



# SHARE

## A FRAMEWORK FOR DEVELOPING A ROADMAP FOR THE ADOPTION OF GRID TECHNOLOGY IN HEALTHCARE

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**Abstract:** This document describes the framework that will be used for developing a roadmap for the adoption of grid technology in healthcare. After introducing the concept of HealthGrid, grid technology adoption status in healthcare and biomedical research is briefly presented. Impact of Legal, Regulatory and Social Frameworks on Grid Technology Adoption are discussed before the goals for the roadmap are introduced.



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## **1. INTRODUCTION**

### **1.1. PURPOSE**

The purpose of the document is to present the framework for developing a roadmap for the adoption of grid technology in healthcare.

### **1.2. APPLICATION AREA**

The document is intended for internal and external use. It will be used as a dissemination tool for the Share project.

### **1.3. REFERENCES**

[R 1]	The HealthGrid White Paper
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### **1.4. DOCUMENT EVOLUTION PROCEDURE**

This document will be updated incrementally via WP3 Activity as new information becomes available. Comments should be sent to the authors.

### **1.5. TERMINOLOGY**

#### **Glossary**

WP1	SHARE project Management Activity
PO	Project Office
PD	Project Director
MB	Management Board
PEC	Project Executive Committee
QR	Quarterly Report
EAC	External Advisory Committee
CC	Cost Claims
PR	Periodic Reports
CA	Consortium Agreement
PM	Person Month
PMx	Project Month x



## **2. INTRODUCTION**

Most healthcare systems in the developed world are facing multiple challenges in their attempt to maintain an acceptable level of care for their citizens. The principal challenges are often experienced and expressed in economic terms, e.g. as issues of

- total cost,
- capacity and responsiveness, and
- allocation of limited resources.

Underlying these economic constraints is the moral challenge of priorities, as governments seek to balance the demands of

- changing demographics, with an ageing population both surviving and remaining active longer;
- increasingly effective treatments for both acute and chronic conditions;
- sophisticated – and sometimes unproven – novel treatments for conditions which not very long ago were considered untreatable.

In an attempt to meet these demands, health systems have increasingly looked to information technology to help, among other things, to optimize the distribution and use of resources, to reduce queues and waiting times, to record and so avoid errors, and to provide modern treatments into remote communities.

Beyond these essentially resource-oriented uses, information technology is also seen as an essential ingredient in a change in medicine itself. In the course of the last two decades, the practice of medicine and healthcare provision in general have moved away from reliance on the doctor's personal knowledge and craft skill to requirement of a scientific basis in diagnosis and treatment, in what has come to be known as 'evidence based practice'. The evidence a doctor or nurse must now take into account is

- published medical knowledge;
- their knowledge of the patient; and
- practical knowledge of what is available by way of procedures, protocols, and so on, in their environment.

In this context also, governments have initiated programmes to create information-driven healthcare systems.

However, these modernization processes face a number of challenges:

- creating and populating, connecting and understanding patient records across organization boundaries and, in due course, across different national health systems;
- increasing the openness and accessibility of systems - e.g. providing patients with ownership of their healthcare record – while
- ensuring privacy, confidentiality and ethical compliance in the socio-legal plane, and
- maintaining data integrity, security and authenticity (e.g. provenance and semantics) in the technical plane;



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- providing appropriate levels of authorization and authentication of users across all the services and the citizen;
- discovering, grading and certificating trustworthy sources of knowledge and case information to guide future action; finally,
- winning the trust and commitment of the medical professions at a time of immense change and economic pressure.

One immediate limitation is in the application of traditional information networks and technology in healthcare. Governments have naturally focussed on the technical issues that are reasonably well understood, even if solutions are not always easy to obtain: robustness of networks, scalability of systems, readiness to handle a very large volume of data. However, in many respects, these reproduce in the technology some of the problems of the traditional paper-driven systems: inflexibility, maldistribution of resources, failure to understand the needs of medical practitioners, failure to support effective collaboration, and an ultimately simplistic equation of quality with 'choice', while minimal provision is made for just-over-the-horizon future technologies such as genomic medicine and individualized prescribing.

