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Summary

This report provides a strategic direction for European and Chinese collaboration in research and industrial uptake of Grid technologies. This is based upon a joint EU-China State of the Art in Grid technologies covering the research, industry, market and strategic aspects; and a preliminary vision of the main research directions in the field.

This report has been written to ensure balance and an even presentation of EU and Chinese perspectives, and of academic and industrial perspectives. This first version of the EchoGRID strategic orientation is a step towards a final vision of the main research directions in the field to be produced at the end of the project in Dec 2008.

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Acronyms

Definitions of acronyms used in the main body of the report.

CERN - European Nuclear Physics Laboratory located near Geneva in Switzerland.

B2B - Business to Business communication, in contrast to B2C or E2E, where businesses can send orders, receive invoices, and trade with each other.

B2C - Business to Customer communication – often automated through the Web so that customers can order goods from businesses and make payments.

BRIC (or CRIB) nations – China, Russia, India and Brazil whose economies are rapidly developing and by the year 2050 will eclipse most of the current richest countries of the world. The thesis was proposed by Jim O'Neill, global economist at Goldman Sachs.

E2E - Enterprise to Enterprise communication.

EGEE - EU funded Enabling Grids for e-Science project which has established a Grid infrastructure across 27 countries.

EGI - European Grid Initiative, planned to provide a sustainable replacement for EGEE

ERP - Enterprise Resource Planning systems – large computer systems produced by organisations such as SAP and Oracle, used to manage organisations.

ETSI - European Telecommunications Standards Institute – a European standards body

EU – European Union.

GDP – The Gross Domestic Product of a region is the market value of all final goods and services produced within a country in a given period of time, usually a year. "Gross" means depreciation of capital stock is not included. Within each country GDP is normally measured by a national government statistical agency according to internationally agreed rules.

ICANN - The International Corporation for Assigned Names and Numbers, based in the USA is the organisation that allocates Internet domain names and IP addresses, and defines Internet policy – see section 7.2.2.

ICT - Information and Communication Technologies.

IGF - Internet Governance Forum, established under the auspices of the United Nations to resolve Internet governance – see section 7.2.3.

IPR - Intellectual Property Rights such as copyright, trademark and patent.

ISO – International Standards Organisation

LHC - Large Hadron Collider – a project at CERN to develop a large particle accelerator hosting several experiments to determine the very early stages of the creation of the universe at very high pressures and energies.

MLP – Medium to Long Term Plan for the 15 year development of China from 2006 to become a world leader in science and technology by 2020.

MOST – Ministry of Science and Technology in China.

NESSI – Networked Software and Service Initiative – an industry lead European Technology Platform that aims to provide a unified view for European research in Services Architectures and Software Infrastructures – see section 6.2.1.17.

NGG - Next Generation Grids Expert Group convened to advise the EU DG INFSO & Media on Grid technologies from 2002-2006.

NGI - National Grid Initiatives to provide scientific Grid computing in individual countries.

OASIS – Organisation for the Advancement of Structured Information Standards – an ICT standards body organised as a consortium which standardises technologies for the Web and Grid which are not as core to the functionality as those addressed by W3C.

OGSA – Open Grid Services Architecture which defines how Grid technologies can be built upon Web Services

OEM – An Original Equipment Manufacturer refers to a situation in which one company purchases a manufactured product from another company and resells the product as its own, usually as a part of a larger product it sells.

Petabyte - is a unit of information or computer storage equal to one quadrillion bytes, 1,125,899,906,842,624 bytes. One Petabyte is about half the volume required to store the entire digitised output of the BBC on TV and Radio since it started broadcasting in 1922.

PKI – Public Key Infrastructure is an arrangement that binds public keys with respective user identities by means of a certificate authority (**CA**). The user identity must be unique for each CA. For each user, the user identity, the public key, their binding, validity conditions and other attributes are made unforgeable in public key certificates issued by the CA.

S&T – Science and Technology.

SOA - Service Oriented Architecture is an evolution of distributed computing and modular programming. SOAs build applications out of software services. Services are relatively large, intrinsically unassociated units of functionality, which have no calls to each other embedded in them. They typically implement functionalities most humans would recognize as a service, such as filling out an online application for an account, viewing an online bank statement, or placing an online book or airline ticket order.

SOKU - Service Oriented Knowledge Utility, proposed by the NGG EU expert group as a long term vision for the Grid.

SME - Small to Medium Sized Enterprise, or Small to Medium Sized Business is an organisation of less than 250 employees under the EU definition.

VO – a Virtual Organisation comprises a set of legally independent organizations that share resources and skills to achieve its mission / goal. The interaction among members of the virtual organization is mainly done through computer networks, particularly through the Grid.

W3C – The World Wide Web Consortium defines the standard technologies that are core to the operation of the World Wide Web, such as HTML and XML – see section 7.2.4.

1 Introduction

There has been considerable funding[1] for Grid Computing as both a research topic and for infrastructure development under the EU Framework Programmes and through national initiatives (e.g. UK e-Science programme). Consequently the topic has become a bandwagon attracting many actors applying their own motivations to the topic with the result that the phrase has become ambiguously overused. Below are listed the main factors that have brought about the current state in Grid Computing:

- Government strategists see the need for large scientific computing resources to address issues of national and international concern such as weapons development (to comply with nuclear test ban treaties), drug discovery (to address new diseases spread quickly in a global community), climate modelling (to address global warming), and generation of power from nuclear fusion (to address the global energy crisis resulting from the decline of fossil fuel stocks).

- The US supercomputer centres planned to link together several vast computer systems to address large scale problems instead of planning for a new single vast monolithic computer in order to overcome problems of both initial investment and maintenance costs.

- Academia and industry observed that the low utilisation rates of many desktop and cluster (e.g. 20%) provided a resource for cycle scavenging to apply to large problems without investment in new large computing resources.

- The consolidation of businesses in many sectors through mergers and acquisition required the interoperation of many computer systems which were designed to operate independently.

- Major product developers in engineering and other industries (e.g. OEMs) wish to control their supply chains more closely by linking their management services into those of their tier1, tier2…tier*n* suppliers which requires interoperability between systems, and a lower cost of ownership of such systems. This leads to new corporate legal arrangements such as partnerships and virtual organisations.

- ERP vendors noting the previous 2 points plan to divide massive monolithic systems into independently operated modules interacting through service oriented architecture (SOA) interfaces.

- 70% of the European economy is performed in SMEs who constitute 99% of the enterprises and employ more than two thirds of the work force[2] but which need to group together in order to provide a sufficiently large value proposition to overcome the risks of operating in the global market – interoperation through SOA could provide this.

- In order to provide an infrastructure to link SME value chains and enterprise supply chains telecom providers have identified a business opportunity in hosting business relationship environments (B2B) which will add value to their existing wire provision that is falling in profitability.

[1] €841,000,000 in 2002-2006, see section 6.2.2

[2] Christoph Leitl; 23 September 2006; http://www.neurope.eu/view_news.php?id=65119

- Management of complex ICT systems has become so expensive that improved self management is required[3] – autonomic computing.

- Software management and total cost of ownership have become a major cost to companies and individuals with the result that alternative methods have been sought to the purchase of shrink wrapped software or software supported at the user's own location. These include application service provision[4] and utility computing.

- Scientific strategists determined that the next major breakthroughs in science would be interdisciplinary and one way to bring about interdisciplinary interaction is to provide a common computing infrastructure to easily support the interaction of teams who have not previously shared research.

- Scientific planners were aware that the requirement for the next generation of research would require a large investment in a few large scale facilities rather than experimentation being undertaken on locally resourced small scale equipment. These facilities need to interoperate with each other and with many diverse research teams across the world.

- The cost of scientific experimentation is increasing considerably, and the gap between theory and experiment requires the use of ICT technologies for modelling and simulation to refine theories into models which can be tested, as well as to analyse experimental data – hence the rising importance of e-Science.

- Specifically, the LHC project at CERN[5] would produce such vast amounts of data that a European or global computing infrastructure was required to undertake simulations, distribute the data and analyse it. This is seen as the first of many facility based research challenges to the ICT infrastructure, so leads the way for e-Science.

- ICT researchers who have experience in the interoperability of systems have identified the description of the components, data, processes as crucial to provide the required advertising, discovery, composition and management of services – the Semantic Grid[6].

- Given the need for businesses and scientific organisations to interoperate with others with whom they have no previous experience there is a need to develop security and trust management – the web or Grid of trust.

- The ICT field of development which contrasts with the Grid infrastructure is that which is user or environment focussed – ambient intelligence or environmental computing – whose researchers have identified the need to use the Grid infrastructure – the Sensor Grid.

- The migration over 40 years from mainframe to mini, to desktop then laptop computing is now moving to handheld computers with a shift in provision to

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[3] By 2006 IT management costs account for up to 70 percent of a CIO's budget, up from 50 percent in 2000. Much of that cost is driven by the time-consuming task of manually integrating incompatible software to manage servers, applications and storage devices - http://www-03.ibm.com/autonomic/wsdm/release.html
4 Grid Based Application Service Provision - http://www.w3c.rl.ac.uk/Euroweb/poster/104/index.html
[5] Direct funding in the LHC project had exceeded £2.5 billion by Jan 2007.

[6] Open Grid Forum
Semantic Grid Research Group - http://www.semanticgrid.org/OGF/

established mobile phone companies[7]. In this situation the major computer vendors need to establish a new business in terms of compute provision or data management – ubiquitous computing.

- By 2007, global ICT based B2C players such as Amazon and eBay make 40% of their turnover from other businesses using them as a marketplace to customers through B2B web service interfaces in an infrastructure which supports in the order of 20,000 processors and 2 Petabytes of data. These companies would like to move to using competitively provided and supported software from commercial vendors instead of developing and maintaining their own.

From this background of actors, technologies and motivations we have come to the point where SOA and Grid technologies have been researched and applied to both science and business. Early adopters have been identified from the scientific community in particle physics and bioscience, while from the business community in automotive engineering, finance, and pharmaceuticals. Other sectors of business and research are following behind as the technologies become more robust, more accessible and the risks of adoption reduce.

The vision resulting from these factors is of a service oriented infrastructure operated by telecom companies which allow businesses to interoperate between their own divisions, and between themselves and their suppliers; scientists will use a global computing utility to perform vast simulations and analyses of data often collected from globally funded facilities to address global problems; individuals will access this infrastructure through their mobile phones; Europe will operate a knowledge economy (product design, legal services, education, banking) with the BRIC nations providing most of the world's manufacturing. This vision is consistent with the basis for the Lisbon Agenda to drive Europe in the early 21st century.

This raises the issue of the relationship of Europe and China in respect of Grid computing. To the established industrial nations of Europe, the rise of China to a capitalist manufacturing powerhouse[8] can be seen as either a competitor to industrial output[9] or as an opportunity for Europe's knowledge marketing[10]. To China, Europe can be seen as both a model to follow towards a healthy economy and as a threat to its growth and independence. Both China and Europe have been aware of the arguments made above and both have invested in the development of Grid technologies. In order to provide the largest computing resource to solve global problems some of the arguments above justify the interoperation of the European and Chinese Grid infrastructures to provide the largest potential resource.

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[7] By 2006 30 countries had mobile phone subscriptions that exceed their population (over 100% penetration) - http://www.demo.com/demoletter/multiple_mobile_phone_ownership_continues.php

[8] The economy of the People's Republic is the fourth largest in the world with economic output for 2006 at $2.68 trillion USD. However, per capita GDP in 2006 was approximately US $2,000 ranking it only 105th of 183 nations. Given the size of the economy, the GDP per capita will rise rapidly as industrialisation increases. Even though China already ranks third worldwide in factory output, in 2005, 70% of China's GDP was still in the agriculturally-dominated private sector leaving plenty of scope for the 281 million person labour force to move to industrial production.

[9] The contribution of manufacturing industry to the UK GDP dropped from 80% to 20% in 2000, and now to 14% in 2007 (Alistair Barr, Is UK manufacturing in terminal decline?, Economic Outlook, Volume 31 Issue 1 Page 9-13, January 2007).

[10] In 1997, China had only 10 million mobile subscribers, by 2001 China overtook the USA to become the world's largest mobile phone market, but by May 2007 almost 40 percent of Chinese own mobile phones, and the number of subscribers is likely to hit 500 million before the end of June 2007 - http://english.people.com.cn/200208/01/eng20020801_100738.shtml

This document describes the state of current research and industrial developments in Grid Computing technologies in both Europe and China to set the background for collaborations between the two. From this background it is argued what the roadmap and strategic direction and priorities for future collaborations should be. The document is the result of a series of collaborative activities including a joint EU/China workshop in February 2007 and a conference in April 2007, both held in China, as well as collaborative research by teams in both areas during the drafting of the document itself. This collaboration has been managed to ensure that the analysis is fair and balanced across the cultural and economic differences of the two communities, we well as having undertaken a broad consultation process to ensure that all views have been accommodated.

Figure: The purple line represents a compute job being sent over the EGEE Grid from CERN in Europe to Beijing for processing, June 2007. View of the EGEE Grid monitor.

2 Chinese and European Visions of the Grid

The vision of the project is for a globally interoperable Grid including both European and Chinese Grid systems. Global interoperability can be achieved through running the same software, running software developed to common standards, or running different software which has clear gateways to support interoperability. To determine which route will be used to achieve the vision, the visions of the Chinese and European Grid communities must be considered. Where these visions are compatible technologically then the technical interoperability can be achieved. Where these visions are compatible in terms of governance and operation, then an interoperable service can be achieved. The timescales of convergence to interoperability at all levels depend upon the motivations, funding, technical development and governance of each Grid community. The annexes describe the research and commercial Grid activities in both Europe and China, here are brief accounts of the visions to which those communities are working.

2.1.1 Chinese Grid Vision

China's leaders have pledged to make the nation an "overall well-off society" (*quanmian xiaokang shehui*), with a per-capita income of $3000 by 2020, up from $1000 in 2002. Achieving that goal will require continued rapid economic growth. The leadership, however, is aware that the high-speed growth of the past 25 years—with its overinvestment, inefficient use of resources, and the devastating effect on the environment—cannot be sustained. The path to creating the overall well-off society will necessarily be characterized by technological innovations supporting greater efficiency and productivity, and institutional innovations supporting improvements in governance—greater market discipline and integrity, less government corruption, and greater administrative accountability.

Despite China's remarkable economic accomplishments, its record of innovation in commercial technologies has been weak, even considering recent improvements in its patenting performance. Instead, its dependence on foreign technology has grown consistently over the past 20 years. It has become increasingly obvious to the planners that those who own the intellectual property, and who control technical standards, enjoy privileged positions in, and profit most from, international production networks. In addition, as a result of continued conflicts with the US and other countries over intellectual property rights and standards, China has concluded that current patterns of control over those areas may not serve China's interests. Rather, they work to serve the international leaders in innovation. Thus, the Chinese industrial economy of the 21st century should, in this view, set its own standards and generate and incorporate its own IPR. [11]

China has a vast peasant population and, as of 2005, a per-capita GDP of only $1700; by those measures it remains a developing country. But by any number of

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[11] R. P. Suttmeier, X. Yao, A. Z. Tan, *Standards of Power? Technology, Institutions, and Politics in the Develop-ment of China's National Standards Strategy*, National Bureau of Asian Research, Seattle, WA (2006), http://nbr.org/publications/specialreport/pdf/SR10.pdf

indicators of academic scientific activity, it is not. China ranks fifth in international S&T publications, above France, Italy, and Canada. Its pool of about 1 million scientists and engineers devoted to R&D is second only to the US, and China is about to surpass the US in the conferring of doctoral degrees in science and engineering. The growth in the number of trained scientists and engineers has been steady, and continues to increase, as does their output of S&T publications. Although the numbers are large as a results of the vast population which China has, the impact of these patents, publications and trained scientists and engineers is disproportionately low.

75% of Chinese industrial enterprises do not employ any R&D staff[12], so even if the university sector produces trained scientists and engineers, produces journal papers and patents, the next stage in the innovation cycle is a barrier since there is not the smooth transition for these personnel and innovations to move into industrial R&D which will have an impact on products and the economy.

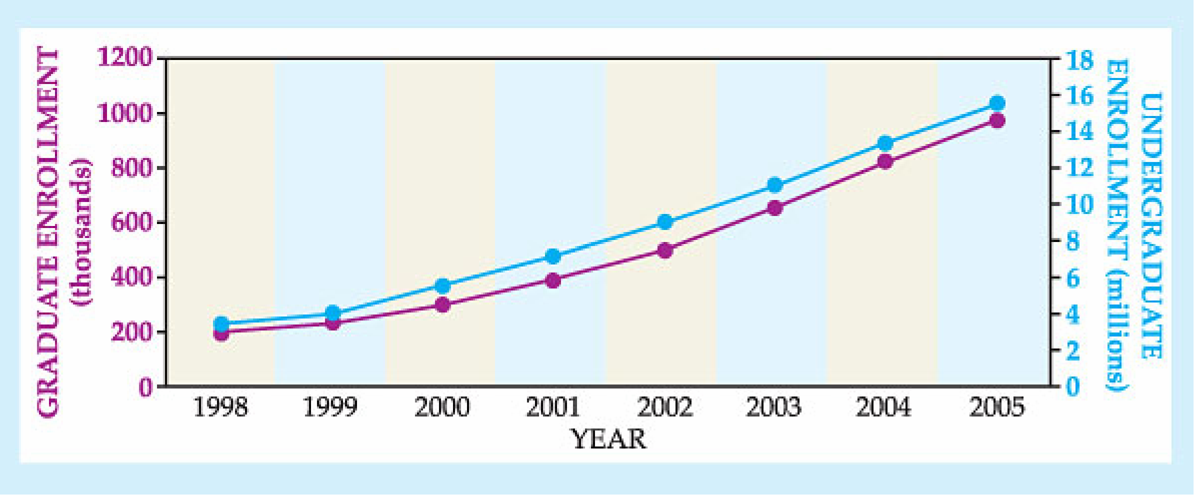

Figure: Student enrolments in Chinese higher education have risen since 1998 at both the graduate (purple) and undergraduate (blue) levels.

There have been criticisms about the effectiveness of such national programs as the National High-Technology Research and Development Program (the 863 program) and the National Basic Research Program (the 973 program). Since the majority of national programs and approximately 15% of the government's R&D expenditures are controlled by MOST, the doubts expressed about the effectiveness of national programs have inevitably been taken as criticism to the ministry as well; detractors charge that MOST champions national programs not just to meet national goals, but also as a way to enhance its budget and overall importance. The funding of the 863 programme has been specifically criticised for being biased and inefficient, lacked transparency, and too often subject to the preferences of MOST officials rather than scientists.

