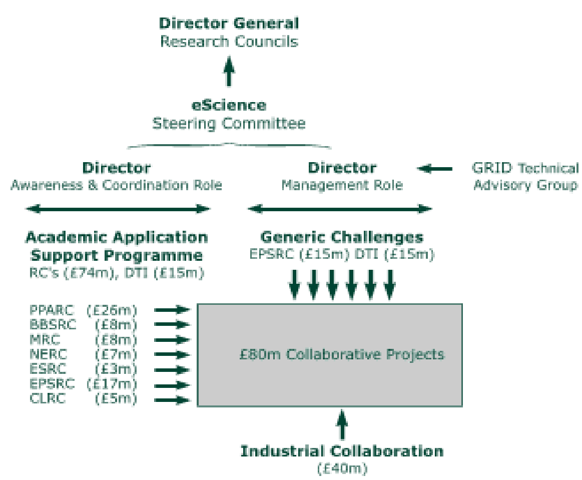
Software applications providing e-government services use a number of data and operations from individual administrative agencies, which in most cases belong to various administration levels (ministries, regions, prefectures, municipalities). There are complex transactions with Public Administration requiring operating cooperation between all involved agencies and the exchange of data for the integration of services to citizens. Web services architecture will lead to the existence of basic electronic services by administrative agency, to provide the functionality required for the integration of complex services in an open manner. Grid environment may provide all infrastructures for authentication and security, exploring basic services and composing complex services requiring access to various distributed data registries, quickly and safely. The grid, through web services and OGSA, provides a standard model for the development of e-Gov applications, distributed as regards development and operation, applications which interoperate and integrate services, providing citizens the picture of a single service provider.

The composition of Web Service technologies, Grid services together with Semantic Web, provide the future e-services.

4.2 Strategy & Support Policies in other countries

The UK example (UK e-Science Program)

One of the most significant and systematic national efforts for the development of Grid infrastructures in Europe was made in the United Kingdom with the programme e-Science (UK e-Science Program). This is a large national initiative for the promotion of grid technologies in scientific and technological applications. This way a large community of scientists and users is created, capable of channelling know-how not only to scientific fields, but also to fields which are directly related to a better quality of life for citizens.



e-Science is based on a number of Grid projects-applications, built around the national Grid infrastructure. The greatest advantage is the large participation of the industry: More than 50 companies are involved in the programme actions, contributing with more than €30M, added to the amount of €140M spent by the British government.

Support is provided to a number of projects in fields such as health and medicine, genome technologies and bioscience, astronomy, high energy physics, environmental sciences, chemistry and science of materials, even social and economics sciences. Each project has participants from the educational and industrial area. The goal of e-Science Grid in the United Kingdom is to provide the necessary infrastructures not only for e-Science, but also for e-Business, e-Government and e-Life.

All Grid application projects are supported by the central infrastructure of e-science programme (Core Project). The core infrastructure provides grid project support centres and an assisted number of tools for using and managing grid infrastructures.

At the first phase of the e-Science R&D Programme (2001–2003), the British government spent in total **£118M (~€170M)** (two sources of financing: £98M from the Department of Trade and Industry and £98M (~€140M) from the Office of Science and Technology (OST)), in two strategic directions: £83M (~€118M) fir application projects (in various scientific fields) and £35M (~€50M) for the core infrastructures and the support of partnerships with industrial partners (whose participation with own funds stood at €40M).

For the second phase (2004–2006) the amount of £96M (€136M) has been budgeted for application projects (in various scientific fields), £16M (€22,7M) for Core Programme and £25M (€35,5M) for Core Grid Middleware.

The example of Italy (INFN Grid):

Italy started the national development of grid infrastructures in the second half of 1999 with INFN Grid (Instituto Nationale di Fisica Nucleare). The first Grid project aimed at creating computational infrastructures for INFN aimed at the performance of LHC experiments. This project had more than 20 collaborating national agencies, over 100 experts from all fields and a budget of ~30 M€ used for the development of local computational centres and relevant grid infrastructures.