In the face of these challenges, a computational innovation, 'grid' technology, or *the grid*, has become available to clinicians in the last few years, first as a research tool and then, in the not-too-distant future, as a serious healthcare infrastructure. The grid is not one technology but many, and the use of the singular is somewhat misleading, but it is convenient inasmuch as it echoes 'the internet' to which it is closely related. Just as the internet, or more precisely the World Wide Web, has provided a massive information platform whose exploitation is limited only by economics (and, in some cases, politics) grid technology promises to scale this up to the provision of unprecedented computational power, online storage and collaboration opportunities. The informatic grid approaches the provision of computational, information and communication services through resource sharing in a seamless and transparent manner, much as the electricity 'grid' provides power to any device plugged into it, irrespective of its purpose or design. Grid computing aims at the provision of a global ICT infrastructure that will enable a coordinated, flexible and secure sharing of diverse resources, including computers, applications, data, storage, networks, and scientific instruments across dynamic and geographically dispersed organizations and communities (sometimes known as 'virtual organizations' or 'VOs'). Grid technologies promise to change the way organizations tackle complex problems by offering unprecedented opportunities for resource sharing and collaboration. Just as the World Wide Web transformed the way we exchange information, the grid concept takes parallel and distributed computing to the next level, providing a unified, resilient, and transparent infrastructure, available on demand, in order to solve increasingly complex problems.

A 'healthgrid' is an innovative use of this emerging information technology to support broad access to rapid, cost-effective and high quality healthcare [R1]. In particular, the areas of healthcare provision and research that can be beneficially affected by healthgrid technology include:

- medical imaging and image processing;
- modelling the human body for therapy planning;
- pharmaceutical research and development;
- epidemiological studies; and
- genomic research and treatment development.



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In all these areas, grid technology can either significantly reduce the cost or time to produce results and evidence, or even provide resources that are able to deliver services that cannot be economically delivered using conventionally networked information systems. Moreover, the emergence of this technology opens new perspectives to enable interdisciplinary research at the crossroads of medical informatics, bioinformatics and system biology to impact healthcare.

With the regular progress of technology and infrastructures, a growing number of grid applications are under development, with several completed and deployed in life sciences and medical research. Within the European Union and its member states, many applications have benefited and still benefit from substantial funding from the European Commission and some individual state funding bodies. Among the present projects, those relevant to health can be roughly classified into three categories:

- Infrastructure projects that aim to offer a stable distributed environment for scientific production. These infrastructures offer a generic multidisciplinary environment where biomedical applications can be deployed.
- Technology projects aim at developing new grid-enabled services and environments relevant to the needs of life sciences and healthcare.
- End-user projects that focus on specific life science or healthcare issues and integrate grid technologies wherever they appear relevant.

Born from discussions between grid application developers and medical informaticians, the concept of healthgrid is now over three years old. The annual HealthGrid conferences are an opportunity to evaluate the growing usage of grids for life science and medical research. Adoption of grids for healthcare is expected to follow their adoption in the life sciences and medical research, provided the legal and ethical framework of member states allows their deployment.

So far, many groups have demonstrated successful use of grids for computationally intensive applications. Notable among these have been a very large-scale deployment of a biomedical application in the area of drug discovery and a reconstruction in simulation of vascular and maxillofacial structures prior to surgery, both in Europe in the last two to three years. On the other hand, apart from a handful of pioneers, very few biomedical data grids have been deployed so far, and yet more sophisticated 'knowledge grids' are still at a conceptual level. This situation is expected to evolve quickly as many projects are focussed on developing data management services and knowledge management tools relevant to biomedical sciences.



### **3. ADOPTION OF GRIDS FOR HEALTHCARE**

Adoption of grids for healthcare is still in its infancy. There are many reasons to this situation. A first obvious reason is that grid technology is still immature and is neither robust nor secure enough to offer the quality of service required for routine clinical use. Another important reason is that all grid infrastructure projects are deployed on national research and education networks which are both separate from the networks used by healthcare structures and very much less secure than they would need to be. Another potential obstacle is the legal framework in the EC member states which has to evolve to allow the transfer of medical data on a European healthgrid. We must also not forget that grids, despite their virtual nature, still require human beings to make choices. Accordingly the economic and benefit case for the use of grids must be made and finally the real work environments and habits of people must be able to accommodate grid based working.