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[12] *People's Daily* online, July 6th 2006, http://english.peopledaily.com.cn/200607/06/eng20060706_280472.html

China views weak research and development as an obstacle to sustained economic growth and a hindrance to its international competitiveness. In 2006 China initiated a 15-year "Medium- to Long-Term Plan for the Development of Science and Technology." The MLP calls for China to become an "innovation-oriented society" by the year 2020, and a world leader in science and technology (S&T) by 2050. It commits China to developing capabilities for "indigenous innovation" (*zizhu chuangxin*) and to leapfrog into leading positions in new science-based industries by the end of the plan period. According to the MLP, China will invest 2.5% of its increasing gross domestic product in R&D by 2020, up from 1.34% in 2005; raise the contributions to economic growth from technological advance to more than 60%; and limit its dependence on imported technology to no more than 30%.

The plan also calls for China to become one of the top five countries in the world in the number of invention patents granted to Chinese citizens, and for Chinese-authored scientific papers to become among the world's most cited. The resources committed to scientific research have led to rapid growth of Chinese-authored papers in *Science Citation Index*–catalogued journals, but their contribution as measured by citations has been disappointing. [13] Planners require in increase in the impact of technological outputs rather than just an increase in the number of those outputs.

Zhiwei Xu, deputy director of the Chinese Academy of Science's Institute of Computing Technology (ICT), in Beijing said in 2005 "We do not view computing grids merely as a technology for distributed scientific supercomputing, but as a way of drastically lowering information technology costs. Our long-term vision is to provide low-cost IT products and services for half of China's population by 2020."[14] In a country of 1.3 billion people[15], that means getting online access to more than 600 million of them.

The vision for 2020 is for a massive Internet based Grid system which is available to bridge the gap from the academic research community to industrial R&D and production, accessible to a large proportion of the vast population in order to boost economic growth.

2.1.2 European Grid Vision

There are several different visions in Europe as to what the Grid technologies will produce for different purposes:

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[13] Office of Naval Research, *The Structure and Infrastructure of Chinese Science and Technology*, access no. ADA443315, Defense Technical Information Center, Fort Belvoir, VA (2006), http://stinet.dtic.mil/cgi-bin/GetTRDoc?AD=ADA443315&Location=U2&doc=GetTRDoc.pdf

[14] http://www.theinstitute.ieee.org/portal/site/tionline/menuitem.130a3558587d56e8fb2275875bac26c8/index.jsp?&pName=institute_level1_article&TheCat=1016&article=tionline/legacy/inst2005/jul05/7w.memprofile.xml&;jsessionid=GyKnSzPW2KQ3GYhrFhphh5QnvcRRQfr2KqHQNW7C9m9LGmLg6Gtx!-200257699

[15] The Chinese census reported in 2001 that the population was 1,260,000,000, including people living on the island of Taiwan. Annual growth was 1.07%, so the population can be expected to grow by 23% by 2020.

1. The research infrastructure vision is of a sustainable central European institution, the European Grid Initiative (EGI)[16], which will co-ordinate planning and operations of interacting National Grid Initiatives (NGI) who will each provide the computing resources. Users will join virtual organisations (VO) which will have usage accounted for on the overall Grid network. The EGI will interoperate with Grid systems outside Europe to provide a single global computing Grid capable of addressing strategic problems immediately as they arise, by applying vast global computing resources. The NGI will be funded by national governments, and the EGI will be funded by contributions from NGIs on the basis of use of the overall Grid infrastructure.

2. The academic research vision of Grid technology includes the virtualisation of services, the rich semantic description of available services for discovery and composition, with trust, security and management services to control the overall technology. This technological vision has been called the semantic Grid[17] from the viewpoint of the improved understanding of the meaning of the descriptions. The idea of implementing these services as autonomic, self-describing objects is described by the concept SOKU (Service Oriented Knowledge Utility) which is most clearly described in the third report of the Next Generation Grids Expert Group (NGG)[18].

3. Industrial visions for enterprise Grid technology vary more widely:

    a. the operation of open VO hosting environments by telecom or network providers which allow the composition of value chains between enterprises (E2E); sometimes limited geographically or to specific industries;

    b. the management of local computer clusters within enterprises;

    c. in general the industrial vision of grids follows the service oriented computing maturity model[19];

    d. The most extreme vision is a global Grid available for use by businesses[20] mirroring the academic research infrastructure, however as described above, there is little commercial reality to this yet[21].

What is common to these four options is that they will all apply Grid technologies in clear business models and plans which will lead to the lower ICT costs, and

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[16] http://www.eu-egi.org/
[17] http://www.semanticgrid.org/
[18] http://cordis.europa.eu/ist/grids/ngg.htm
[19] http://www.enterprise-architecture.info/Images/Services%20Oriented%20Enterprise/EA_Service-Oriented-Computing1.htm
[20] http://epubs.cclrc.ac.uk/work-details?w=36595
[21] http://www-03.ibm.com/Grid/Grid_press/pr_924.shtml

increased knowledge based employment in Europe in line with the Lisbon Agenda. The EU GridCoord project[22] tried to unite these visions into a single view:

> "The vision is of a world-leading Grid utility of resources, tools and applications that is a key enabler for European Research, Industry and Commerce." Where the Grid utility vision and purpose is of an "infrastructure that enables Research to be conducted more efficiently, reduces its costs, facilitates collaboration, increases the scale of the research challenges that can be tackled and is an enabler for pan-European collaboration, and therefore enables Europe to sustain and increase its world leading research base; Industry to control its costs, increase its productivity, to innovate and diversify, improve its ability to collaborate and co-operate and provides a means of pan-European trading services and resources, and therefore enables Europe to sustain and increase its high-value industrial sector."

[22] Dr. Geleyn Meijer. University of Amsterdam, www.eu-gridresearch.org/modules.php?name=UpDownload&req=getit&lid=41

3 Roadmap for EU-China Grid interoperability

This section defines roadmaps developing a shared European and Chinese vision of future Grid research perspectives for both research and industrial communities. This vision will establish a clear Technological and Research Agenda on which both sides may collaborate.

The purpose of a roadmap is to provide a route from the current state to the state foreseen in the vision for the future. The roadmap is useful if it is focussed to the vision regarding other developments as context. The roadmap needs to include timescales defining when events will happen, and to incorporate an analysis of the major risks from the context which could block the roadmap.

The European and Chinese visions have been described in chapter 2, while the context for the development of international Grid systems has been outlined in the introduction in chapter 1. The industrial enterprise and academic research grids have been treated separately since they have very different present states, and different visions. The objective of the visions is the provision of interoperable international Grid systems covering the resources and users in Europe and China.

The current state of national European research Grids in Europe (section 6.2.2) and China (section 6.1.4) are described in the annexes, as well as the state of the EGEE projects and planned EGI integrating them at the European level (section 6.2.1.5).

The inter-operation of European and Chinese grids is being addressed (section 7.1.2) by the EU-China Grid project which is linking the gLite middleware of EGEE through a gateway to the GOS middleware of the CNGrid Grid in China. Further, OMII Europe has established a component exchange scheme with OMII China which has already demonstrated that the CROWN scheduler can operate over both the OMII Europe and CNGrid infrastructures (section 7.1.9). The CNGrid is the largest of the Grid infrastructures in China funded by MOST, with the plan for it to be used for both academic and commercial purposes.

No attempts have been identified to link the European national or EGEE Grid to the other main Grid infrastructures in China (NSFC Grid, China Grid), which use their own middleware and which are planned to continue to operate as infrastructures for academic research. There is also no roadmap yet defined in China to integrate or ensure interoperability between these grids.

The visions for the use of academic research grids in both Europe and China share the need for the largest possible available interoperable computing resource in order to address potential disasters, and maximise the potential to profit from opportunities that arise.

The conventional activities to stimulate interaction are required to underpin this roadmap: joint workshops, staff exchanges and fellowships, support for attendance at common international conferences. However, the route to achieve the vision of interoperable grids requires further technical activities as well.

3.1 Roadmap for Existing Academic GRIDs

To improve the interoperability of the existing and near-term European and Chinese academic research grids the following stages are foreseen:

1. Develop gateways for interoperability of jobs across European and Chinese Grids (advancing work currently undertaken in the EUChinaGrid project) to allow jobs to be computed on the larger joint EU-China Grid without all parties needing to run the same software as currently required by the EGEE project arrangements;

2. Exchange and develop common components for job submission and job management between Europe and China (advancing work currently undertaken in the OMII Europe) to allow a more sophisticated control of jobs submitted than a gateway would allow;

3. Test the interoperability of components between grids (continuing work started in the ETSI plugtests) to ensure that components are available according to common standards and are interoperable;

4. Establish international standards for architectural components and interfaces (extending work undertaken by the OGF GIN) to ensure that future components are developed to common standards to allow jobs to run across the European and Chinese Grids.

5. Maintain common PKI certificate interoperability through the International Grid Trust Federation (IGTF), and establish other trust enhancing mechanisms internationally to ensure that the security mechanisms allow jobs to be run across both European and Chinese Grids when required; to facilitate the contribution of resources to the Grids by more research establishments by assuring the security of the Grid, and to ensure that breaches of security have global consequences;

6. Establish common internationalised controlled vocabularies and representation for automatic policy management that can be localised in the EU and China to allow policies for security, service level agreements, accounting etc… to be enforced across the joint EU and Chinese Grids thereby supporting more sophisticated job management beyond simple submission;

7. Agree common financial accounting procedures for jobs and Virtual Organisations to allow sustainable resourcing of the Grid infrastructure across both the EU and China;

8. Establish an international governance institution to resolve conflicts and oversee interoperability.

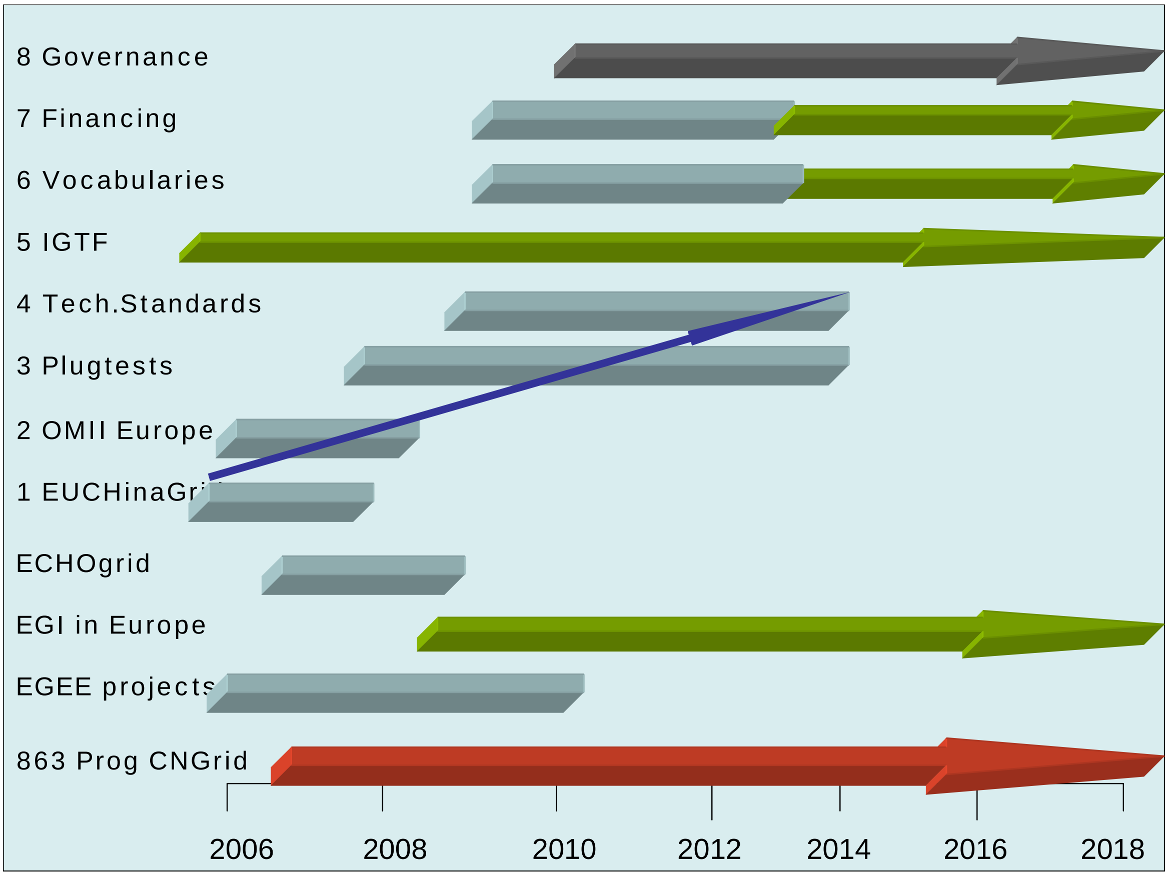

Figure: Roadmap of activities towards an interoperable EU-China Grid infrastructure.

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The figure summarises the temporal dependencies of these actions. It also captures in the colours used, the difference between actions led and sustained by China (red) and those research actions led by Europe (blue) while sustainable institutions led by member states, or non-governmental organisations are shown in green. The issue of governance of a global Grid is still sufficiently unclear in terms of its leadership or its sustainability that it is shown in gray.

The blue arrow indicates the dependencies of these technical activities upon each other as they move towards open standards established through international bodies. The standardisation will start in the OGF, but for it to have impact with a broad range of commercial users, it is expected to move through the more established standards bodies of OASIS, W3C and OSI. Technical standards in these bodies take 3 years to achieve once the working group is established. Therefore if the standards are to be in place by 2014, the proposals need to be submitted to the standards bodies by 2011. To bring this about the technical interoperability issues need to be resolved before then.

It is expected that action points 1 and 2 for gateways and component exchange will need to be funded after the present phase is complete. However, it is essential that any future funding is clearly balanced between the EU and China both to overcome the perception that one zone is supporting the development of the other, but also to ensure the active participation of both sides. The existing two projects in these areas have initiated good relations and co-working which have produced very positive interoperable technical developments, however these will need further support to maximise the return on the current investment.

Action points 6 and 7 are shown as requiring some research action in the early phase which will require joint funding between EU and China, followed by the establishment of sustainable mechanisms, which again may be through the established standards bodies.

This roadmap does not yet address the details of how to bring about these action points or the actors who need to be brought together to do it. These details will need to be further elaborated in the next version of the roadmap. The roadmap identifies the areas where these details do need to be refined.

3.2 Roadmap for Commercial and Academic GRIDs

So far this academic roadmap has been driven from the current research infrastructures towards a vision of a global Grid appropriate for research. The industrial vision will involve a different path, although it will overlap with – and initially depend on - the research e-infrastructure considerably, as it did in the development of the Internet (1970-present) and the World Wide Web (1989-present).

We will assume the NESSI vision of the E2E service oriented architecture (see section 6.2.1.17) as the technical basis of any commercial inter-enterprise Grid developments. The current developments towards this are following a similar pattern, although they are ensuring the bottom up development of reliable standards based infrastructure whose development up the stack is governed by the needs to maximise consultancy profits by those involved. As a result, the standard approach to the Grid stack follows the web services stack up to service composition (by orchestration or choreography) with the required security and accounting. Developments in this area underpin the OGSA layers of the scientific computing stack. However, the higher commercial applications which parallel the distributed scheduling, and VO management of the academic research Grid remain proprietary in the commercial SOA world as these are the unique selling points of the companies involved.

Another significant difference between the commercial and academic Grid worlds concerns the advertising of services. SOKU and the Semantic Grid visions describe the need for rich semantic descriptions of services to meet the needs of service composition. These are active research fields in their own rights which this roadmap for EU-China Grid interoperability acknowledges but does not address.

Another area which this roadmap does not address is that of Grid applications. Many of the national and EU projects described in earlier chapters are focussed on particular disciplines or market sectors (e.g. aerospace). Even if the lower levels of the grids interoperate the issues of application interaction and interoperation need to be addressed further.

However, a version 1 roadmap is presented tentatively below which can be used as the basis for further discussions - both within EchoGRID project partners and the community with which the project interacts - on the details of action points and actors to achieve the vision: a vision applicable for commerce and industry yet also serving the needs of the academic community. In this way a firmer roadmap should be available before project end.

The key elements are:

1. the assertion that the end-point of the vision is applications built using SOKU web/Grid services resting on SOKU middleware, in turn resting on an operating system developed into a service-based, component-structured facility derived from Linux;
2. the tracing of the key dependencies and their developments to achieve this: essentially the development from web services through OGSA to common Web&Grid services with (semantic) ontology support where the services are SOKU and therefore autonomic and self-composing;
3. the development away from GLOBUS or gLite to incorporate web & Grid services. This implies the end of monolithic middleware and the ability of Grid and web services to be unified;
4. the development of a Grid-services-based Linux operating system to provide the underlying operating services required including improved security and performance in a highly-connected environment.

Clearly, the present state includes a complex set of competing middleware offerings, none of which are following a clear service-oriented architecture and therefore not easily developable into a SOKU environment. Nonetheless, both European and Chinese middleware could be used as a basis. It needs to be developed to a service-orientation architecture and embracing the SOKU concept, especially in the areas of scheduling and resource management which commonly are monolithic within the existing architecture. Detailed work has to be done to map the steps from existing middleware to that required for the vision; this can be done in parallel with work on convergence such that both objectives (development to service-oriented architecture and convergence of European and Chinese Grid middleware) are achieved.