Subsequently, the Grid.IT initiative was developed, where the INFN was in charge for the creation of the national Grid infrastructure and the proper operation of the centre operating and providing grid services at national level (national Grid Operation Service (GOS). The national research network GARR supports the operation of Grid.IT. GOS of INFN already supports both the operation of applications from various scientific fields of different Italian research and technology agencies, and is expected to play a similar part in the framework of the new project EGEE (financed by the European Commission for the creation of a European Grid infrastructure).

The Italian eScience Grid.it infrastructure supports the following scientific fields:

- Astrophysics
- Biology
- Computational Chemistry
- Geophysics
- Earth Observation

- but other sciences are joining thanks to new MIUR funds (e.g. new S-PACI and other PON projects)

Budget: €8.1 M , 3-Year Project, Commencement: November 2002.

Project under the National Strategic Program (FIRB program) of the Ministry for Education and Research (MIUR-FIRB, Ministry for Education, University and Research) in the area of Enabling IC Technologies of the Italian Information Society. The project title is "Enabling Platforms for High-Performance Computational Grids Oriented to Scalable Virtual Organizations" and constitutes the proposal of the most representative agencies in Italy, in the area of Grid technologies: INFN, ISTI-CNR, ICAR-CNR, ISTM-CNR (Institutes of the Italian research centre -CNR) and ASI and CNIT (National Consortium on Telecommunications). The project budget is 23M€ of which 8M€ correspond to own funds and 15M€ from MIUR-FIRB, Ministry for Education, University and Research.

A new initiative started from INFN and experience from several projects financed by the MIUR- FIRB and CNR aimed at promoting participation of Italian agencies in R&T projects in the 6th framework programme and other international grid actions is IG-BIGEST (Italian Grid for eBusiness, eIndustry eGovernment, eScience & Technology http://www.pd.infn.it/bigest/) .IG-BIGEST coordinates with INFN and includes all Italian scientific institutes, the largest computational centres of the country and many companies which want to participate and invest in original tests on IG-BIGEST.

The Netherlands example (Virtual Lab E-Science project)

The Netherlands have a complete grid infrastructure which includes:

- Networking infrastructure at gigabit interconnection speeds (SURFnet with projects Gigaport and Gigaport Next Generation, http://www.gigaport.nl)

- A set of e-science applications under the initiative Virtual Lab E-Science project (also containing applications-actions from e-business)

- Large scientific community of users, from universities and research institutes.

The Amsterdam WTCW (Amsterdam Science and Technology Centre- http://www.wtcw.nl) has two significant initiatives in the area of Grid infrastructures:

a) **e-Sciencepark Amsterdam** ('Global scientific collaboration and next generation enabling infrastructure') providing coordination and infrastructures for e-Science activities in the science and technology part in Amsterdam and all over the Netherlands. The science park hosts a large number of modern infrastructures, providing national supercomputer service, maintenance of the national research network SURFnet5, research and scientific users driving e-Science developments, as well as many relevant national and international collaborations.

b) the **Virtual Lab e-Science,** a programme of a total budget of 55,6 mio Euro, of which 27.6 m Euro will be financed by the national centre BSIK *(Besluit subsidies investeringen kennisinfrastructuu*) and consists of the following 4 priorities:

  - e-Science in applications

- Generic Virtual Laboratory methodology
- Large Scale Distributed systems
- Scaling up to & validating in ‘real life applications’

The project includes 21 collaborating agencies from Universities and research institutes such as the University of Amsterdam, Vrije Universiteit, Delft University, FOM (physics) AMOLF and NIKHEF institutes, NWO and CWI and TNO, and private agencies such as the companies Philips, Unilever and IBM or others such as LogicaCMG and FEI. There is close collaboration with the projects Giga Port Next Generation Networks and Giga Port Next Generation Applications, and Netherlands Bio Informatics Centre.