Despite the existence of these hurdles, pioneer projects have not been stopped from exploring and demonstrating the potential impact and relevance of grids to such outstanding healthcare issues as early diagnosis of breast cancer or improved radiotherapy treatment planning. Grids are expected to bring a significant added value in the development of individual medicine which requires the exploitation of biological and medical data, but this is still a research field.



## **4. ADOPTION OF GRIDS FOR BIOMEDICAL SCIENCES**

The wealth and complexity of data produced by life sciences in the last ten years requires more and more resources and services for their storage and analysis. Medical research is also evolving quickly with the generalized use of images and the growing integration of molecular biology in the perspective of individualized medicine.

### **4.1. LIFE SCIENCES**

Molecular biologists face a daunting challenge: the relevance of their research requires constant access to the databases containing the knowledge acquired so far. Comparative analysis is an essential step in most molecular biology data analysis workflows. This analysis has to be frequently repeated to keep up with the exponentially growing volume of data. Comparative analysis is often the first step in complex workflows to extract information from the data in genomics, transcriptomics and proteomics databases. At a basic level, a grid can help distribute the databases in order to make them accessible to the biologists and provide the computing resources required by data analysis. Bioinformatics portals are presently under development on top of grid infrastructures.

Grid technology also holds great promise as a means to address biological data complexity. Indeed, the last few years have witnessed the development of hundreds of databases providing specific representations of biological data. Interoperability of these databases is key to the development of the kind of integrated approaches needed to start modelling living organisms. Several projects focus on addressing this interoperability issue using the grid technology.

Other projects have been developing tools and environments to ease the design of data analysis workflows for biologists. The next step is to achieve the integration and deployment of these high level interfaces on grid infrastructures so as to offer to the biologists the data and computing resources needed for their analysis.

### **4.2. MEDICAL RESEARCH**

Grid technology entry points into medical research have been most often related to the need to manipulate large cohorts of medical images. The volume of medical images produced in European hospitals is comparable to the volume of data expected from the CERN Large Hadron Collider, estimated to be of the order of several petabytes per year. Storing these images and running algorithms to extract salient features from them requires enormous resources. Attempts to distribute the storage of medical image databases on the grid have been hampered by the very limited data management services made available on the grid infrastructures in Europe so far. Nevertheless, largely in response to this and similar demands in other scientific fields, research under way will add the necessary functionality of data management services to grid infrastructures.

Another important issue for grids is epidemiology. Medical data registered in primary care and hospitals is huge, and normally this information can only be processed in simple statistical analysis. Data mining would reveal new relations, early detect foci and raise alarms or assist on the selection of the best and most effective treatments. However, computing requirements for such large scale heterogeneous data mining are presently too high for Public Health authorities.



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However, adoption of grids in medical research depends heavily on the availability and extension of such services. Attempts to use grids to manage patient medical and biological data are presently being explored in several projects. The success of these approaches depends again on the capacity of the grid to provide the tools needed to manipulate these data.

#### **4.3. DRUG DISCOVERY**

'In silico' – i.e. computational - drug discovery is one of the most promising strategies to speed up the drug development process. Virtual screening is about selecting in computer models the best candidate drugs acting on a given target protein. Screening can be done in vitro in a 'wet lab' but it is very expensive as there are now millions of chemicals that can be synthesized. If it could be done in silico in a reliable way, one could reduce the number of molecules requiring in vitro and then in vivo, i.e. live, testing from a few millions to a few hundreds.

In silico drug discovery should foster collaboration between public and private laboratories. It should also have an important societal impact by lowering the barrier to the development of new drugs for rare and neglected diseases. New drugs are needed for neglected diseases like malaria where parasites keep developing resistance to the existing drugs or sleeping sickness for which no new drug has been produced for years. New antibiotics against tuberculosis are also needed as the treatment now takes several months and is therefore hard to manage in developing countries.