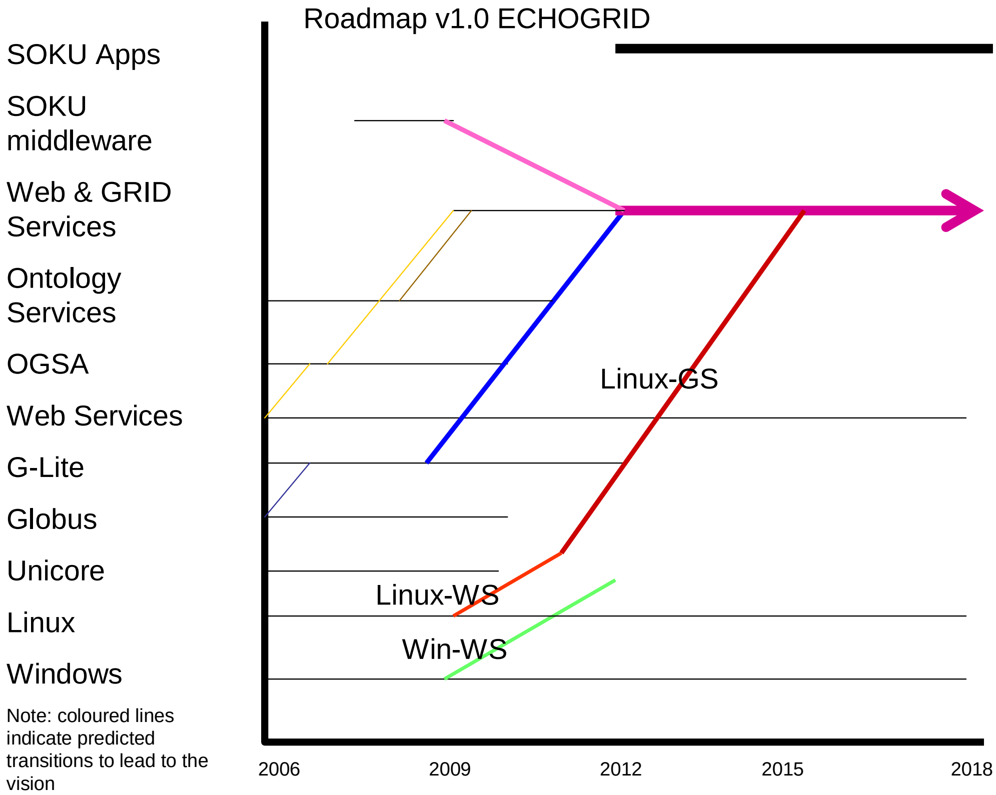

Figure: Strawman Roadmap to stimulate discussion and lead to a shared vision

4 Strategic Priorities

Previous chapters have identified the current state in Grid technologies in Europe and in China, they have compared the visions from the two zones, and produced a roadmap to lead to the vision from the current state. This chapter identifies specific strategic priorities to be addressed in both Europe and China in order to progress along the roadmap in order to achieve the common vision.

The strategic priorities fall into four categories:

4.1 Vision

It is necessary to discuss and agree a shared vision of the end-point in 2018 and the dependencies related to key technological development steps to achieve this. The figures above are intended to stimulate this and will be refined in the light of discussions within the EchoGRID consortium and particularly with the community with which the EchoGRID team interacts.

Once the high-level vision and dependencies are agreed, we can refine the roadmap to details and 'back-map' to existing offerings and planned developments in both the academic and commercial work, in both China and Europe.

4.2 Technical Priorities and Standardisation

It is essential to continue to move forward the technical co-operation on gateway development, component exchange and interoperability testing if the roadmap is to be followed. At a rather basic level interoperability needs to be proved and mutual confidence in team working needs to be established.

It is also essential to establish a home for Grid standards in an international standards body that has the respect of both academic researchers and industry if that technical interoperability is to be sustained. This requires the standards body to agree the vision and steps and ensure standards are developed and ratified in a timely manner.

4.3 Business Models and Plans

To enable businesses to take advantage of the Grid it is essential to publicise use cases of the benefits of the technology to business. This will not only broaden the business community involved, but also provide a basis for technical decisions which will be made.

It is also essential to have respected representatives of business involved in the definition of the vision and dependencies to achieve it. They have to be convinced that the business model is valid and appropriate for their organisation. When convinced they will be excellent ambassadors within their own organisation but also representing their organisation on standards bodies and at external events – including with supply-chain partners and customers.

4.4 Political Action

There are general issues of the prioritisation of values which differ considerably between Europe and China. These are being addressed outside the scope of the technologies described here. However, for business and science to take advantage of these technologies any momentum to converge those values must be maintained.

The different funding sources in Europe, and the different ministries in China need to agree a common approach to funding co-operation and interoperability of Grid technologies within their own zones, and between them. These decisions require senior ministerial involvement and cannot be undertaken by technical staff alone; and require the funding organisations to be convinced of the vision and the dependencies to achieve it..

The groundwork needs to be laid for an international Grid governance organisation in order to avoid the problems which have arisen with ICANN and which the IGF is now trying to resolve. If this is not done, the Grid will become controlled by the US in the same way that the internet was. By taking a strong lead in development to an agreed vision, Europe and China can take precedence in this area of technology with concomitant benefits in business, R&D, education and quality of life.

5 Conclusions & Plans

There are active developments in both research and industrial areas for Grid technology in both Europe and China. There are on-going collaborations but these are currently very tentative. There is a concern in Europe that the contribution of the Chinese to these collaborations is only to gather information and research results and not to contribute constructively to a joint development of technology.

The visions for the Grid from the perspectives of Europe and China have similarities but also significant differences. The European vision includes both scientific computing grids and industrial enterprise grids. The position in China is dominated by government planning and expenditure. The different ministries involved have each taken their own action and it is not clear how these will come together. It is equally unclear how the role of China in the major inter-governmental organizations will impact international interoperability. These details need to be investigated more in order to produce a more detailed roadmap in the next version of this report.

A roadmap has been presented to move towards a common vision for scientific computational grids based on the EGEE projects and the subsequent sustainable EGI in Europe along with the integration of the major Chinese grids. The position for interoperation and alignment of governance of the commercial grids is less clear.

Strategic actions have been identified as priorities to be addressed both in Europe and in China in order to progress the roadmap. However these are tentative, and require the actors with authority and vision to carry these out to be identified.

It must be admitted that this is a first version of this report, and it does not provide the detailed analysis required to produce a useful roadmap. It does not clearly identify the organizations and individuals that need to be included in collaborative activities to move forward a mutually beneficial development of Grid technologies between Europe and China. The general, if only mundane, picture presented of Grid developments in Europe and China, and the existing collaborations is accurate, but there is not sufficient analysis of exactly why what has happened is the way it is, not where it will be. It is planned to deepen this analysis in the next part of the project for the next version of this report.

A second, visionary roadmap has been presented. It will be used as a ‘strawman’ for discussions and decisions. It is hoped that this will stimulate an agreed vision and dependencies to achieve it which can then be resourced appropriately to strengthen the EU-China collaboration and thus achieve e pre-eminence in this field yielding benefits of industry, commerce, R&D, education and the quality of life.

EchoGRID is therefore planning to combine a top-down perspective (European Commission/MOST) to a bottom-up approach (consultation of EU / Chinese academic and industrial communities) to perform a fine-tuning of the main research priorities in order to refine this common EU-Chinese Grid roadmap for its next release, providing a framework for future research and industrial collaborations.

2008 is going to be a very important year for China in terms of its international visibility because of it hosting the Olympic Games, and many other events including many international computer conferences. This provides an opportunity to increase contacts between the European and Chinese Grid research communities, but also in the standards area, and for businesses, and most importantly at a political level. To bring about the long term vision of growing, sustainable economies in both Europe and China we need to make the best use of these opportunities.

6 Annex 1: Analysis of Grid Research and Industrial Status

The purpose of this chapter is to state the current state of Grid technology in China and Europe and the desired vision state as a basis for the roadmap presented in chapter four which shows a route to achieve the vision. This chapter provides a summary of the current state of research and industrial adoption of Grid technologies in Europe and China. The chapter therefore can be viewed as a two by two matrix: Europe/China by Research/Industry. Also included are summaries of the visions for the future Grid technology as foreseen from the European and Chinese perspectives.

6.1 Chinese Grid Status

Before considering the main Grid projects, we will cover some background information.

6.1.1 Chinese Research Funding

There are three major public sector funding sources for Chinese IT researchers in the Grid area:

- Ministry of Science and Technology (MOST)[23] which supports several programmes:
    - the Hi-Tech Research and Development Program (863 Program[24]), initiated in March 1986 and aimed at enhancing China's international competitiveness and improving China's overall capacity of R&D in high tech areas[25];
    - the National Basic Research Priorities Program (973 Program) which addresses key scientific problems and issues that the nation's development is facing; and
    - the Key Technologies R&D Program**,** which embodies the principle of orienting science and technology towards the main fields of economic development.
- the National Natural Science Foundation of China (NSFC), which supports basic research and some applied basic research in the natural sciences as well as its own IP network (NSFCNet) and its own Grid infrastructure on top of

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[23] Wan Gang, minister of science and technology, Vice Ministers: Li Xueyong, Cheng Jinpei, Wu Zhongze, Liu Yanhua, Shang Yong; Cao Jianlin, Chief of Science and Technology Daily: Zhang Jingan.

[24] http://www.most.gov.cn/eng/programmes1/200610/t20061009_36225.htm

[25] From 1986 to 2001, the 863 Programme received 5.7 billion RMB of funding, but produced over 200 billion RMB of economic return, including over 2,000 patents and 47,000 theses.

NSFCNet (CROWN and China Science Grid) .
NSFC's annual budget for all funded projects has gone from 80 million RMB in 1986 to over 2 billion RMB in 2004.

- the Ministry of Education, which supports its own IP Network (Chinese Education and Research Network - CERNET) and a Grid infrastructure on top of CERNET (ChinaGrid);

The 863 Program is administered by the Ministry of Science and Technology (MOST). According to its 2002 Annual Report (latest available on the website), the total funding under this program is 4.4 billion RMB. In 2002, the 863 Program was implemented in the form of Priority Project, Key Project and Guidance Project.

- Priority projects of the 863 Program in 2002 consist of 2 categories: frontier exploring research (Type A) and applied research (Type B). This led to more participation by industry in the 863 Program. In 2002, 30% of newly approved projects were undertaken mainly by enterprises (industry)..
- With regard to key projects, 26 key projects under the 863 Program were initiated and implemented on a full scale in 2002. Most of them were based on technology integration and targeted to the critical technology demand of economical and social development.
- To support local governments to develop high-tech industry, 43 guidance projects were initiated 2002. These types of projects were mainly funded and managed by local governments with technical support from the 863 Program.

In a recent year (2002), the percentage of funding from the 863 program by expenditure were 20% for Information, 33% Biotechnology and Advanced Agriculture, 17% Advanced Materials, 10% Advanced Manufacturing and Automation, 14% Energy, and 6% Resources and Environment.

The funding and decision-making process of the 863 Program consists of the following steps:

- Feasibility study of strategy by the Expert Group (which consists of scientists and researchers in the topic area)
- Release of call for projects by the Expert Group
- Evaluation of applications by internal and external experts
- Result of the evaluation reported to the Expert Committee for consulting
- Large projects are submitted to open debate
- Approval by the MOST

This process is quite typical for most funding opportunities, including the selection of ***Key Labs*** or ***Key Institutes***, where an individual or an organization submits an application, which is reviewed by a group of experts (similar to our panel review process), and the funding agencies make the final decision based on the recommendations of the expert group.

6.1.2 Chinese Research Institutions

There are about 36 key universities under the ministry of Education. Those universities are very active in research. Adding key universities supported by the local governments and different ministries, there are totally about 100 key universities in China.

Another track of research is the Chinese Academy of Sciences (CAS), a top national research organization. There are more than 90 research institutes under CAS, forming a research system parallel to universities.

In terms of education in Computer Science and Technology, China offers PhD and Master degree programmes in three disciplines: Computer Architecture, Computer Theories and Software, and Computer Applications. The organisations which can offer PhD degree in computer science and technology are qualified by a very strict procedure. Currently, there are 28 universities and institutes that can offer PhD degrees in one or two disciplines. Among them, 15 universities and one research institute have been authorized by the Ministry of Education to offer Ph.D. degrees in all three descipilines in Computer Science and Technology. These organisations are:

Tsinghua University
National Defense University of Science and Technology
Beihang University
Zhejiang University
Harbin Institute of Technology
Peking University
Nanjing University
Shanghai Jiaotong University
Northeast University
Huazhong University of Science and Technology
University of Science and Technology of China
Xi'an Jiaotong University
Fudan University
Southeast University
Northwestern Polytechnical University
Institute of Computing Technology (Chinese Academy of Sciences)

In addition,, there are 132 universities that only offer only master degrees in computer science and technology.

6.1.3 Chinese IP Networks

The network infrastructure in China is operated by telecommunication companies such China Telecom, China Netcom, China Unicom, and China Mobile. They construct and manage the network infrastructure all over the country. Since the late 1990’s, there has been a trend to use IP network as the basis of all communications, including data, voice, and media.

There are several IP networks operated by organizations other than those Giant communication companies. Among them, two are prominent; China Education and Research Network (CERNet) and China Science and Technology Network (CSTNet). The former is invetsed and operated by the Ministry of Education. The later is under the support and management of Chinese Academy of Sciences. CERNet’s backbone is run over leased dark fibers, supporting a 2.5 – 10 Gbps transmission rate with coverage over 36 PoPs in all province capitals. CERNet connects1500 universities and colleges in more than 200 cities with over 20 million users.

Figure: CERNet 1, 2005

CSTNet operates over a combination of fibers and satellite links to reach all institutes and observation stations across the country. In the next 5 years, there will be a significant upgrading to the scale and bandwidth of CSTNet.

In 2003, China launched an ambitious next generation Internet program, China Next Generation Internet (CNGI). All major communication companies and CERNet and CSTNet are involved. Those companies and network operators developed 6 IPv6 backbones which are eventually connected to form a IPv6 network testbed. The government investment to CNGI exceeds one billion RMB. One of the largest IPv6 backbone, CERNet 2, has been put in operation by the end of 2005.

The National Science Foundation of China has its own effort in IP networks. A high speed IPv6 network, NSFCNet, has been constructed in 2000. It has a 10 Gbps backbone and covers 6 sites in Beijing city. Extensive technological experiments and application demos have been conducted over this testbed.

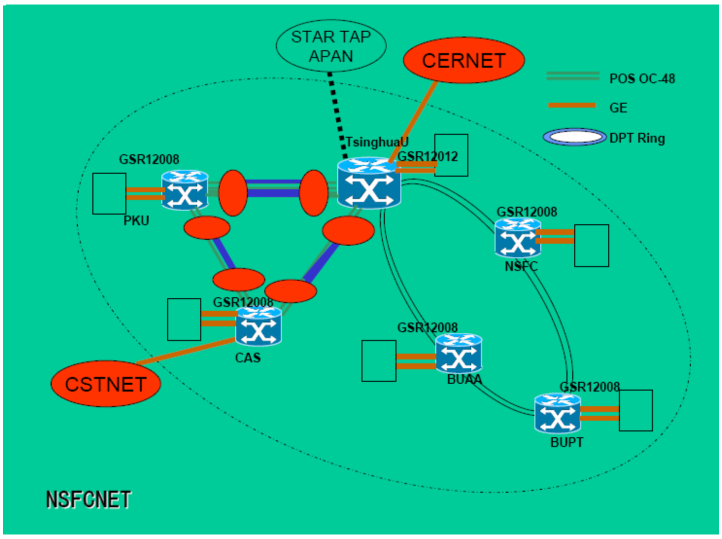

Figure: NSFCnet Oct 2005.

6.1.4 Research Status in China

Research on high performance computing and Grid technologies has been one of the strategic research initiatives in China in the past 10 years. China has funded a series of Grid projects to pursue technological breakthrough and to establish its Grid infrastructure.. An article by Yang et al in 2004[26] has been the main source of knowledge about Grid research in China to most European research communities, although the US NSF delegation visit report from 2006 is also insightful[27].

6.1.4.1 CNGrid[28]

Funding agency: Ministry of Science and Technology (MOST)

Partners: Beihang University, Computer Network and Information Center (CNIC) of CAS,
Shanghai Supercomputing Center, Xi'an Jiaotong University, University of Science and
Technology of China, Tsinghua University, Hong Kong University, Institute of Applied Physics and Computational Mathematics, National University of Defense Technology (first
phase), new partners from second phase: Shandong University, Huazhong University of

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[26] http://www.springerlink.com/content/kx534qwh2r5307jr/

[27] Report to National Science Foundation: Insightful Understanding of China's Higher Education and Research in Computer Science and Information Technology. U.S. Senior Computer Scientists Delegation Visit to China, May-June 2006; http://dimacs.rutgers.edu/Workshops/China/

[28] http://www.cngrid.org/

Science and Technology, and Shengzhen University.

Contact: Depei Qian (Chief scientist of the 863 key project),depeiq@buaa.edu.cn, Xuebin Chi (Director of the CNGrid Operation Center), chi@sccas.cn

Starting date and duration:
2002 to 2005 (first phase), 2006-2010 (second phase)

Maximum national contribution:
100 million RMB (first phase), 640 million RMB (second phase)

Website: http://www.cngrid.org

The National High-tech R&D Programme, the 863 program, sponsored by the MOST, is the major source of government funding on Grid research in China. One of its major efforts is the China National Grid (CNGrid). The first phase of CNGrid was supported by the national high-tech program via the key project "High performance Computer and Core Software" from 2002 to 2005, with a government funding of 100 Million RMB and twice of this amount of matching funding from local government and application organisations.
CNGrid is a testbed that integrates high-performance computers with a new generation of information infrastructure. The major tasks undertaken by the first phase CNGrid include: [1] the development of two high performance computers to equip CNGrid major sites; [2] the development of Grid software to support Grid applications and Grid operation and management; [3] the development of several productive Grid applications for demonstrating the feasibility of using Grid technology in applications. In the first phase of CNGrid, ten applications were selected from 4 areas including research, resource and environment, service, and manufacture.

By the end of 2005, CNGrid completed its first phase development. The second phase of CNGrid was launched in Sept. 2006 with a government funding of 640 million RMB. Most of the funding will be spent on the development of high productivity computers. The money spent on Grid technology will exceed 100 million RMB. The matching money will also be provided by other government agencies and application organisations.

The major activities conducted by the first and the second phase of CNGrid are summarized in the following sections.

2.1.4.1.1 *CNGrid testbed development*

CNGrid consists of 8 nodes across the country. Among those nodes, two are major nodes, they are Computer Network Information Centre (CNIC) of CAS in Beijing and Shanghai Supercomputing Centre (SCC) in Shanghai. Other 6 ordinary nodes are: Tsinghua University and Institute of Applied physics and Computational Mathematics in Beijing, Xi'an Jiaotong University in Xi'an city, University of Science and Technology of China in Hefi city, National University of Defense Technology in Changsha city, and Hong Kong University in Hong Kong. The following figure shows the location of CNGrid sites.

The CNIC node is equipped with Lenovo DeepComp 6800, a 5.324 TFlops machine developed by Lenovo. SCC is equipped with Dawning 4000A, a 10 TFlops computer developed by Dawning Computer. By the end of 2005, CNGrid has reached a total computing resource of 18TFlos and a total storage capacity of 200TB.

The CNGrid Operation Center has been establishes, which is based on one of the major node, the CNIC node. It is responsible for the operational management of the Grid environment and technical support to the users.