4.3 Potential -Intervention mechanisms for grid development in Greece

For the development of basic Grid infrastructures and the dissemination of the new technology to greater groups of users from research and technology agencies (research centres, institutes, universities, etc), the task force HellasGrid was set up, under the OP Information Society. This intervention of the OP ITS promotes the development of a central national policy on Grid issues.

In particular, the HellasGrid task force, having evaluated both Greek reality in infrastructures and human resources and the needs deriving from individual user communities (research community, economy-businesses, etc), but also international experience and best practices developed in other countries, advanced in grid issues, proposed the inclusion of actions in the OP ITS promoting the development of distributed grid services on a regional basis as well. The areas of pilot application come from the research field and applications which, traditionally, require computational grid infrastructures, such as high energy physics, astronomy, computational chemistry, meteorology, bioinformatics and distributed tele-collaboration and virtual reality applications (in general e-Science and high standard e-Learning applications).

HellasGrid, in collaboration with the Managing Authority of the OP Information Society, will directly submit a complete plan for the development of pilot grid infrastructures and services to selected centres all over Greece, with the necessary involvement of all research agencies for the successful operation of infrastructures and the dissemination of technology to as many Greek research groups. The goal of the pilot project to be included in the OP ITS is to create a solid technological basis for the national Grid and motivate all research groups as regards grid technologies, and familiarization with the software and provided services.

In order to support and exploit the pilot Grid infrastructure, the creation of a national framework is required for:

- the interconnection of the Greek Grid to national-international networks (Grid infrastructures at European and global scale);
- user access policy;
- the policy for the use and potential billing (in the future) of available services;

- the ability to provide grid services to and from businesses (e-business through the grid).

Moreover, the state needs to support the research agencies operating in the area in order to strengthen grid collaborations at national level on the one hand and participation in international initiatives and collaborations which promote infrastructure technology and grid services at global level on the other hand.

For equal participation of Greek agencies in projects and international actions, support should be provided from competent authorities to the country's international representation in the European Union and international fora.

The competent Ministries: Ministry of Development (responsible for preparing and implementing the national research and development policy), Ministry of National Education and Religious Affairs (responsible for the inclusion of information and communication technologies in learning), Ministry of Economy and Finance (responsible for the Operational Programme Information Society), Ministry of Transport and Communications (acting as the agency of broadband access networks) must support and exploit grid infrastructures and research and development, education, and information and knowledge dissemination potential provided, including relevant actions in their priorities. Through vertical initiatives of the Ministries and interventions in individual competencies of each agency, it is possible to develop new potential for the productive integration of grid technologies in the institutional operation of each agency, as is currently the case with the simple online interconnection on the Internet.

Grids will be the new Internet in the years to come, the highway for information, but also knowledge and services, the new area through which all e-services will be provided for sciences, economy and public administration.

An indicative action plan:

- Development of a core infrastructure and basic services (e.g. user authentication, security certificates, management of resources) through the pilot project HellasGrid by 2004.

- Development of research agencies pilot applications (e-Science) by 2004.

- Complementary action (within the OP ITS) for support to the collaboration and involvement of agencies to the exploitation of the HellasGrid pilot infrastructure, having middleware and applications as a priority.

- Development of e-government pilot projects with the use of grid technologies, promotion of best practices.

- Creation of a framework and guide of technical and operating specifications (standards and technologies) for the development of applications and the provision of grid services in research, administration and economy.

- Accessibility (with security certificates) for the entire research and educational community by 2005.

- Encouragement for secure services and e-government, e-health applications through Grid infrastructures by 2007.

- Creation of a development, project support and grid applications team (as an incubator).

- Announcement of actions for the support of R&T infrastructures and grid applications through agencies such as the General Secretariat for Research and Technology, etc.

- Integration of broadband networks and grid applications on a single platform for the provision of services to citizens.