In silico drug discovery on grids is a growing field. The first step computes docking probabilities for millions of ligands. Grids of 'PC farms' (i.e. linked commodity desktop computers) are ideally suited for this task. In a recent international trial on malaria drugs, the relevance of the grid to such problems has been clearly demonstrated: 46 million ligands were docked in a total amount of 80 CPU years<sup>1</sup>. In the foreseeable future, scientists should be able to conduct a complete in silico drug discovery pipeline on the grid. Such a pipeline would allow the rapid identification of promising compounds.

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<sup>1</sup> See <http://wisdom.eu-egee.fr>



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## **5. IMPACT OF LEGAL AND REGULATORY AND SOCIAL FRAMEWORKS ON GRID TECHNOLOGY ADOPTION**

Grid computing ("the grid") is a promising new technology which aims to enhance the services already offered by the internet. This new paradigm offers rapid computation, large scale data storage and flexible collaboration by harnessing together the power of a large number of commodity computers or clusters of other basic machines. The grid was devised for use in scientific fields, such as particle physics and bioinformatics, in which large volumes of data, or very rapid processing, or both are necessary. Unsurprisingly, the grid has also been used in a number of ambitious medical and healthcare applications. While these initial exemplars have been restricted to the research domain, there is a great deal of interest in real world applications. However, there is some tension between the spirit of the grid paradigm and the requirements of medical or healthcare applications. The grid maximises its flexibility and minimises its overheads by requesting computations to be carried out at the most appropriate node in the network; it stores data at the most convenient node according to performance criteria. On the other hand, a hospital or other healthcare institution is required to maintain control of its confidential patient data and to remain accountable for its use at all times. Despite this apparent conflict in requirements, we suggest that certain characteristics of the grid provide the means to resolve the problem: in the spirit of this paradigm in which "virtual organisations" arise ad hoc, "grid services" may negotiate ethical, legal and regulatory compliance according to agreed policy.

The specific legal and regulatory issues which arise in the context of healthgrid computing relate primarily to the fact that health data are special. In all European legal systems health data are protected by a higher level of privacy and confidentiality regulation than most other person identifying data, and the duties placed upon people handling such data are usually more onerous than for other less sensitive types of data.

However, as stated in the introduction of this document, adoption of grids for healthcare is expected to follow their adoption in the life science and medical research, provided the legal and ethical framework of Member States allows their deployment.

To move ahead and to ensure the deployment of the healthgrid technology within the European Union, action will thus be needed in legal and ethical areas, which would be a major challenge for the European Union and for its Member States.

Four key legal issues seem essential to deal with in order to allow the implementation of healthgrids notably by favouring the confidence of the patients, the legal certainty and the respect for a certain ethics. These issues are as follows:

### **5.1. DATA PROTECTION ISSUES**

Although personal data are the object of diverse European legislations, the problem of the protection of these personal data (medical or not), still raises several questions that would be of importance in healthgrids implementation, such as:

- Data processing;



- Access rights of data subjects;
- Responsibilities of data controllers and processors;
- Free flows of personal data within the Member States;
- Data protection national legislations harmonization.

## **5.2. CONFIDENTIALITY AND SECURITY ISSUES**

The confidentiality and the protection of patients' health personal data are governed by diverse European rules, as well as by the requirements of ePrivacy legislation regarding communications infrastructure, making healthgrids security critical. The key question is therefore if the grid itself can be legally classified as secure.

## **5.3. LIABILITY ISSUES**

Another important issue for healthgrids is liability - who is responsible in case of dysfunction of the system or of problem in the supply of services that would cause serious harm to the patient

## **5.4. INTELLECTUAL PROPERTY RIGHTS ISSUES**

The creation and implementation of healthgrids will also raise important issues in the area of intellectual property rights, such as information ownership, software patent issues, intellectual property laws harmonization or problems for the use of "common" public domain components (e.g. open source, free licence, etc).