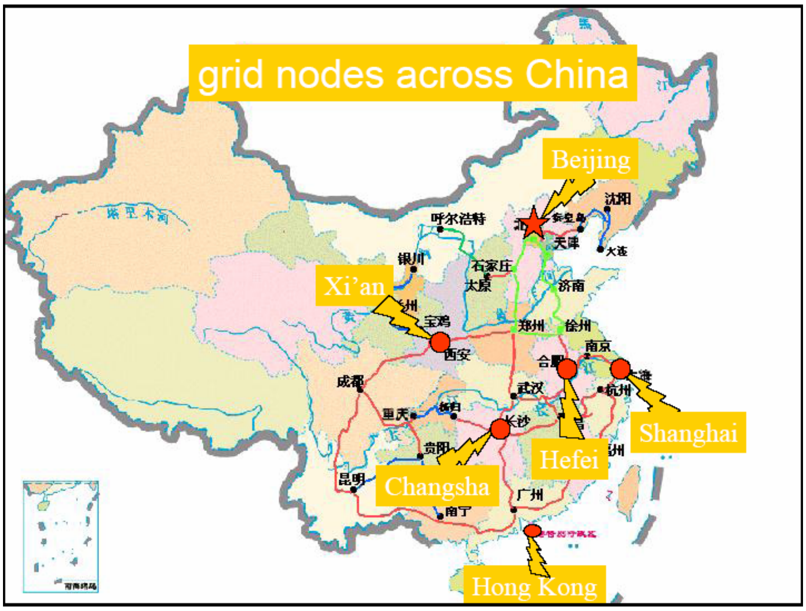

Figure: CNGrid node locations across China, Dec 2005.

The second phase of CNGrid will upgrade CNGrid in both number of sites and resources. The number of CNGrid nodes will be increased to 12, the total computing power will be increased to 300TFlops, and the total storage capacity will be 1PB.
In the first call of the second phase of CNGrid, NUDT failed to get continuous support from the key project, but three new nodes were selected as the CNGrid nodes, they are: Shan Dong University node in Jinan city, HUST node in Wuhan city, and Advanced Technology Research Institute of CAS in Shenzhen city.

2.1.4.1.2 *Grid software development*

Developing a Grid software is one of the major tasks of CNGrid and is viewed as the main innovative activity. A set of Grid software CNGrid GOS has been developed during the first phase of CNGrid. GOS takes a computer system approach combined with SOA in its design and implementation. Similar to the traditional operating system, GOS emphasizes issues such as address space, process/states, and virtualization. It puts more attention to service abstraction and software architecture. Functions that meet common requirement of Grid applications were selected for implementation. The CNGrid GOS implementation is based on Web Services. New features and concepts such as Grid Community (Agora) and Grid Process (Grip) are developed to create Grid services and virtual organizations. Major services include jobs, data, information, security, etc. The user interface is provided by a Grid portal

and a language such as GSML. A Grid resource
monitoring system is developed which can monitor the resources from the physical network up to layered services. The latest version is CNGrid GOS 2.5 which supports IPv6 protocol.
In the second phase of CNGrid GOS development, the team will emphasize the robustness and usability of the software to meet the user requirement. CNGrid GOS 3.0 will be released by the end of 2007 followed by the next release by the end of 2009.

Partners: Institute of Computing Technology (ICT) of CAS, Tsinghua University, National
University of Defence Technology, Beihang University
Funding agency: Ministry of Science and Technology (MOST)
Contact: Prof. Zhiwei Xu, zxu@ict.ac.cn.
Starting date and duration: 2002-2005 (first phase), 2006-2010 (second phase)
Maximum national contribution: 13 million RMB (first phase), 23 million RMB (second
phase)

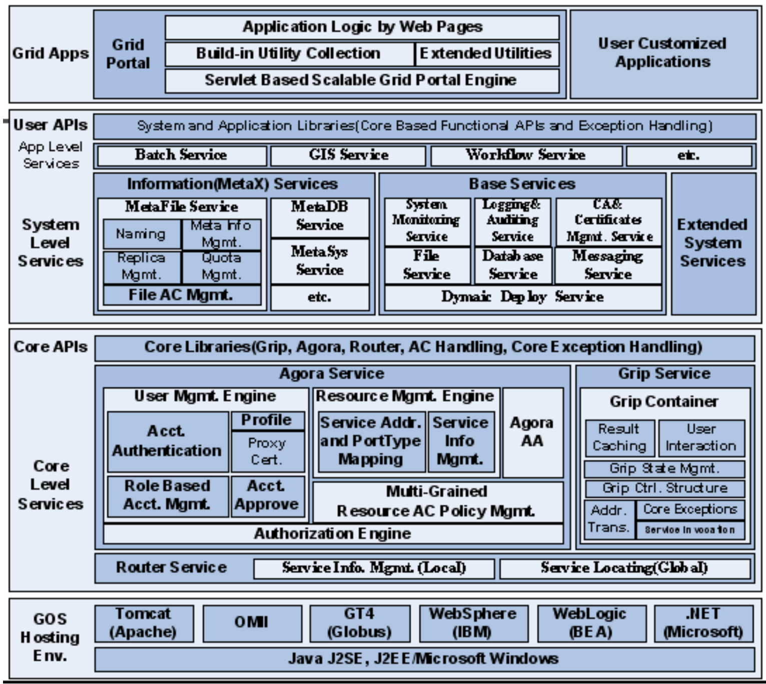

Figure: CNGrid Grid Operating System (GOS) Architecture

2.1.4.1.3 *Grid applications development and deployment*

CNGrid has supported 10 applications in its first phase. Major applications are described as follows.

Scientific Data Grid (SDG)

Short Description: The SDG project was supported by the national high-tech program via
the 863 key project "High performance Computer and Core Software" (first phase of

CNGrid) from 2002 to 2005. A second round support comes from the new 863 key project “High Productivity Computers and Grid Service Environment” (second phase of CNGrid) from 2006 to 2010.
Scientific Data Grid is an application Grid aiming at boosting the sharing, exploitation and utilization of scientific data resources. Based on the computing infrastructure and Grid software platform of CNGrid and mainly supported by the mass data resources of scientific databases distributed in more than 40 institutes of the Chinese Academy of Sciences, the Scientific Data Grid sets up a science-oriented and practical Grid environment for scientific research. Currently, SDG is equipped with a 50TB tape system and tera-scale computing capability. Scientific data resources, composed of 388 specialty databases, 322 online, come from 45 institutions participating in the Scientific Database Project funded by the Chinese Academy of Sciences. Scientific data resource has reached 16.7TB. A virtual database is established by means of metadata technology. Middleware for information services, data access services, security infrastructure and storage services is developed.

Application systems are from three disciplines including astronomy, high energy physics and Chinese herbal medicine. They are developed in the Scientific Data Grid. Typical applications include virtual astronomical observatory and cosmic ray data processing.

Partners: Computer Network Information Centre (CNIC) of CAS, National Astronomical Observatory, Institute of High Energy Physics
Funding agency: Ministry of Science and Technology (MOST), Chinese Academy of Sciences (CAS)
Contact: Prof. Baoping Yan, CNIC, CAS, ybp@cnic.ac.cn, Dr. Kai Nan, CNIC, CAS, nankai@cnic.ac.cn
Starting date and duration: 2002-2005 (first phase), 2006-2010 (second phase)
Maximum national contribution: Funding from MOST was about 2.8 million RMB (first phase), 4.8 million RMB (second phase)

Drug Discovery Grid (DDG)

Short Description: The DDG project was supported by the national high-tech program via the 863 key project “High performance Computer and Core Software” (first phase of CNGrid) from 2002 to 2005. A second round support comes from the new 863 key project “High Productivity Computers and Grid Service Environment” (second phase of CNGrid) from 2006 to 2010.

Virtual drug screening using simulation on high performance computers is a brand-new approach in drug discovery. By using computer to screen a vast compound database, a large amount of the real world compound screening becomes unnecessary and the success rate of finding effective compounds is also increased. Since the application of computer in drug screening has extremely good prospects and is very cost effective, there is an increasing demand.

The aim of developing the Drug Discovery Grid is to set up a Grid environment to provide new drug screening services. Computing resources in DDG are used in P2P mode. This means that any idle computing resources in the environment, regardless of whether it is a supercomputer or a cluster computer, will be used for drug screening. A simple user interface is developed so that once the user is authorized to log in, all he needs to do is to submit the job and eventually retrieve the result.

Research on new drugs for curing diabetes has been supported by DDG.

Figure: Drug discovery Grid portal.

Partners: Shanghai Institute of Materia Medica, Chinese Academy of Sciences (CAS), Shanghai Jiaotong University, Beihang University
Funding agency: Ministry of Science and Technology (MOST), Chinese Academy of Sciences (CAS)
Contact: Prof. Kunqian Yu, Shanghai Institute of Materia Medica, yukunqian@gmail.com
Starting date and duration: 2002-2005 (first phase), 2006-2010 (second phase)
Maximum national contribution: Funding from MOST was about 2.8 million RMB (first
phase), 3.8 million RMB (second phase)
Website: http://www.ddgrid.ac.cn

China Meteorological Application Grid (CMAG)

Short Description: The CMAG project was supported by the national high-tech program via the 863 key project "High performance Computer and Core Software" (first phase of CNGrid) from 2002 to 2005. A second round support comes through the new 863 key project "High Productivity Computers and Grid Service Environment" (second phase of CNGrid) from 2006 to 2010.

The China Meteorological Application Grid (CMAG) uses Grid technology to build a platform for Chinese numerical weather forecasting services. CMAG's major components include the Grid portal, GRAPES mesoscale NWP system, NWP control interface GridWeather, user management system, code management system CVSExplorer and visualization system. Using the CMA dedicated communication system and distributed computing resources, the CMAG becomes a platform which covers regional centers located in Beijing, Guangdong, Shanghai, Wuhan and Guangxi provincial meteorological offices. It achieves interconnection and sharing of computing resources and NWP software among the Chinese Academy of Meteorological Sciences, the National Meteorological Information Center, and the regional centers. CMAG will eventually become an environment for operational NWP services and for cooperative NWP research and development.

At present the GRAPE mesoscale NWP system is running routinely on CMAG. Authorized users can access the CMAG portal (via http://Grid.cma.gov.cn:8080/) to inquire about NWP products and to perform daily weather forecast services.

Partner: Institute of Meteorological Research
Funding agency: Ministry of Science and Technology (MOST), China Meteorological
Bureau
Contact: Prof. Xuesheng YANG, Institute of Meteorological Research
Starting date and duration: 2002-2005 (first phase), 2006-1010 (second phase)
Maximum national contribution: Funding from MOST was about 3 million RMB (first phase), 4 million RMB (second phase)
Website: http://Grid.cma.gov.cn:8080/

Bioinformation Application Grid (BAGrid)

Short Description: The BAGrid project was supported by the national high-tech program via the 863 key project “High performance Computer and Core Software” (first phase of CNGrid) from 2002 to 2005. BAGrid was built to tackle the massive data and information resulting from biology research. First, it is able to solve problems associated with the high volume of information requiring classification, conformity and storage under different conditions in biological research. Secondly, it designs better algorithms and more efficient pipelines to match the need of information processing. Thirdly, it provides cooperation schemes for collaborative projects.

Major functions of BAGrid include: aggregation and sharing of heterogeneous data resources, integration and sharing of computing resources, collaboration and cooperation among projects, packaging common bioinformatics software into Grid services, and enabling cooperation among different project teams.

Major achievements include:

- Building databases for rice, silk worm, and domestic chicken genomes, using the results of national research together with those of international cooperation projects
- Developing a bioinformatics computing Grid with a rich set of bioinformatics software (Blast, BGF, etc.) and deploying the software to multiple computing centers located in Beijing, Shanghai, etc.
- Performing the sequencing of the silk worm and domestic chicken genomes

on the genome sequencing collaboration platform built within the project
- Completing a full-scale annotation of the rice genome by using the gene annotation functions developed by the project

Partners: Beijing Institute of Genome (BIG)
Funding agency: Ministry of Science and Technology (MOST), Chinese Academy of Sciences (CAS)
Contact: Prof. Jun Wang, BIG, wangj@genomics.org.cn
Starting date and duration: 2002-2005
Maximum national contribution: Funding from MOST was about 1.6 million RMB in the first phase. So far, there is no further support from CNGrid for new development of this project in the second phase.
Website: http://biogrid.genomics.org.cn

Geological Survey Grid (NGG)

Short Description The National Geological Application Grid (NGG) project was supported by the national high-tech program via the 863 key project "High performance Computer and Core Software" (first phase of CNGrid) from 2002 to 2005. It was developed for national geological survey applications. This system achieves resource interconnections, sharing, and coordination at the application level by introducing Grid technologies and web services.

As a Grid application system, NGG offers basic data and information services for researchers and public users. The system is based on three-layer network infrastructure in China Geological Survey, and is designed in such a way that China Geological Survey acts as the portal for resource sharing and service provision. It monitors and coordinates all system operations. As regional centers for data-sharing, the regional geological survey centers deploy databases and software environment. The provincial geological surveys provide raw data service, deploy professional research centers with high performance computing capabilities, process mass data, and share application software. NGG helps the China Geological Survey to develop its infrastructure for information services and establishes a comprehensive e-framework for geological research.

The deliverables of NGG include groundwater resource evaluation and mineral resource assessment. These applications demonstrate basic services such as data integration, resource aggregation, and information processing.

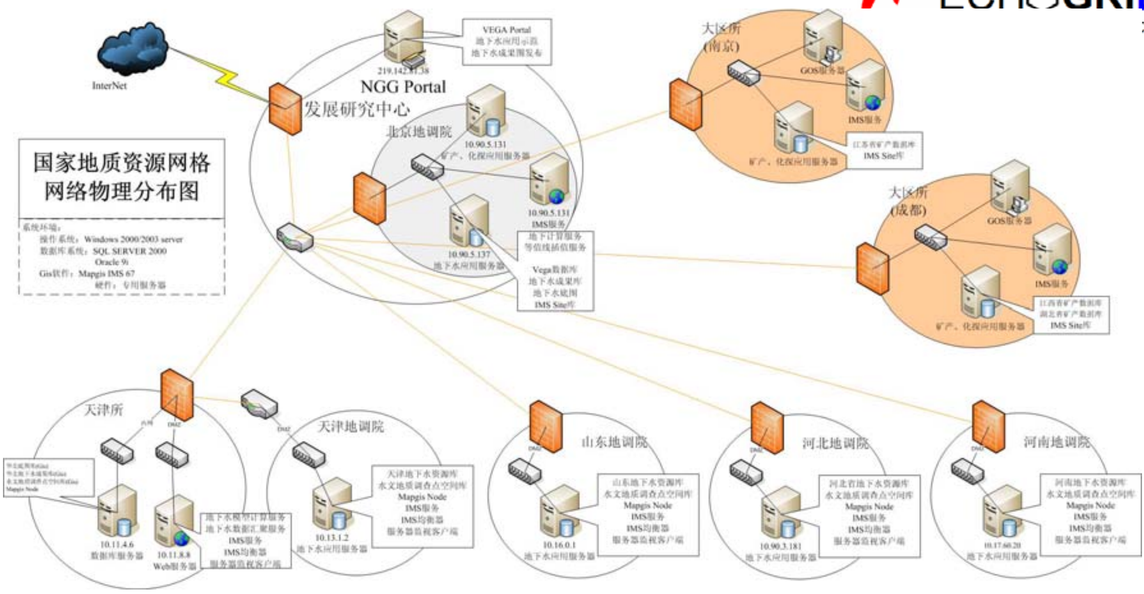

Figure: The NGG environment

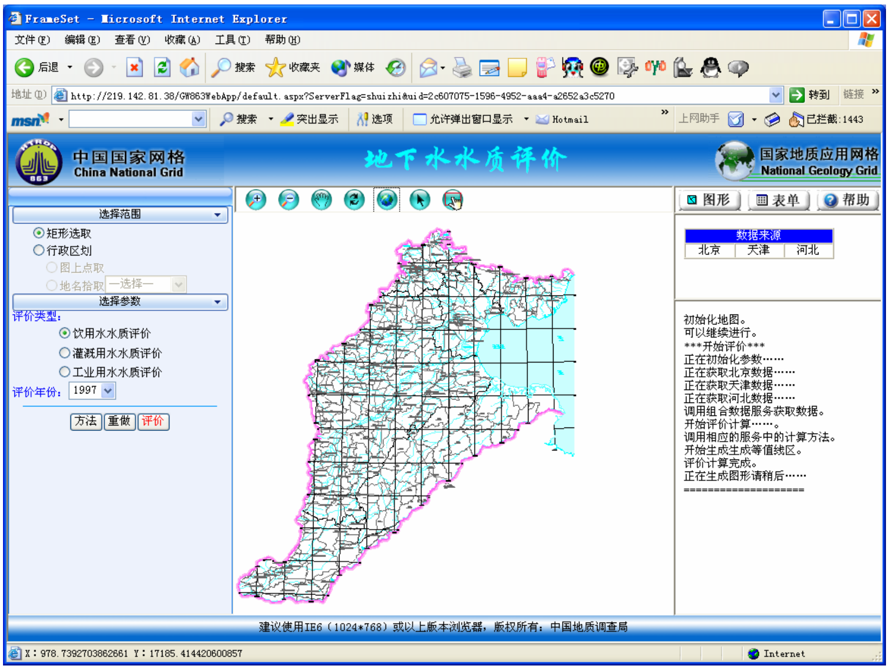

Figure: NGG Grid Portal

Partners: Development Center of China National Geological Survey
Funding agency: Ministry of Science and Technology (MOST), China National Geological Survey
Contact: Prof. Yongbo ZHANG, Development Center of China National Geological Survey
Starting date and duration: 2002-2005
Maximum national contribution: Funding from the MOST was about 3.2 million RMB in first phase of CNGrid. So far, no further 863 funding has been assigned to this project in the second phase.

Website: http://www.ngg.cgs.gov.cn/nggportal/

Digital Forestry Grid (DFG)

Short Description The Digital Forestry Application Grid (DFG) was supported by the national high-tech program via the 863 key project “High performance Computer and Core Software” (first phase of CNGrid) from 2002 to 2005. The project aims at supporting the construction of a national digital forestry to meet the needs of forestry and eco-construction projects. Based on the most current Grid technologies, it has established a domain application Grid for forest resources and forestry eco-projects. Sharing forestry information resources can provide an effective support to management and decision-making processes.

Major activities include:

- establishing the architecture and standards of a Grid-based digital forestry application system,
- integrating and encapsulating resources such as data, computing power and software at national, provincial, and county levels, and
- applying results from this project to provide guidance and support to national forestry projects such as turning farmland back into forests.