5 Proposals for the development of grid services and operating framework

5.1 Objectives

Greece must create a national grid infrastructure for research and development, which will cover the entire country, while in parallel in will enable Greece to play a strategic role for grid development in the entire region of South-eastern Europe- Mediterranean. In the next 2 years, a core national grid infrastructure must have been created, which will constitute the interconnection node to the respective European and global infrastructure.

The development-implementation of grid technological solutions can follow a bottom-up or top-down concept. In this document, the first approach will be adopted, created, at a first stage, small autonomous grid environments (*IntraGrids*), which, when interconnected, can create static or dynamic ExtraGrids.

5.2 Implementation strategy

5.2.1 IntraGrids: "The exploitation of grid technologies in organizations and businesses for best exploitation of resources"

The implementation of the grid infrastructure within an organization enables best exploitation of available resources. As shown in the previous paragraph, transition to such a structure requires the design and development of a set of new services:

At first, the existence of a Certification Authority (CA) of users and services is required, which will form the primary security infrastructure, necessary for the operation of each grid infrastructure (annex E, chapter 2.2). Every organization may implement its own CA to meet internal needs. It should be noted that the creation and management of a CA may be the source of large expenses for an organization. In case where the cost for creating and managing a CA is forbidding for an organization, the project may be assigned to a third reliable certification organization.

In parallel to the CA, it is necessary to implement a Virtual Organization service, which will operate ancillary to the CA, and complete the user authentication system. Then Replica Catalogue, Information Index and Resource Broker services must be implemented, which constitute the main core for managing grid operations.

The next step is the installation of the necessary Middleware on the available resources of the organization, so that these are available on the grid infrastructure.

Finally, the most important and most difficult stage is the customization of the software used by the organization, so that it can use the grid infrastructure.

Some of the organizations which could benefit from the creation of grid infrastructures are research and educational centres, the state and private businesses.

In educational and research institutions, the creation of grid infrastructures will avail researchers of low cost computational power. At the same time, educational institutes will act as cradles for the creation of new grid technologies, the development of applications and training of students. Currently in Greece educational institutes are mature enough to receive and use grid technologies.

As regards public administration, according to suggestions of the European Union in relation to eGovernment, the development of Grid infrastructures will directly affect the operation of services of the public sector and therefore the service of citizens.

In business, Grid technologies can be developed for optimization of internal operations, while forming a new area for commercial exploitation. It is a fact that in the years to come, demand in computational and storage resources, combined with the rapid development of network infrastructures, ,will lead to the creation of a new market for **Grid Service Providers** (GSP), an evolution of the current Application Service Providers (ASP).

At the same time, there is an increasing tank of computational resources in Greece, consisting of home computers. Common users on the one hand make use of a ridiculously small percentage of their storage and especially processing ability, and on the other hand seek for better and cheaper network services, given the popularity of certain Internet applications used on a daily basis. Therefore, Interned providers in Greece may process a more advantageous price and services policy for those users which could offer their computer to relevant supercomputer Grids. Therefore, the telecommunications agency will be at the same time a Grid provider, thus expanding its market and enhancing potential of collaborations.

5.2.2 **ExtraGrids: "The policy of collaboration"**

A new dimension in the implementation of Grid technologies enables the interconnection of more than one IntraGrid in one ExtraGrid. Organizations will be able to optimize B2B (Business to Business) and B2C (Business to Customer) operations.

The interconnection of two or more IntraGrids requires the preparation of a policy based on which sharing of resources will be made.

The first step is the establishment of two-way trust relations between Certification Authorities and then the creation of a new VO, to be the link between individual IntraGrids. It should be noted that, despite that Grid infrastructure for an organization is a specific natural entity, the existence of multiple VOs with different objectives, enables meeting different needs.

The next step is the creation of a central Information Index, which will operate as a superset of respective services to individual IntraGrids.