## **5.5. THE WIDER SOCIO-ECONOMIC AND ETHICAL FRAMEWORK**

As well as strictly legal and regulatory issues a Roadmap for the adoption of healthgrids will also need to consider the wider ethical considerations, as well as the social and economic frameworks into which the technology is to be applied.

According to a recent study, eHealth ICT such as healthgrid is emerging as the new industry, alongside pharmaceuticals and the medical devices sector, to become the third largest industry in the European health sector. According to this study, by 2010 spending on eHealth technology may account for up to 5% of the total health budget of the 25 Member States from just 1% in 2000 for 15 Member States<sup>2</sup>. European industry has every opportunity to become a leading global player in this fast growing industry if a wider, more integrated European market can be established, supporting their competitive position in a fast growing global health ICT market<sup>3</sup>.

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<sup>2</sup> SIBIS, Benchmarking Highlights 2002: Towards the Information Society in Europe and the US, May 2003. See <http://www.sibis.org/>.

<sup>3</sup> See Deloitte and Touche (2003) eHealth: HINE - Health Information Network Europe; 2003 report. Considering present constraints on spending in this market, this is probably a by far too optimistic estimate. - On the other hand, Frost & Sullivan estimates in its 2004 report on The Market for Telemedicine in Europe that just this segment will grow till 2010 to about \$ 1.8 bn or around 42% per annum, an even more optimistic prognosis.



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Accordingly a roadmap for healthgrid adoption must address the wider economic and social issues of this global health ICT market. Such analysis, based on economic theory is essentially concerned with the optimal allocation of limited resources which have alternative uses<sup>4</sup>. Resources are goods and services, which represent means towards an end – ultimately the satisfaction of the needs and wants of human beings, citizens in our society.

Economic analysis is often thought of as focusing only on perfect market mechanisms, where needs or wants are articulated as demand for physical goods and services in complete markets with competing suppliers exist and where trade and pricing are closely related. This, however, is not the case. Much of modern economic theory focuses on so called failures of the market. These include cases of imperfect and incomplete information in the marketplace, externalities and public goods, markets where competition is restricted, and resource allocation by mechanisms other than trading in markets. These are all features of the healthcare sector, requiring us to look in detail at such aspects as stakeholder groupings, their purposes and the benefits flowing to them.

In the case of healthgrids this will entail looking in some detail at the interests of a wide range of stakeholders the healthcare setting including healthcare organisations, professionals, suppliers, insurers and of course patients in such factors as quality, safety, speed, efficiency, security and mobility and mapping then onto the opportunities and risks offered by healthgrid technology.

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<sup>4</sup> Dernburg TF, McDougall DM: Macroeconomics (3<sup>rd</sup> edition), New York: McGraw-Hill, 1968, p. 41



## **6. PROPOSING A ROADMAP FOR HEALTHGRIDS**

European leadership on grid deployment is recognized at a world level. This leadership is also internationally acknowledged in the area of healthgrid. The concept of grids for health was born in Europe in 2002 and has been carried forward through the HealthGrid initiative ([www.healthgrid.org](http://www.healthgrid.org)) and its associated conferences. This European initiative has edited, in collaboration with Cisco Systems, a ‘white paper’ setting out for senior decision makers the concept, benefits and opportunities offered by applying newly emerging grid technologies in a number of different applications in healthcare.

Starting from the conclusions of the healthgrid White Paper [R1], the SHARE project aims at identifying the important milestones on the road to achieving wide deployment and adoption of healthgrids in Europe and at devising a strategy to address the issues identified in the action plan for a European e-health research strategy.

The SHARE project thus fits with other RTD mapping projects such as the eHealth ERA project which shows eHealth RTD taking place across a wide range of ICT technologies, one of which is healthgrid, explicitly represented in this view. Other examples are broadband (applied, say, to health consultation), electronic health records (EHR) or home platforms (e.g. for advanced home care provision). Healthgrid RTD, like all eHealth RTD, is to be seen as having a medium-term exploitation perspective, with pre-deployment and innovation activities required before applications utilising RTD results becomes part of a health system.