Partners: Institute of Forest Resource Information
Funding agency: Ministry of Science and Technology (MOST)
Contact: Mr. Xu ZHANG, Institute of Forest Resource Information
Starting date and duration: 2002-2005
Maximum national contribution: Funding from MOST was about 1.8 million RMB. So far, no further 863 funding has been assigned to this project in the second phase.

Aviation Grids (AviGrid, SimGrid)

Short Description: The AviGrid project was supported by the national high-tech program via the 863 key project “High performance Computer and Core Software” (first phase of CNGrid) from 2002 to 2005. This project, undertaken by AVIC II of China, has constructed a Grid platform for the company to provide effective support for optimizing resource utilization as well as for establishing a distributed design, simulation, manufacturing, and testing platform for the aviation industry. AviGrid was built upon AVIC II’s WAN network and integrates computing resources in different institutes and enterprises to form a distributed virtual computing environment. It has established mechanisms to share expensive CAD software, computing hardware and data resources. Applications for aircraft topological structures optimization and enterprise business modeling have been developed. AviGrid has benefited the company by improving the utilization of resources, reducing purchase of software licenses, and enabling distributed collaboration.
The major activities of AviGrid include:

- establishing a Grid platform for the aviation manufacturing industry,
- enabling software sharing by floating license and services,
- enabling sharing of heterogeneous distributed data,
- establishing services for sharing computer hardware resources, and
- development of aircraft topological optimization and modeling R&D process of aviation enterprises.

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Partner: AVIC II of China
Funding agency: Ministry of Science and Technology (MOST), AVIC II
Contact: Prof. Degang Cui, AVIC II, dgcui@vip.163.com
Starting date and duration: 2002-2005
Maximum national contribution: Funding from MOST was about 3 million RMB. So far, no further 863 funding has been assigned to this project in the second phase.

Simulation Grids (SimGrid)

Short Description: The SimGrid project was supported by the national high-tech program via the 863 key project "High performance Computer and Core Software" (first phase of CNGrid) from 2002 to 2005. Based on the requirements of the aerospace industry, this project focuses on research and application of large-scale collaborative simulations in connection with space-related products. Following the principle that this research has to be application- and demand-oriented, focused on grids, using innovative cutting edge technology, the project has gradually established and improved the SimGrid infrastructure. A SimGrid portal has been established. Key technologies for simulation applications have been developed. A secure, open and general purpose simulation platform has been established. Several applications have been developed and deployed over SimGrid. These efforts help to establish a new model for developing, implementing and using simulation in space industry. The combination of simulation and Grid technologies resolves the limitation of traditional technologies and allows a dynamic resource sharing and collaboration.
Partners: China Aerospace Science & Industry Corporation (CASIC)
Funding agency: Ministry of Science and Technology (MOST), CASIC
Contact: Mr. Xudong Chai, CASIC
Starting date and duration: 2002-2005
Maximum national contribution: Funding from MOST was about 1.2 million RMB. No further funding from the MOST in the second phase of CNGrid.

Since the beginning of the second phase of CNGrid, several new Grid applications have been selected and supported. The following projects are launched by the end of 2006.

Data Grid for Chinese Traditional Medicine Database Application

Partners: Institute of Information of Traditional Chinese Medicine, Chinese Academy of Traditional Chinese Medicine
Funding agency: Ministry of Science and Technology (MOST), China Academy of Traditional Chinese Medicine
Contact: Meng Cui, Institute of Information of Traditional Chinese Medicine, China Academy of Traditional Chinese Medicine
Starting date and duration: 2006-2010
Maximum national contribution: Funding from MOST is about 5.8 million RMB

Grid-Based Railway Cargo Information System
Partners: Information Technology Centre, Ministry of Railway (MOR)
Funding agency: Ministry of Science and Technology (MOST), MOR
Contact: Zhiming Xing, Information Technology Centre, Ministry of Railway,

Starting date and duration: 2006-2010
Maximum national contribution: Funding from MOST is about 5 million RMB

Computational Chemistry Applications
Partners: CNIC, CAS
Funding agency: Ministry of Science and Technology (MOST), CNIC
Contact: Zhong Jin, CNIC, Chinese Academy of Sciences (CAS)
Starting date and duration: 2006-2010
Maximum national contribution: Funding from MOST is about 4 million RMB

Water Resource Grid
Partners: Information Center, Ministry of Water Resource (MWR)
Funding agency: Ministry of Science and Technology (MOST), MWR
Contact: Yang Cai, Information Center, Ministry of Water Resource
Starting date and duration: 2006-2010
Maximum national contribution: Funding from MOST is about 5 million RMB

Astronomical Grid for Parallel Numerical Astronomical Computing
Partners: Shanghai Astronomical Observatory, Chinese Academy of Sciences (CAS)
Funding agency: Ministry of Science and Technology (MOST), CAS
Contact: Xinhao Liao, CAS
Starting date and duration: 2006-2010
Maximum national contribution: Funding from MOST is about 5 million RMB

6.1.4.2 China National Science Foundation's effort on Grid

China National Science Foundation started its effort on e-Science and Grid technology in 2003. After a series workshops on debate and discussion of the objectives, a key initiative on network based scientific research was launched by the end of 2003. This initiative is composed of three levels activities: Basic research on fundamental issues of Grid technology, Grid testbed for research, and Grid-related demo applications.

Two group work on the Grid middleware platform and Grid testbed:

- Group 1: ICT/CAS, HUST, Peking U., Tsinghua U., Xi'an Jiaotong U., and Shanghai Supercomputer Center (CSGrid project)
- Group 2: Beihang U., Peking U., Tsinghua U., NIC/ CAS, NUDT (China Research and Development Environment Over Wide-area Network, ***CROWN***)

The CSGrid and CROWN projects described in the follows represent the major effort of the initiative.

6.1.4.2.1 Science Grid (CSGrid)

China Science Grid (CSGrid) from Jan. 2004 to Dec. 2007 receives 8 million RBM funding from the Natural Science Foundation of China. The aim of CSGrid is to provide support for the full-life cycle of scientific research activities, including scientific data collection, data analysis, processing and evaluation, and collaboration among scientists,. It is based on Grid computing theory and integrates computing and science instruments resources to build a testbed for scientific research

CSGrid is a Grid platform over several existing Grid testbeds, such as China Grid and CNGrid. Six high performance computers are connected into CSGrid, more than 100 types of resources are wrapped into services. The major features of CSGrid are:

- wrapping legacy applications into services or other components that could be interoperated with other Grid resources,
- providing interoperability between CSGrid, ChinaGrid, and gLite, and
- providing high manageability of SOA architecture.

The team members of CSGrid are: Institute of Computing Technology, Peking University, Huazhong University of Science and Technology, Shanghai Supercomputing Center, Xi'an Jiaotong University and Tsinghua University.

6.1.4.2.2 China Research and Development Environment over the wide-area network - Crown Grid[29]

This project is from Jan. 2004 to Dec. 2007 and also receives 8 million RBM funding from the Natural Science Foundation of China. Currently it covers 6 sites and is also connected to the GLORIAD network.

CROWN (China Research and development environment Over Wide-area Network) is a Grid testbed that facilitates scientific research in different disciplines. The CROWN environment consists of three parts: [1] resources, including computers, clusters, and storage devices, interconnected via a nation-wide network infrastructure, [2] Grid middleware and tools to meet the common requirements of different scientific research activities in many different descilines, and [3] a number of applications to demonstrate the feasibility and robustness of CROWN. The current list of applications covers the areas of biology, astronomical observation, atmospheric physics, and digital museums.

[29] http://www.crown.org.cn/en/

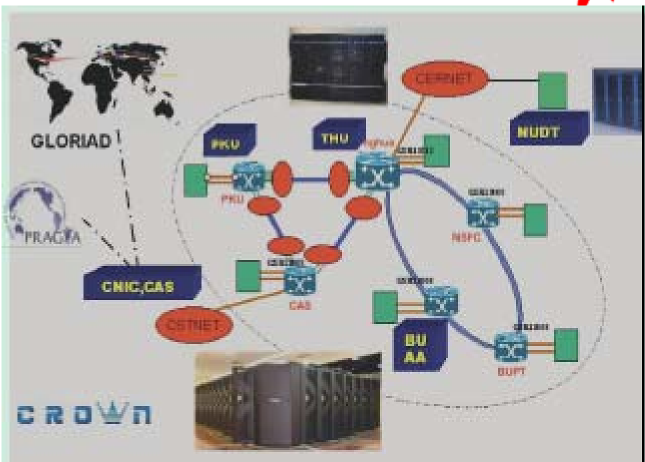

Figure: Crown Grid structure

6.1.4.3 *ChinaGrid*[30]

The China education and research Grid (ChinaGrid) was funded by the Ministry of Education. ChinaGrid is based on CERNET (China Education and Research Network), with a network backbone of 2.5Gbps DWDM and a total outgoing bandwidth outside of China of 800 Mbps. Its phase 1 is from 2003 to 2005, starting with 12 universities and growing to 20 by 2005, Up to now, the computing power aggregated by ChinaGrid has exceeded 15Tflops. And its storage capability also achieves 150TB.
ChinaGrid is supported by the CGSP (ChinaGrid Support Platform), which is the Grid middleware developed for this Grid project. The applications developed by ChinaGrid are in the following five areas: image processing, bioinformatics, on-line courses, computational fluid dynamics, and large-scale information processing.

Figure: ChinaGrid, Dec 2005.

30 http://www.chinagrid.edu.cn/

The middleware CGSP developed by ChinaGrid is based on OGSA and WSRF. Its first version (CGSP V1.0) was released on Jan 10 2005, developed by a joint team from Huazhong University of Science and Technology(HUST), Tsinghua University, Peking University, BUAA and Shanghai Jiaotong University.

Partners: 22 key universities, including:
Huazhong University of Science and Technology,
Tsinghua University,
Peking University,
Beihang University
South China University of Technology
Shanghai JiaoTong Unversity
South East University
Xi'an JiaoTong University
National University of Defense Technology
North East University
Zhongshan University
Shandong University
North West Polytechnical University
Zhejiang University
Fudan University
Tongji University
University of Science and Technology of China
University of Electronic Science and Technology of China
Renmin University of China
Lanzhou University

Contact: Prof. Hai Jin, hjin@hust.edu.cn

Starting date and duration: 2003 to 2005

Maximum national contribution: 20 million RMB from the Ministry of Education of China, 2 million from the 863 programme (via CNGrid)

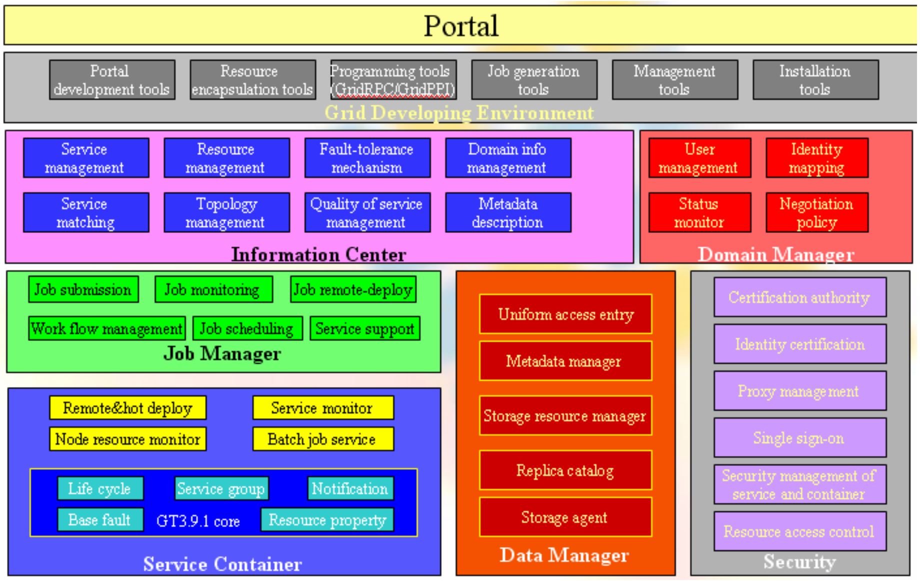

Figure: ChinaGrid's middleware CGSP Architecture

6.1.4.4 Asia Pacific Grid Policy Management Authority

The main role of a PMA is to coordinate a Public Key Infrastructure (PKI) to be used with Grid authentication middleware. The APGridMA is one of the three members of the International Grid Trust Federation (IGTF)[31] along with the European Grid PMA and the Americas Grid PMA.

The APGridPMA[32] was launched on the 1st June 2004, and by Feb 2007 had 13 members from the Asia Pacific region, including the Institute of High Energy Physics (IHEP) Beijing[33] representing China. There are now 6 production quality certification authorities in operation in the region.

6.1.5 Industrial Status in China

Chinese market outlook

The growth of china since its opening to the West has created a huge demand for the products, services and knowledge that Western companies can supply, especially those in the IT industry.

China attracts and concerns at the same time Western companies. In fact China offers no simple answers for foreign investors: making good decisions requires taking account of politics and culture, as well as economics. Its poor infrastructure and lack of familiarity with Western business norms mean that Western companies cannot

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31 http://www.gridpma.org/
32 http://www.apgridpma.org/
33 http://www.ihep.ac.cn/english/index.htm

make investment decisions and transfer their practices into China until events determine the geopolitical environment. Western enterprises have realized that investing in China means exposing themselves to a certain level of security risk — from politically motivated hackers, industrial espionage, arbitrary rule-making by China's bureaucracy and so on.

However, China's entry into the World Trade Organization (WTO) in late 2001 indicates its desire to be a serious global trading partner, but the country's policy of software protectionism undermines its sincerity. While this protectionist stance is not in violation of China's WTO membership, it does go against the spirit of the agreement. The government is a dominant IT consumer and should set an example, especially when China's top 100 companies are state-owned and likely to follow suit in support of government initiatives.

Key issues about IT in China

One of the main issues about the information technology sector in China is that of software licensing, privacy and security. China's traditional understanding of knowledge as free of charge for the common benefit has led to widespread piracy of software. Western enterprises have to guard the rights to their intellectual property (IP) created or deployed in China.

Just as an example, on 9 September 2004, China's National Copyright Administration (NCA) announced that Microsoft had recently filed complaints against three manufacturers — Beijing Zhong Xin Lian, Tianjin Tian Bao Gang Die and Tianjin Minzu Wenhua Guang Die — alleging that they had produced counterfeit versions of Microsoft products.

In the past few years, China — long known as a major violator of IP rights — has made substantial progress in fighting IP abuse. The Chinese government has brought its regulations up to international standards, and while it still has a long way to go, it has taken significant steps in enforcement. China is in fact following the path of the United States, Japan, South Korea and Taiwan, making the transition from being an intellectual property abuser to an intellectual property generator.

The Microsoft case has to be watched closely, because it should indicate how much progress China has really made in IP protection. Solid enforcement of IP rights in China will give investors greater confidence in China as a base for research and product development.

Protectionisms and open source software strategies

On 18 August 2003, Chinese and western media sources reported that, by year-end 2003, China’s State Council intends to mandate that all government ministries purchase only China-made software at the next upgrade cycle. The move is meant to support the local software industry and protect state information security. Those seeking exceptions will need to submit a special request.

In support of this "home grown" campaign, China is leveraging localized products from open-source software (OSS) and local vendors. This will likely stimulate growth in China's contribution to the OSS market, as China adapts products for its needs, returning the adaptations and enhancements to the community under the General Public License.

However, while this "China-made-only" policy may be feasible on desktops, it is not yet feasible in the enterprise application space. The intent may be to influence the desktop/office automation market, but a side effect that will be more difficult to manage is the purchasing of database, ERP, CRM and supply chain management products — categories in which the scarcity of local and OSS offerings will handicap government enterprises.

Open-source software is playing an increasing role in China's government IT systems. However, there are many hurdles to overcome before an open-source scenario can take hold in China and spark the country's IT industry. The main concerns over code quality and ownership must be resolved at worldwide level. As for GSM technology in the past, Grid technology is a promise to become a global technology, but before this happens, many technical and non-technical issues (which often present the most significant barriers to take up) must be resolved.

Chinese IT players are well willing to act in many EU Grid initiatives, but Chinese government intervention and support is strongly recommended in this context. The government has an important enabling role to play in helping the industry to exploit the potential of Grid technologies and to make sure that EU collaboration efforts are concerted and supported at national level. In particular, the advent of an open source scenario can foster the adoption of Grid technologies at commercial level, while at the moment Grid commercialisation is facing some difficulties in China.

IT vendors in China – partnerships

As stated above, at present there is a general scarcity of local software products in China. Some IT companies are getting involved in Middleware and SOA projects (e.g. Tongtech), but most IT industries are doing outsourcing business. Furthermore, very few Grid experiences at industrial level have become known to our study, however this specific issue will be constantly investigated throughout the EchoGRID project.

China is viewed by western enterprises as a fruitful land for IT investments, but just as important as what the business will do in China is finding the right partner. The government wants to develop strong domestic vendors and prefers that Western enterprises partner with Chinese companies to transfer specific business skills and approved technologies to them, as well as to develop global offers. This preference becomes a mandate for certain key markets, such as information technology and communications, although China's membership in the World Trade Organization (WTO) has loosen restrictions.

On 30 June 2005, China's Sino-India Cooperative Office announced that Chinese companies will partner with Microsoft and Tata Consulting Services (India) to establish a software services company to compete in Chinese and global markets. Operations are expected to start by early 2006. This partnership demonstrates the Chinese government's intention to strongly improve the country's software development capability and become a major force in the global software services industry. The success of this venture and the benefits it could bring for other providers could help propel China into a global-sourcing leadership position.

Grid industrial experiences

> *"The Grid market in China parallels the country's adoption of IT - relatively early stage, uneven, large-scale and poised for rapid growth" (Mr. Songnian Zhou, CEO and co-founder of Platform Computing).*

This quote of the CEO of Platform Computing, one of the main western companies doing business with Grid technologies in China, reveals that the adoption of Grid technology could be a great opportunity for the development of the Chinese economy. In particular, the lack of legacy IT infrastructures in China and the strong demand for business growth suggests to move rapidly to a distributed IT infrastructure such as Grid, instead of following the path of the Western countries (e.g. Client/Server architectures).

The Grid ecosystem in China is very different from that of the EU as described in the previous sections. We have conducted our study bearing in mind that Grid is more than just middleware vendors aimed at high power computing, and we have developed our research around the following lines:

- **University/research and Government**: the most remarkable Grid initiatives are from Universities and research organisations. The most important are evolving around the Chinese 863 and 973 programmes and other publicly funded projects. The 863 program is technology oriented to support the industry and economy, while the 973 program is more oriented to key scientific issues the country is facing and emphasizes fundamental research *(for a full reference on this, please see the section specifically dedicated to research experiences in China).*

- **Industry**: China is an important customer for international Grid industries. Our study has highlighted that currently China has no remarkable vendor companies in this specific field, but several industries have a high potential of becoming clients of Grid-based services, especially the manufacturing industry as described in the following point.