In education, in the last years, significant efforts have been made to that direction and already many research institutes have set up ExtraGrids, with the implementation of shared VOs, covering experiment groups. The field of high energy physics is an illustrative example, where needs in computational power and storage have led to the creation of ExtraGrids, from Europe and America to Asia and Australia. It should also be stressed that in science, the dissemination of Grids in Greece will provide researchers with a powerful computing tool but also a vehicle for participating in international financed programmes, thus stimulating activity in an area where lack of action has multiple negative effects.

The public sector could most benefit from the adoption of Grid technologies. Despite the fact that important steps have been taken to the adoption of new technologies, the largest part of the public sector lags significantly. The creation of dynamic ExtraGrids may give new potential to areas of the public sector with recorded computational needs (e.g. financial services, municipalities, etc). A possible and sustainable solution is to develop Grid infrastructures at crucial points of the public sector, which can also serve other sectors. At this point, the development of broadband networks will act as a catalyst, enabling the provision of such services.

The Pan-Hellenic School Network has continuously updated computational infrastructures (e.g. PCs) with low exploitation rates. The same is the case with other agencies and services of the Public Sector. Supervising authorities may, in the near future, become Grid service providers to other private and or public agencies (PPC, General Secretariat for Civil Protection, hospitals) obtaining the gains from the right to use such infrastructures. The priority here is coordination, information mainly about security and preparation of protocols governing such sharing.

In recent years, intense activity has been observed in the private sector to the direction of e-commerce, which requires the existence of flexible computerization systems, which communicate and exchange information securely. In parallel, the requirement of a modern business to draw information from all subsystems simultaneously, process such information and produce conclusions and assessments, lead to the need for greater computational power. The introduction of Grid technologies in businesses will result in the creation of flexible infrastructures, scalable depending on requirements, at the same time enabling best exploitation of computational resources. At the same time, the clearly specified open architecture of Grid infrastructures shows new ways to e-commerce, offering high levels of security.

This does not exclude a gradual transition from the purchase of computational infrastructure to its leased use both at hardware and software level. This would bring deep changes to the high technology market, stress the role of networks and benefit the creation of nodes concentrating know-how and infrastructures in Greece.

5.2.3 InterGrids: “Heading to World Wide Grid”

Expanding the original concept of ExtraGrids, one could imagine the existence of a global Grid infrastructure. Several efforts have already been made by the main players in the area of Grid technologies for the establishment of mutually accepted standards.

In Greece, the first step has been taken by EETT, in an effort to create a core Certification Authority at national level.

The HellasGrid task force believes that by 2004 the HellasGrid organization must have been created for the coordinated development of grid technologies, according to the successful model of GRNET. The HellasGrid organization will undertake coordination of projects in the educational community, while being the link to similar actions at a global level.

In the context of creating the HellasGrid organization, the creation of 3 support centres is suggested, geographically covering the entire country (Northern, Central and Southern Greece).

At the same time, the creation of a core coordinating organization of GSPs at a national level is recommended (**GRId eXchange – GRIX**), under the model of Athens Internet Exchange. This organization will see to the proper interoperability of IntraGrids all over Greece and will provide the necessary guidelines for interconnection to the respective infrastructures at global scale.

5.3 The first steps to three directions for Greece

The HellasGrid task force recommends the following strategy for the introduction of Greece to grid technologies:

5.3.1 **Development, implementation and support of Grid infrastructures in educational and research institutes– Grids & eScience**

- Gradual implementation of IntraGrid infrastructures in **4 institutes** by the end of 2004 and interconnection for the creation of the first Greek ExtraGrid with the **submission of a HellasGrid pilot project Technical Bulletin**. Educational and research institutes to participate in the first pilot grid infrastructure will be selected so as to cover a large part of the country. Thus the total required initial investment for the development of HellasGrid will be depreciated within a reasonable period of time, since infrastructures will be used by multiple agencies, according to appropriate use policies. Emphasis should also be placed to consumer attraction. It is obvious that the cost of individual access to large computational power and relevant computational services is forbidding contrary to the Hellasgrid development model.

- Setting up of an **administrative and technical team** to support the Hellasgrid infrastructure and policy-making. Hellasgrid will be the communication link with respective organizations at European and global level.

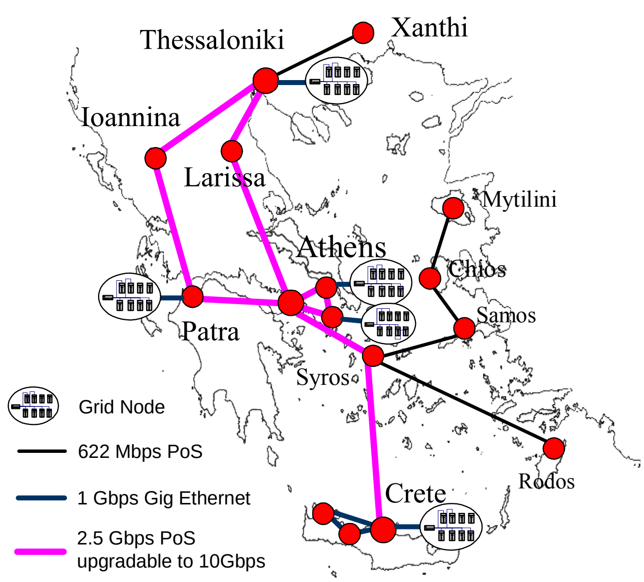


Figure 5.1 – Development of HellasGrid basic infrastructure

- Creation of **4 Support Centres**, which will geographically cover the entire country (Central- Eastern, Southern, Northern and Western Greece).

  The implementation and operation of Support Centres will be closely related to the creation of the above **4 computational centres** (which together with the central storage and computational node of GRNET stand at 5). At the first phase of implementation of the Support Centres, the know-how and experienced to be gained from the implementation of the pilot project HellasGrid will play an important role.

- Development of a policy for the attraction of new infrastructures. Motives should be provided for the integration of computational or other equipment in HellasGrid. To this direction, it is important that infrastructures are exploited, such as the one of the Pan-Hellenic School Network, with the creation of Scavenger Grids and University islands. The State has invented large amounts for the creation of network and computational infrastructures to meet the needs of primary, secondary and higher education which are under-exploited in majority. The School Network numbers about 10,000 computers which remain unexploited most of the day (evening-night) and which could be used for the creation of dynamically shared Scavenger Grids. Also, savings could be made with the coordinated withdrawal of workstations and their use either as clustered servers, thin clients, or even spare parts.

- Gradual inclusion of the remaining research units in the national research and technology grid infrastructure by the end of 2006.

5.3.2 Enhancement of private sector initiatives (2004-2005) – Grids & eBusiness

- Announcement of pilot projects aimed at developing commercial provision of grid services. In this role, current Internet Service Providers (ISPs) such as e-mail, DNS etc and Application Service Providers (ASPs), and web hosting, can evolve into Grid Service Providers providing computational cycles, storage area and other resources or data such as photographs from satellites or telescopes. In fact, current data centres will be transformed into Grid centres. Demand to that direction may be created from large trading companies, such as banks, IT companies, etc for disaster recovery issues. Security, accounting-billing and personal data protection will be particularly important.

- Announcement of pilot projects aimed at the implementation of Grid technologies in businesses, with parallel encouragement of collaborating actions to the implementation of ExtraGrids as analyzed above.

- **Creation of GRIX** (**Grid Exchange**) under the model of **Internet Exchanges** for the coordination of initiatives in the private and research sector and exchange of resources between communities. Accounting and billing will be particularly important.

5.3.3 Development and implementation of Grid infrastructures in the public sector- Grids & eGovernment (2005-2006)

- Proclamation of pilot projects for the creation of Grid infrastructures and applications in critical areas of the public sector on transactions and service of citizens, as previously analyzed.