- **Business models**: Some western vendors are pushing the service side of the technology in order to meet this potential market. At present, Chinese providers offer Grid software and solutions as an open ASP to various organisations willing to consolidate their IT infrastructures and increase their productivity. *(this model will be further investigated during the EchoGRID project).*

As an example of this model we report the experience of **Shangai Supercomputer Centre**. The SSC partnered with Platform Computing to provide the ASP system infrastructure to its customers, including Grid portal for user access, workload processing capabilities, SLA (service level agreements), security and other IT related issues. SSC customers include General Motors Shangai R&D Center, Aviaton Industry Corporation of China and Baogang Steel Works (the iron and steel giant). This confirms that the Chinese manufacturing industry is emerging as a major adopter of IT and one of the biggest spenders.

An example of the industry adoption of Grid technologies in China is **Platform Computing**, an international "Grid oriented company" that sales its products and solutions over the world and that has a sale quarter in China too.

Two of the most important of Platform Computing's customers is the CNIC supported by the 863 program and the Shanghai Supercomputer Center (SSC) invested by the Shanghai Municipal Government for about RMB100 million and once ranked as the 14th most powerful computing system in the world. SSC is using Platform's Grid computing solutions in order to offer an open service support system, and to provide industry-driven high performance computing cluster services such as system monitoring and management, cluster management and license management for SSC's customers in industries including weather forecasting, geological exploration, genomic research and aerospace.

Other client industries of Platform Computing export solutions can be found in Industrial Manufacturing (one of the most important sectors in China), Oil & Gas, Electronics, Financial Services, Government, Life Science, telecommunications, Aviation and transports.

Voltaire (www.voltaire.com) is another interesting case. The company provides advanced interconnect solutions for High Performance Grid Computing and has strategic agreements with a big number of international partners as IBM, HP, SUN, NEC, SGI. Shanghai and Beijing universities are Voltaire's customer. Shanghai University has selected the Voltaire Grid Director ISR 9288 to deliver the ultimate interconnect performance to build up a supercomputer cluster. The cluster has a high bandwidth and low latency out of the box and is the number 209 in the top 500 list on November 2004.

Intel has an important project in Chinese Grid world too. The target is the Olympic Games in Beijing on 2008. The China's Ministry of Education (MOE) is building a Grid to connect 100 Chinese universities. This Grid will be used to help the "Digital Olympic" initiative to support the Olympic Games in Beijing. The performances will be very high with more than 15 teraflops and this system will be one of the world's most powerful high-performance computing grids.

In summary, various industries in China have targeted IT as the next major infrastructure effort, and Chinese market is considered a strategic environment by the Grid solution suppliers. However, there are no native Grid enterprises in China and no self made Grid network. These preliminary conclusions has been reached through in depth research into existing studies and reports (see bibliography) and through speaking with industry stakeholders, from Grid users to Grid vendors, as well as industries participating to Grid-related research projects.

All the views expressed in this study should be considered constructive, rather than critical.

6.2 European Grid Status

European Grid developments where initiated because of three main factors:

- The US research community was developing Grid systems, and Europe did not wish to be left behind
- The £2.5 billion LHC experiment at CERN in Geneva was planned to start in Nov 2007 producing 200Gb of data per second with a requirement for the data to be distributed and analysed.
- The vision of a computing utility into which users could plug small local appliances was judged to be a solution to the problems of rising software costs and increased need for interoperability of commercial computing systems.

The two lines of commercial development of Grid technology and the development of an academic research Grid infrastructure have developed in parallel with little interaction. Funding has been provided by national funding bodies and by the EU FP6 IST programme for both lines. Commercial R&D funding has also been provided by the major multinational vendors as well as niche SME and service companies.

6.2.1 Research Status in Europe

6.2.1.1 Identification of European Research Initiatives

Grid computing has emerged as an important new field, distinguished from conventional distributed computing by its focus on large-scale resource sharing, innovative applications, and high-performance orientation, and recently towards collaborative platforms and ubiquitous/utility computing. The numerous national Grid

initiatives in Europe and the Sixth Framework Programme (FP6) launched by the European Commission form a substantial critical mass of research institutes and industrial partners united around a joint research agenda on Grid technologies.
In the new Framework Programme (FP7), the F2 Unit on Grid technologies has been replaced by the Future and Emerging Technologies – Open Unit. Most of the active research projects funded by this former F2 Unit have been transferred to Unit D3 and F3.

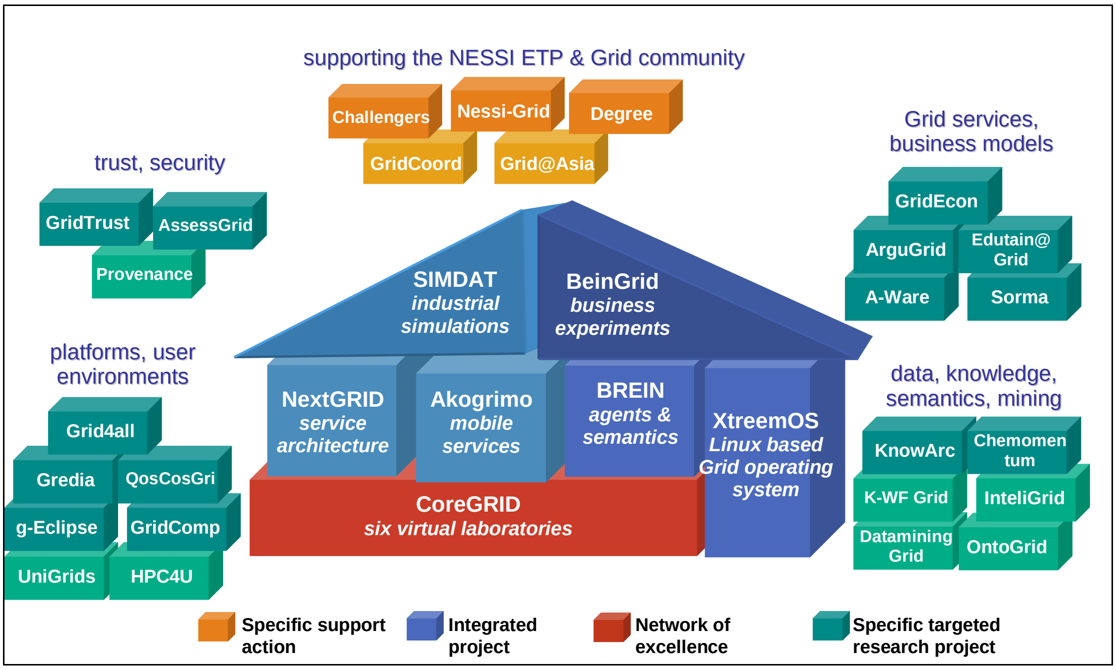

Figure: EU DG INFSO & Media, F2 unit portfolio

In the following paragraphs we provide details on the major European Research Initiatives that are ongoing or have been completed within FP6 or FP5 (mainly GRIA FP5 project due to its outcome – the GRIA[34] middleware).

6.2.1.2 BEinGRID – Business Experiments in Grid

The main objective of the Business Experiments in Grid (BEinGRID)[35] project is to foster the adoption of the so-called Next Generation Grid technologies by the realization of several business experiments and the creation of a toolset repository of Grid middleware upper layers.
BEinGRID undertakes a series of targeted business experiment pilots designed to implement and deploy Grid solutions in a broad spectrum of European business sectors (entertainment, financial, industrial, chemistry, gaming, retail, textile, etc).

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[34] http://www.gria.org/

[35] http://www.beingrid.com/

Eighteen business experiments are planned in the initial stage of the project with a second open call for proposals in the latter stages. Secondly, a toolset repository of Grid service components and best practise will be created to support European businesses that wish to take-up the Grid. To minimise redevelopment of components, BEinGRID deploys innovative Grid solutions using existing Grid components from across the European Union and beyond.

6.2.1.3 BREIN – Business objective driven REliable and Intelligent grids for real busiNess

BREIN[36] is a project that aims into taking the e-business concept developed in other Grid research projects and namely the concept of so-called "dynamic virtual organisations" towards a more business-centric model, by enhancing the system with methods from artificial intelligence, intelligent systems, semantic web etc. Thus, the BREIN project will enable business participants to easily and effectively use Grid technologies for their respective business needs.

Most current Grid solutions show little or no focus on the business needs of organisations and/or individuals, thus making it difficult for these entities to adapt their services accordingly to meet these goals. This is partially due to the complex structure of these frameworks, and partially due to the lacking support for abstract issues, as these Grid frameworks generally focus on the virtual organisation and not on the individual entity. The BREIN project aims at compensating these deficiencies by taking a more "user-centric" approach towards a framework, thus increasing interest in Grid frameworks and decreasing integration effort:

6.2.1.4 CoreGRID

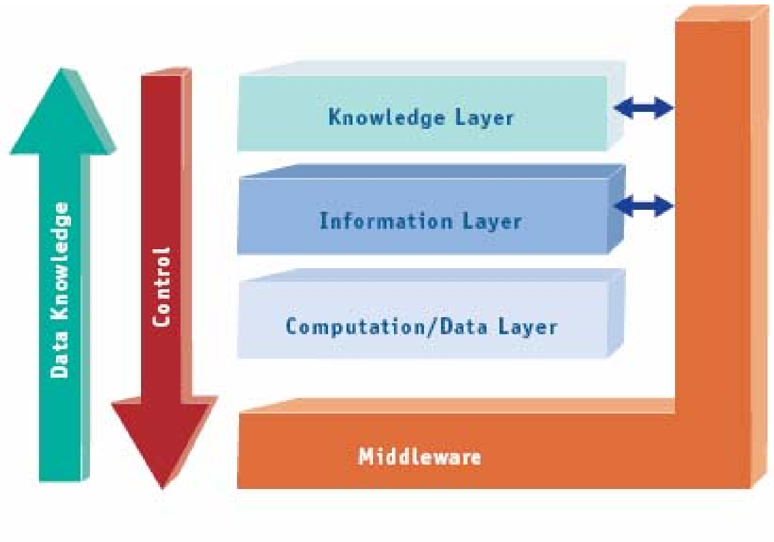
CoreGRID[37] is a European "Network of Excellence" (NoE). The network aims at strengthening and advancing scientific and technological excellence in the area of Grid and Peer-to-Peer technologies. The Network brings together a critical mass of well-established researchers (119 permanent researchers and 165 PhD students) from forty-two institutions that have constructed an ambitious joint programme of activities. This joint programme of activity is structured around six complementary research areas (Virtual Institutes) that have been selected on the basis of their strategic importance, their research challenges and the recognised European expertise to develop next generation Grid middleware, namely:

- Knowledge & data management
- Programming models
- System architecture
- Grid information resource and workflow monitoring services
- Resource management and scheduling
- Grid systems, tools and environments.

[36] http://www.eu-brein.com/

[37] http://www.coregrid.net/

These research areas have been selected on the basis of their strategic importance, their research challenges and the European expertise in these areas to develop next generation grids.
The Network is operated as a European Research Laboratory (known as the CoreGRID Research Laboratory) having six virtual institutes mapped to the areas that have been identified in the joint programme of activity. The Network is thus committed to set up this Laboratory and to make it internationally recognised and sustainable.



CoreGRID vision of the Next Generation Grid

6.2.1.5 EGEE, Enabling Grids for E-sciencE

EGEE[38] is a FP6 project with the aim of building on recent advances in Grid technology and developing a service Grid infrastructure which will be continually available. The project will primarily concentrate on three core areas:

- The first area is to build a consistent, robust and secure Grid network that will attract and incorporate additional computing resources on demand.
- The second area is to continuously improve and maintain the middleware in order to deliver reliable services to users.
- The third area is to attract new users from industry as well as science and ensure they receive the high standard of training and support they need.

Two pilot application domains were selected to guide the implementation and certify the performance and functionality of the evolving infrastructure. One is the Large Hadron Collider Computing Grid supporting physics experiments and the other is Biomedical Grids, where several communities are facing equally daunting challenges to cope with the flood of bioinformatics and healthcare data. At present there are more than 20 applications from 10 domains on the EGEE Grid infrastructure such as Astrophysics, Computational Chemistry, Earth Sciences, Financial Simulation, Fusion etc.

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[38] http://public.eu-egee.org/

Currently, the Grid infrastructure deployed runs with its own middleware stack, gLite and of over 20,000 CPU in addition to about 10 Petabytes (10 million Gigabytes) of storage, and maintains 20,000 concurrent jobs on average.

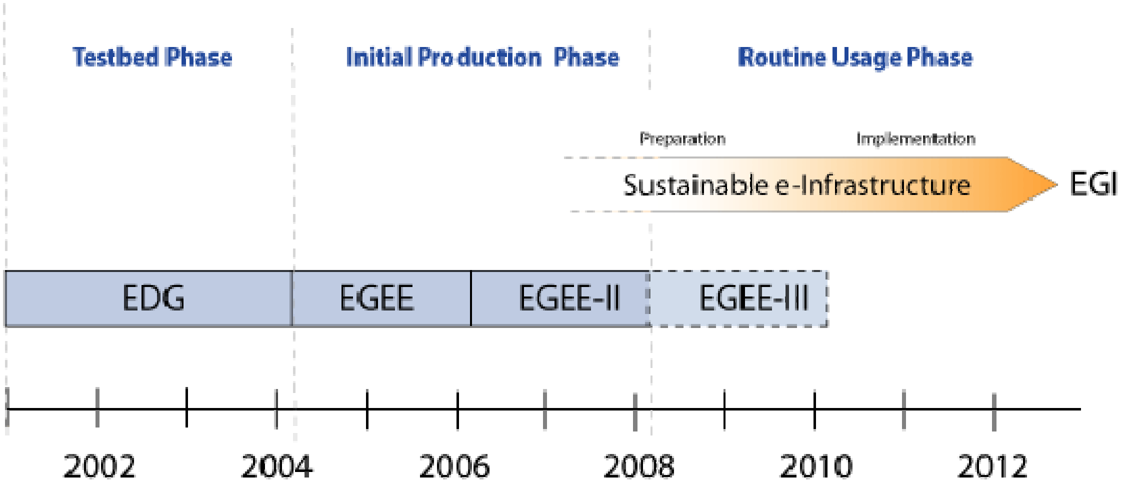

Figure: The timeline of the series of EGEE projects funded by the EC and the planned implementation of a sustainable infrastructure as the EGI.

The EGEE project is responsible for the development and maintenance of the gLite Grid middleware which it deploys.

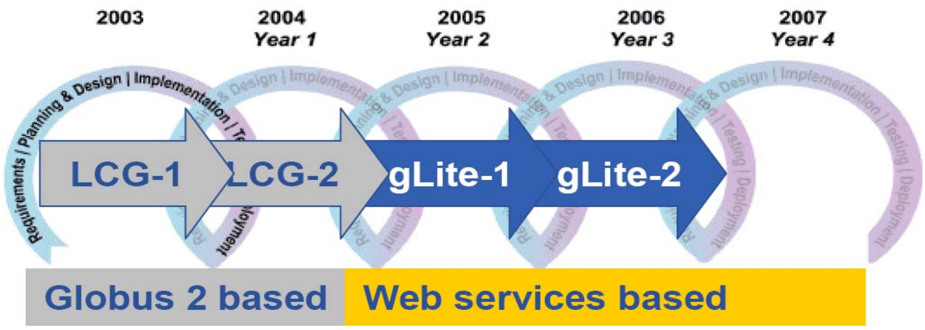

Figure: The evolution of the EGEE Grid middleware

The gLite software includes components from several other developers, which in turn usually include parts of the Globus Toolkit (GTk). GTk version 1.0 was released in 1998, V2.0 in 2002, V3 in 2004, and V4 in 2005. 2004 saw the formation of Univa Corporation, a company devoted to providing commercial support for Globus software, and 2005 the creation of the Globus Consortium by a group of companies with an interest in supporting Globus Toolkit enhancements for enterprise use.

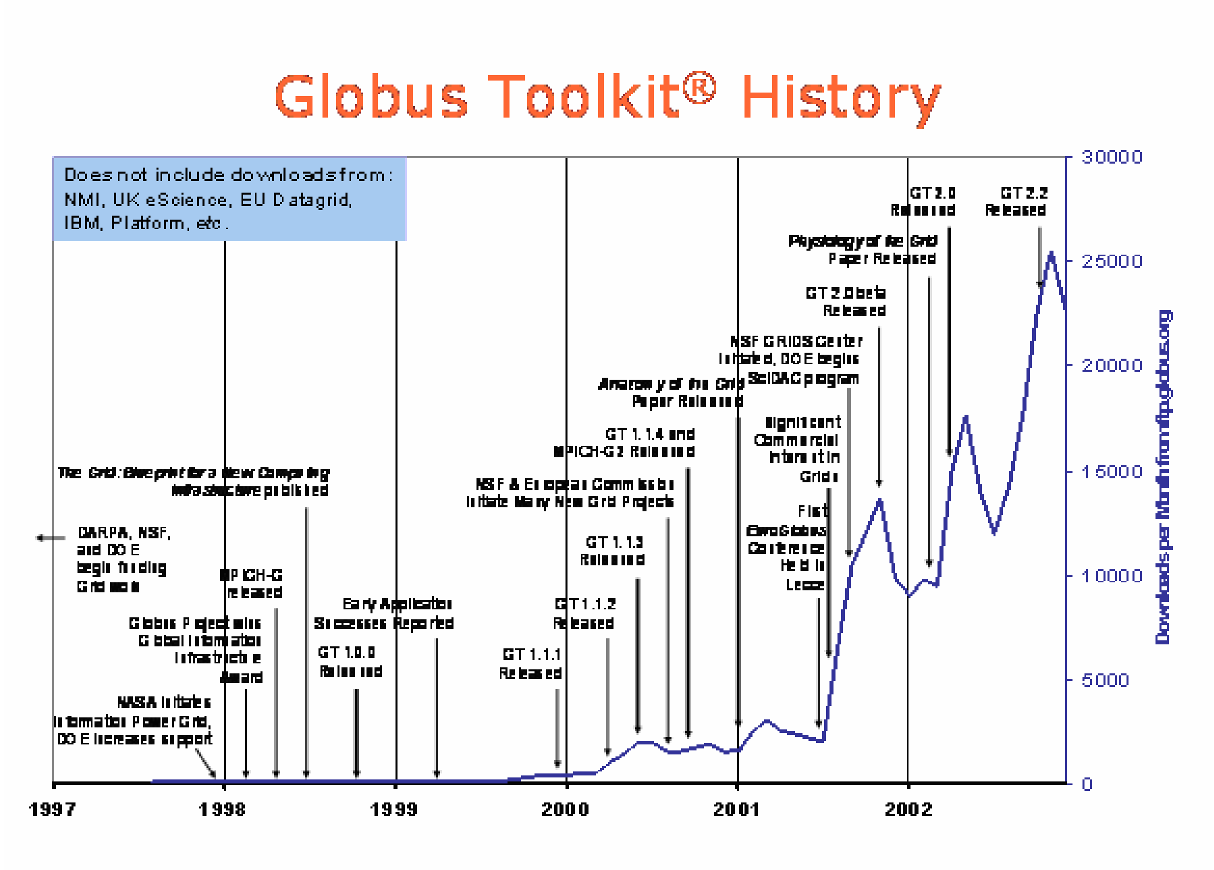

Figure: Significant events for the globus toolkit.