- Expansion of pilot projects, strengthening other sectors and enabling access for the regions.

6 Conclusion

As arises from the analysis above, the European Union, the USA and many countries with independent actions have already finished the first round of investments aimed at the development of all elements which will turn Grid technology into practice. A large number of research projects have developed parts of the middleware required for actual link of computers to a uniform set.

The second round of investments has already begun: Leaders in the rally to Information Society have started developing National Grid Initiatives. Actions at European and international level aim at interconnecting national Grids to **transnational, international Grids** to provide next generation services.

The prerequisite for the above is the existence of open, reliable and standard middleware, to arise from the large Research Programmes for eScience in Europe (EGEE, DEISA, SEE-GRI, etc) and America (NSF Cyberinfrastructure, OMII). Based on this software, the overlying applications must be created or adapted, at first for the research community (eScience), but gradually for eBusiness and eGovernment applications.

Hellasgrid Task Force was set up with the aim of analyzing the international background and prepare the suggestion of any necessary actions to the Information Society. As a result of the works of the Task Force, it is recommended that a national investment be promptly made in the initial development of a Greek Grid to be the first involvement of Greece in a high technology sector.

The Task Force recommends the development of a Hellasgrid pilot project, to include among other things the development of a number of computer and storage clusters, interconnected on a hierarchical Grid over an ultra-high speed network of GRNET2, the creation of operation and support teams, the improvement of middleware, and the customization of new Grid applications, with obvious benefits for citizens.

It is also recommended to set up an administrative and technical HellasGrid team for policy making and support of actions, to support interface with respective actions in Europe.

The integration of Grid infrastructures, middleware and applications with the Greek research and technology network (GRNET) in a standard system of e-Infrastructures constitutes the best possible exploitation of advanced network resources and services of GRNET which can serve the new generation e-Science applications, which are the first enabling the use of a new technology.

It is important, though, to stress that for the successful progress of Grid technologies in Greece and the proper exploitation of relevant proposed infrastructures, it must be ensured that **needs and requirements of different groups of applications and users are properly met.** For this reason, actions of dissemination and information of potential users should be provided for, in order to realize Grid potential and the importance to adapt applications for parallel use with distributed memory, so that they can operate using the distributed e-Infrastructure. Apart from the dissemination of Grid technologies to all possibly interested scientific communities in Greece and regular questionnaires for the recording of demands, depicted, in a first attempt, by the Hellasgrid task force http://www.hellasgrid.gr/results, the Task Force recommends the survey for the creation of a quality assurance group able to represent a large number of scientific groups and continuously feedback the HellasGrid project administrative and technical team. The quality assurance group may be identified with or be part of the technical team of the proposed HellasGrid project.

Namely, national efforts should focus on the creation of a human network to frame the proposed core infrastructures and form the critical mass for the adoption of new technologies. Adoption will only be possible where the human network is properly trained. The human network may constitute the country's link to relevant research projects in the European Union and internationally. Obviously, the human network will provide feedback as regards meeting the needs of user applications. Such a network will require long-term financial support since the ultimate goal of the effort is full participation of Greece in the European and later global Grid. It is also recommended to proclaim a new set of projects, which will not only strengthen institute infrastructures but also special middleware, applications, dissemination and educational actions.

Concluding, with IT revolution at its peak, Grid technologies are expected to play a major role in the creation of the new generation computers and networks, implementing at a low initial cost and high scalability, distributed platforms for shared processing and editing of data. **The implementations of grid architectures cover a wide range of applications and lead to various solutions, from specialized sensor networks, to shared exploitation of excess PC resources, to High Performance Computing & Networking, HPCN. Greece must invest and participate in this global effort, taking advantage of the know-how of the research-scientific community, and the existing high performance network infrastructures in universities, technical educational institutes and research centres, the Greek Research and Technology Network GRNET and broadband Gigabit connections to GEANT.**

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