Part of the complex inter-relationship of the different software is shown in the figure below. One confusion that arises, is that each group packages and develops its own software, and usually operates a Grid that uses the software. For example, NorduGrid is part of the LHC Computing Grid (LCG) although it runs its own Grid middleware and neither gLite, nor the LCG middleware.

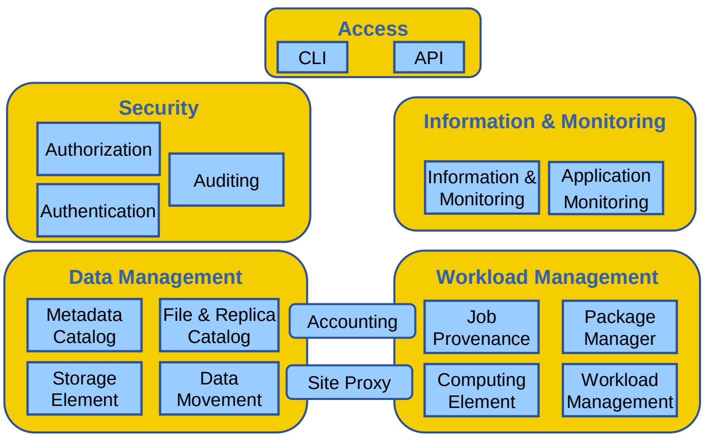

Figure: gLite middleware services, May '07

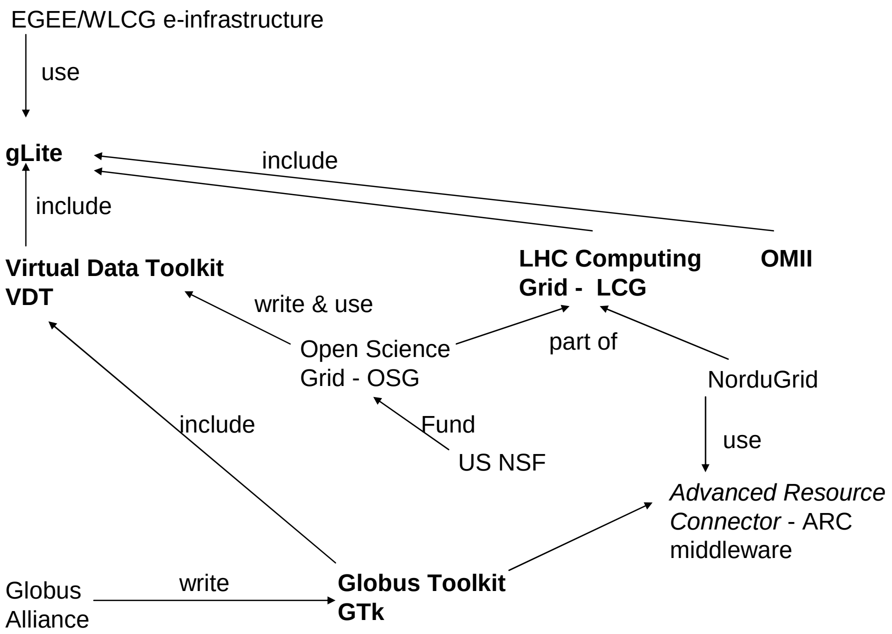

Figure: some of the dependencies between the major Grid toolkits

One result of this successive addition to the basic Globus toolkit is that there is a progressive reduction in the range of the operating systems over which the final Grid middleware will operate. Wheres Globus will operate over Unix and Windows operating systems, the only operating system currently supported by gLite 3 is Scientific Linux 3.

6.2.1.6 Akogrimo – Access to Knowledge through the Grid in a Mobile World

Akogrimo [39] is a FP6 funded Integrated Project aiming to radically advance the pervasiveness of Grid computing across Europe. In order to achieve this goal, in addition to embracing layers and technologies which are supposed to make up the so-called Next Generation Grids such as e.g. knowledge-related and semantics-driven Web services, Akogrimo architects and prototypes a blueprint of an NGG which exploits and closely co-operates with evolving Mobile Internet infrastructures based on IPv6. Strategically, these infrastructures are considered as the Beyond-3G enabler.

- From a technical point of view, Akogrimo especially leverages mobility, QoS, AAA and security functionalities provided by corresponding network-related middleware systems of such infrastructures. However, pursuing this goal, Akogrimo addresses at the same time issues unresolved so far concerning 'mobile and pervasive services in the Internet world' by looking at the Grid and Internet with an integrative architectural view.
- From a user's point of view, Akogrimo provides the technologies and concepts to establish a 'virtual home', with nomadic and mobile environments for solving complex problems across network technology and provider domains. In generalizing the core Grid concept – namely the resource-sharing concept - Akogrimo patterns these environments as 'Mobile Dynamic Virtual Organizations'. The MDVO concept will incorporate network-identity-based concepts of personalization, profiling, privacy, security and trust.
- From the provider's point of view, an Akogrimo world provides new business models and opportunities eventually making commercially viable NGGs a reality.

6.2.1.7 XtreemOS

The XtreemOS [40] project aims at investigating and proposing new services that should be added to current operating systems to build Grid infrastructure in a simple way. XtreemOS targets the Linux well-accepted open source operating system extending it to Grid with native support for virtual organizations.
A set of operating system services, extending those found in the standard Linux distribution, will provide Linux users with all the Grid capabilities associated with current Grid middleware, but fully integrated into the OS. The underlying Linux OS will be extended as needed to support virtual organizations spanning across many machines and to supply appropriate interfaces to Grid OS services.
Installed on each participating machine (personal computer, cluster of workstations, mobile devices), the XtreemOS system will provide for the Grid what a traditional

[39] http://www.mobilegrids.org/

[40] http://www.xtreemos.eu/

Operating System offers for a single computer (e.g. abstraction from the hardware, secure resource sharing between different users etc). By integrating Grid capabilities into the Linux kernel, XtreemOS will also provide a more robust, secure and easier-to-manage infrastructure for system administrators.

6.2.1.8 NextGRID – Architecture for Next Generation Grids

The NextGRID[41] project is another Integrated Project funded by FP6. The goal of NextGRID is the architecture that will lead to the emergence of the Next Generation Grid. This will prepare the way for the mainstream use of Grid technologies and their widespread adoption by organizations and individuals from across the business and public domains. This widespread use will be a significant step towards meeting the vision of the European Research Area and the goals of the e-Europe Action Plan. This project will seek architectural solutions that streamline all aspects of Grid operation: installation and maintenance of the infrastructure, development and deployment of Grid applications, user orchestration of the resulting resources, and operation of business models and processes through which the use of Grid technology can be made economically viable.

6.2.1.9 HPC-Europa – High Performance Computing for Europe

HPC-Europa[42] is a FP6 project aiming at the integrated provision of advanced computational services to the European research community working at the forefront of science. The services were delivered at a large spectrum both in terms of access to HPC systems and provision of a suitable computational environment to allow the European researchers to remain competitive with teams elsewhere in the world. Moreover the Research Activities and Networking Activities actions contribute to foster a culture of cooperation to generate critical mass for computational activities, to drive new advance in HPC allowing so to better structure the European Research Area.

Though this may entail the development of additional computing services to support this Grid portal the JRA2 primary aim will be to build a reliable end-user environment for HPC-Europa consumers. This end-user environment should simplify the use of Grids on the one hand, and on the other make it easy to plug-in new services and functionality. Users will be provided with a friendly and easy to use interface by allowing them to interact with these services through standard means such as a web-browser. So, the Grid portal acts as an intermediary between users and Grid resources and resources themselves

[41] http://www.nextgrid.org/

[42] http://www.hpc-europa.org/

6.2.1.10 SIMDAT

SIMDAT[43] is a FP6 project that aims at developing generic Grid technology for the solution of complex application problems and using this new technology in several industrial application sectors. The strategic objectives are:

- to test and enhance Data Grid technology for product development and production process design,
- to develop federated versions of problem-solving environments by leveraging enhanced Grid services,
- to exploit Data Grids as a basis for distributed knowledge discovery,
- to promote defacto standards for these enhanced Grid technologies across a range of disciplines and sectors,
- to raise awareness for the advantages of Data Grids in important industrial sectors.

6.2.1.11 TRUSTCOM

TRUSTCOM[44] is a FP6 Integrated Project that produced and implemented a framework for Trust, Security and Contract Management enabling secure collaborative business processing in on-demand, self-managed, scalable, and highly dynamic Virtual Organisations (VO). This allows companies and other business entities (including individuals) to securely share resources like computation, data, information and services across enterprise boundaries in order to collectively exploit market opportunities or provide services, which the participants could not tackle by themselves. The framework defines the business relationships in a contractual agreement where the schedules covering the collaborative business process models, service level agreements, reputation requirements on partners, and access control policies are enforced by the software environment hosting the collaboration. It is mainly based on open WS standards, and the results include 14 patents applied for by Microsoft, IBM, SAP and BT who will incorporate the results into their enterprise products.

[43] http://www.scai.fraunhofer.de/simdat.html

[44] http://www.eu-trustcom.com/

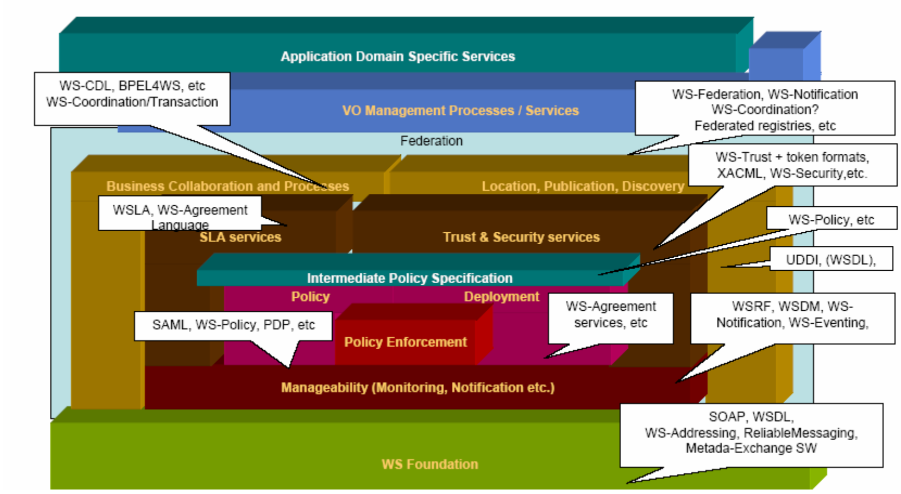

Figure: A component architecture to support the TrustCoM framework for security, trust and contract management of dynamic VO.

6.2.1.12 Ontogrid

Ontogrid[45] is a FP6 project that makes a number of contributions to architecture in three broad areas: Semantics, P2P and Agents. The operation of the Grid middleware itself is dependent on the capturing and harnessing of metadata, as well as the metadata required for the Grid applications themselves. The aim of the Semantic Web is to explicitly expose metadata relating to Web resources to better support intelligent agents. The Semantic Grid aims to follow a similar path in the Grid setting. The key focus of the OntoGrid project is in this provision of semantics -- the development of intelligent middleware, the use of explicit metadata, ontologies and semantics for discovery, matchmaking and the exploitation of Semantic Web technologies for metadata management. To that end, OntoGrid provides Semantic Grid Architectures.

6.2.1.13 InteliGrid - Interoperability of Virtual Organizations on a Complex Semantic Grid

The InteliGrid project[46] is extending the semantic Grid paradigm to support dynamic virtual organizations (VO) that collaborate on the design, production and maintenance of products that are described in complex, structured, product model databases. Such VOs are typical for industries with long and dynamically changing supply chains like automotive, shipbuilding and aerospace. Perhaps the most complex VOs are in architecture, engineering and construction. Semantic interoperability of software and information systems belonging to members of the VO is essential for efficient collaboration within the VO.

[45] http://www.ontogrid.net/ontogrid/index.jsp

[46] http://www.inteligrid.com/

The main result of the project is the generic business-object-aware extensions to Grid middleware, implemented in a way that would allow grids to commit to an arbitrary ontology. These extensions are propagated to toolkits that allow hardware and software to be integrated into the Grid. The demonstration will show the next generation of key engineering collaboration software using the inteliGrid middleware – an ontology service, a product model database server, a project Web collaboration service and characteristic computer aided design software.

6.2.1.14 ELEGI – European LEarning Grid Infrastracture

ELeGI[47] is an on going FP6 IP project aiming to progress effective human learning by promoting, supporting and validating an innovative learning paradigm shift. One of the expected results is the definition and design of a distributed domain-specific service oriented architecture based on a Grid middleware to support the proposed learning process.

6.2.1.15 GRIA - Grid Resources for Industrial Applications

The GRIA project 0, funded in the FP5, had the aim of implementing an application testbed, incorporating the innovative Grid infrastructure services described above, and evaluating it against a range of distinctive data and process intensive applications. The starting point will be an existing open-source Grid infrastructure. The project produced end-to-end Quality of Service models, based on previous work on Grid performance modelling, and support for secure manageable end-to-end business processes for outsourcing and settlement. The project also developed plug-in services for this, creating an effective testbed for industrial use, through technology developments in three key areas:

- Quality of Service: end-to-end performance and service level estimation, and service level management facilities based on mapping (i.e. scheduling) of applications onto resources
- Interoperability: implementation of system and application resource definition, interaction and discrimination services, according to emerging standards
- Business processes: software support for generic Grid business models and processes and integration of PKI technology to support the structured, secure interactions needed between users and suppliers of Grid resources and services.

The final outcome of this project is the GRIA middleware which is continually updated with new features / services.

6.2.1.16 Next Generation Grid Expert Group

The Next Generation Grid Expert Group (NGG) is a panel of experts convened by the EC. The purpose of their meetings and discussions was to identify potential research

[47] http://www.elegi.org/

priorities for the Next Generation Grid. In order to ensure a comprehensive and consistent outcome, experts were invited from across the spectrum of relevant fields.
The Expert Group's Terms of reference were to:

- Identify research priorities for the next 5-7 years and propose pragmatic steps to be taken;
- Propose a roadmap for the implementation of these steps (in view of upcoming calls for proposals);
- Align technology priorities and means of implementation with policy objectives, e.g. European Research Agenda, European Centres of Excellence, etc.;
- Network/liaise and discuss findings with the Grid research community;
- Propose actions to increase efficiency in international collaboration.

The Expert Group was to produce a report in line with the objectives defined above.

In July 2004, the extended expert group for Next Generation Grids (NGG2), selected by the European Commission, has issued a report titled "Next Generation Grids 2: Requirements and Options for European Grids - Research 2005-2010 and Beyond". This report builds on the earlier findings of the NGG report 2003 and the experience gathered since in the first EU-funded Grid projects of the Fifth Framework Programme. In conjunction with the NGG report 2003, the new report establishes a European vision and technological requirements towards the realisation of the "invisible Grid", offering key features for a service-orientated knowledge utility, a new paradigm for software and service delivery, for the next decade, according to the NGG2 expert group. The goal of the NGG2 report is to develop a coherent programme of research activities, complemented by industry-driven initiatives such as public-private partnerships to enhance the European position in Grid technologies within the Sixth and upcoming Seventh Framework Programmes.

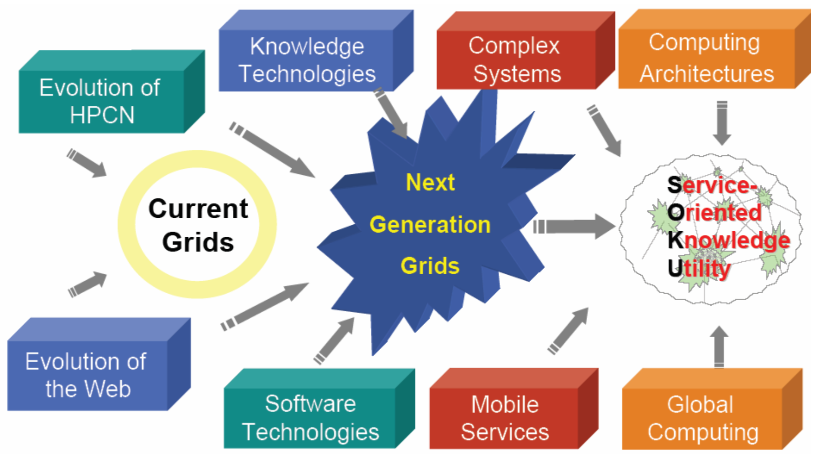

Figure: The evolution of the SOKU vision proposed by the NGG3 Expert Group.

6.2.1.17 The NESSI European Technology Platform

NESSI (Networked Software and Service Initiative)[48] was launched in September 2005 by 13 key European stakeholders in Software and Services. It is the Networked European Software and Services Initiative, an industry-led Technology Platform that aims to provide a unified view for European research in Services Architectures and Software Infrastructures by:

- Developing a visionary strategy for software and services driven by a common European Research Agenda, where innovation and business strength are reinforced by
- Providing European Industry and the Public Sector with efficient services and software infrastructures to improve flexibility, interoperability and quality
- Mastering complex software systems and their provision as service oriented utilities
- Establishing the technological basis, the strategies and deployment policies to speed up the dynamics of the services eco-system
- Developing novel technologies, strategies and deployment policies that foster openness, through the increased adoption of open standards and open source software as well as the provision of open services
- Fostering safety, security and the well-being of citizens by means of new societal applications, enhanced efficiency of industry and administrations, and competitive jobs

NESSI operates in the context of a wide continuum of information and communication technologies, and envisages close collaboration with other global research initiatives. NESSI already agreed to fully adopt the NGG group vision and discussion started with the CoreGRID Network of Excellence.

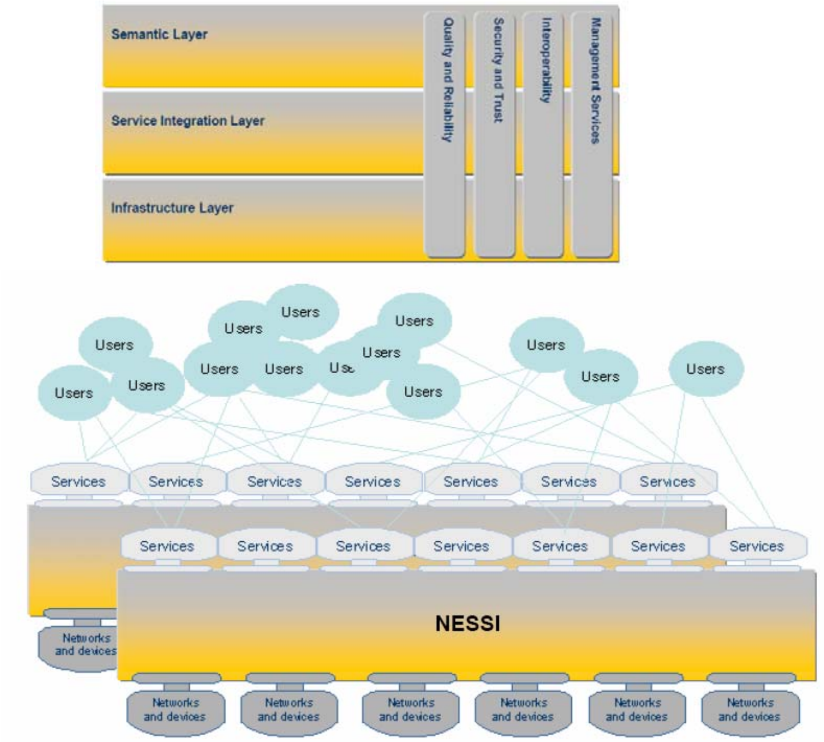

Figure: Two views of the NESSI vision of the E2E service oriented architecture

[48] http://www.nessi-europe.com/Nessi/

6.2.1.18 NESSI-Grid

NESSI-Grid is a Specific Support Action with the objective of contributing to the activities of the NESSI technology platform with a specific focus on the next generation Grid technologies that will foster the provision of IT Services as utilities. The NESSI-Grid project will help industry, research organisations, public authorities, financial institutions and other stakeholders across the EU to join forces and coordinate their actions for the contribution of Grid and service architecture strategies to NESSI's Strategic Research Agenda (SRA) and their implementations. While the SRA contribution constitutes a key component of NESSI-Grid, the project will also address related structural, educational, and regulatory matters (standards, IPR, research infrastructure, training). The main goals and activities pursued by NESSI-Grid are to:

- actively assist and support those working groups initiated by the NESSI European technology platform that will elaborate, maintain and monitor a common target SRA, contributing to the technology pillar of 'Software, Grids, Security and Dependability' as defined in the seventh research framework programme
- involve SMEs and link with current ERA-Net initiatives and with the international scientific community, thereby gathering experts in the domain and promoting participation of new players
- investigate the requirements, in both technical and business domains, for large research infrastructures in Europe
- support the development of Grid and IT utilities business domains, investigating user needs and ways of satisfying them in close cooperation with the Grid, service oriented architectures and IT utilities stakeholders
- promote (in cooperation with NESSI and with existing bodies) the required standardisation actions as business drivers, especially in the field of regulations, to support business process interoperability.

6.2.1.19 CHALLENGERS

CHALLENGERS Specific Support Action[49] aims to provide the organizational and administrative framework that will support the gathering and consultation work of a group of experts from the research and business community with well established experience and deep knowledge in the area of Grid technologies. The focus of the consultation work performed by the proposed group of experts will be:

- The Forward Looking Technologies (FLT) related to the Grids, as well as to their association and dependency with the advances with other well established or emerging ICT (Information and Communication Technologies)
- The Vision and Challenges in the area of Grids encountered by the Community for the coming decade

[49] http://www.challengers-org.eu/

- The potential impact of the realization of the Vision in the industrial and business sector

The expected outcome that will be delivered by the CHALLENGERS working group, as a result of the aforementioned work and of the activities performed within the frame of the project will be to:

- Investigate enabling technologies and market trends against the mainstream focusing also on holistic view and complementarity or converging disciplines;
- Consolidate and describe the vision of the research community for the Grids technology for the coming decade
- Increase awareness of the next decade vision for Grids among researchers of different but complementary or converging disciplines
- Introduce and recommend a Research Agenda and a roadmap of key technology challenges
- Assess the business, economic and societal impact contributed by tomorrow's Grid technology, in conjunction and convergence with other key ICT
- Address the needs of critical infrastructures, public safety and security applications and life improvement.

6.2.1.20 DEGREE - Dissemination and Exploitation of GRids in Earth sciencE

DEGREE[50] is a project aiming to build a bridge linking the ES and Grid communities throughout Europe, and focusing in particular on the EGEE-II Project. An ES applications panel with a range of candidate applications suitable for porting to Grid will make sure key ES requirements for porting and deployment on the Grid middleware are identified, communicated and discussed within the Grid community. At the same time the DEGREE SSA will ensure the ES community is informed and up to date on Grid developments and potential benefits.

The results will provide feedback to the Grid community and dissemination in the ES community will increase awareness of and involvement with Grid developments.
In order to ensure that ES requirements are taken into account in the next Grid generation, DEGREE will initiate different collaborations; at short, medium and long term via EU horizontal collaborations, specific collaboration with Grid projects and participation to the e Infrastructure Reflection Group (e-IRG). The main objectives of the project are the following:

- Disseminate, promote uptake of Grid in wider ES community
- Reduce the gap between ES users and Grid Technology
- Explain and convince ES users of Grid benefits and capability to tackle new and complex problems.

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[50] http://www.eu-degree.eu/

6.2.1.21 EUGridPMA[51]

The EUGridPMA is the international organisation to coordinate the trust fabric for e-Science Grid authentication in Europe. It collaborates with the regional peers APGridPMA for the Asia-Pacific and The Americas Grid PMA in the International Grid Trust Federation.

The EUGridPMA itself does not issue certificates. It coordinates national and regional authorities that do the actual certificate issuing to end entities. The map below shows the European countries which host certificate issuing authorities.

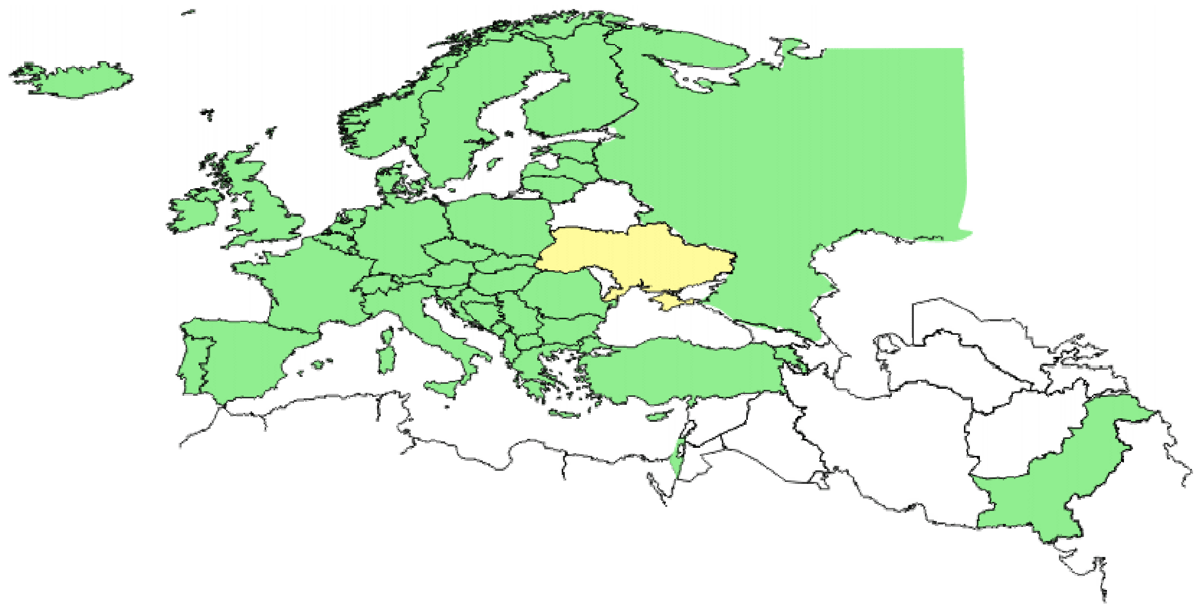

Figure: The countries which host certificate issuing authorities are shown in green

The table below lists all members (both issuing authorities and relying party members) of the EUGridPMA.

Member	Representative
ArmeSFo CA	Ara Grigoryan *Alternate:Arsen Hayrapetyan*
GridCanada CA	Darcy Quesnel
CERN	Alberto Pace *Alternate:Emmanuel Ormancey*
CERN CA (discontinued)	Ian Neilson *Alternate:Maria Dimou*
CNRS Grid-FR	Sophie Nicoud *Alternate:Edith Knoops*
CNRS Projets	*no member, root CA for Grid-FR*

51 http://www.eugridpma.org/members/worldmap/

CNRS Top	*no member, root CA for CNRS-Projets*
CyGrid CA	Kyriacos Neocleous *Alternate:Yiannis Ioannou*
CESNET	Milan Sova
DutchGrid CA	David Groep PGP KeyID 0x6F298418
GermanGrid CA	Ursula Epting PGP KeyID 0x114BAFF3 *Alternate:Ingrid Schaeffner*
HellasGrid CA	Christos Kanellopoulos *Alternate:Christos Triantafyllidis*
Grid-Ireland	Brian Coghlan *Alternate:David O'Callaghan*
INFN CA	Roberto Cecchini
IUCC CA	Erez Etzion *Alternate:Eddie Aronovich*
NorduGrid	Anders Waananen
PolishGrid	Pawel Wolniewicz
LIPCA	Jorge Gomes *Alternate:Nuno Dias*
RussianDataGrid CA	Lev Shamardin
SlovakGrid	Jan Astalos *Alternate:Hiroslav Dobrucky*
DataGrid-ES	Rafael Marco
UK e-Science CA	Jens Jensen
DoeGrids CA	Mike Helm *Alternate:Bob Cowles*
ESnet Root CA	*no member, root CA for DOEGrids*
Belnet Grid CA	Pascal Paneels *Alternate:Rosette Vandenbroucke*
Grid-PK	Mehnaz Hafeez *Alternate:Usman Ahmad Malik*
SIGNET (Slovenia)	Borut Kersevan *Alternate:Jan Jona Javorsek*
SEE-Grid Regional	Christos Kanellopoulos *Alternate:Christos Triantafyllidis*
Estonian Grid	Lauri Anton *Alternate:Andi Hektor*
RMKI (Hungary, dis.)	Jozsef Kadlecsik
Austrian Grid CA	Willy Weisz
SWITCH	Kaspar Brand *Alternate:Christoph Graf*
NIIF/HungarNet	Tamas Maray *Alternate:Ede Feher*
DFN (GridGermany)	Marcus Pattloch

	Alternate:Reimer Karlsen-Masur
RDIG	Eygene Riabinkin *Alternate:Lev Shamardin*
BalticGrid CA	Lauri Anton
TR-Grid CA (ULAKBIM)	Asli Zengin
pkIRISGrid	Javi Masa *Alternate:Diego Lopez*
SRCE (Croatia)	Dobrisa Dobrenic *Alternate:Ivan Maric*
BG.ACAD	Luchesar Iliev *Alternate:Stanislav Spasov*
SWITCHaai SLCS	Christoph Witzig *Alternate:Kaspar Brand*
AEGIS	Dusan Radovanonic
Member	**Representative**
The DEISA Project	Jules Wolfrat *Alternate:Vincent Ribailler*
The Enabling Grids for e-Science in Europe (EGEE) Project	David Groep
The LHC Computing Grid Project	Dave Kelsey
The SEEGRID Project	Nikos Vogiatzis *Alternate:Fotis Karayannis*
TERENA TACAR	Licia Florio *Alternate:Diego Lopez*
Open Science Grid Security Technical Group	Bob Cowles *Alternate:Don Petravick*

6.2.2 National Grid Initiatives

In addition to EU funding, most European nations have also funded national Grid initiatives, and indeed the funding from member states of the EU has been greater than that from the EU itself as shown in the figure and table below.

In order to ensure a sustainable Grid infrastructure, the member state funding is generally believed to require co-ordination and the National Grid Initiatives (NGI) will require integration through a central European Grid Initiative (EGI) which will be supported by contributions from the member states.

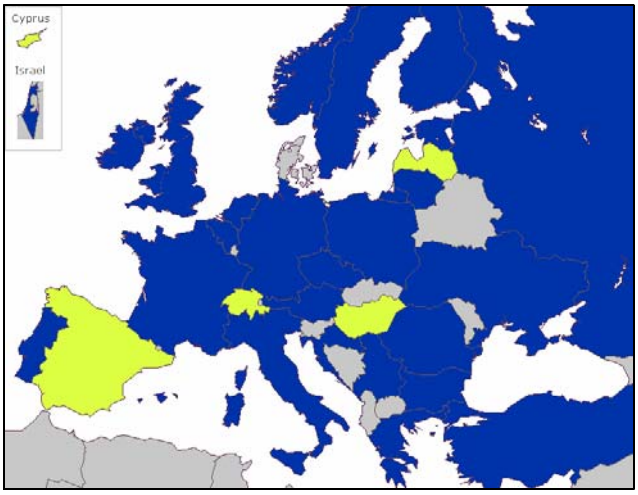

Figure: National Grid initiatives in Europe (Blue: NGI, Green: No NGI, Gray: No data).

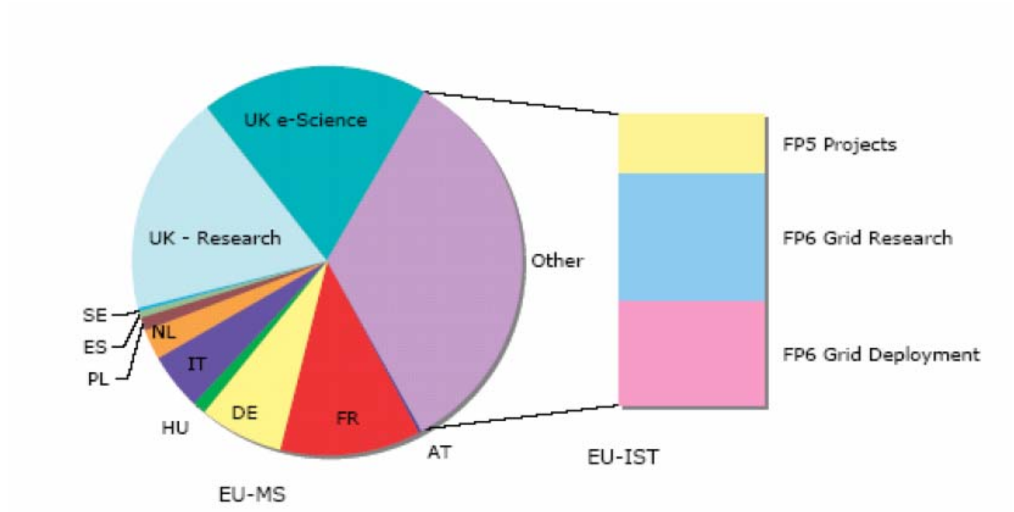

Figure: Approximate funding 2002-2006 in M€ by EU member states and the EU IST programme (R&D)[52].

[52] GridCoord project, achievement sheet, ftp://ftp.cordis.europa.eu/pub/ist/docs/grids/gridcoord-interim-sheet_en.pdf

Countries	million EUR
AT	2,7
FR	98,3
DE	58,8
HU	8,6
IT	40,7
NL	20,0
PL	9,1
ES	4,5
SE	2,3
UK - research	155,0
UK e-Science	158,0
FP5 projects	58,0
FP6 Grid deployment	100,0
FP6 Grid research	125,0
Total	841,0

Table: Approximate funding 2002-2006 in M€ by EU member states and the EU IST programme (R&D).

In the following table we cite the national Grid initiatives per country[53]:

Country	**National Grid Initiative**
Austria	Austrian Grid Initiative http://www.austriangrid.at
Belgium	BEgrid http://www.begrid.be/
Bulgaria	Bulgarian Grid Consortium, BGGC, http://www.Grid.bas.bg/consortium.htm
Croatia	CRO-Grid http://www.srce.hr/crogrid/
Czech Republic	METACentrum http://meta.cesnet.cz
Estonia	Estonian Grid, working under Estonian Educational and Research Network (EENet) http://Grid.eenet.ee
Finland	CSC – Scientific Computing Ltd., www.csc.fi
France	EGEE-France
Germany	D-Grid, https://www.d-Grid.de/index.php?id=1&L=1
Greece	HellasGrid, HG, www.hellasgrid.gr
Ireland	Grid-Ireland http://www.Grid.ie/
Israel	Israel Academic Grid (IAG) http://iag.iucc.ac.il
Italy	Italian Grid Infrastructure, IGI, http://www.italiangrid.org
Lithuania	Lithuanian Grid LitGrid http://www.litgrid.lt
Netherlands	Netherlands National Science Grid, internally known as BIGGRID project
Norway	Norwegian Grid (NorGrid), www.norgrid.no Nordic Data Grid Facility (NDGF),

[53] EGEE-II, Status and Perspectives of National Grid Initiatives, EU Deliverable: DNA5.1

	www.ndgf.org
Poland	PIONIER - Polish Optical Internet - Advanced Applications, Services and Technologies for the Information Society A national programme
Portugal	Iniciativa Nacional Grid - INGRID
Romania	Acronym: RoGrid URL: www.rogrid.ro
Russia	Russia National Grid Initiative (RuNGI), no URL yet
Serbia	Academic and Educational Grid Initiative of Serbia AEGIS http://aegis.phy.bg.ac.yu
Sweden	Swedish Grid, SweGrid, http://www.swegrid.se/ and http://www.snic.vr.se/
Turkey	TR-Grid National Grid Initiative, TR-Grid NGI http://www.Grid.org.tr
UK	UK National Grid Service www.ngs.ac.uk
Ukraine	UAGI - Ukrainian Acadenic Grid Initiative

Table: National Grid Initiatives

There is considerable variation in the middleware used across national grids in Europe. Although they are based on the Globus or gLite components, they have made local modifications and extensions to promote their local interests.

One example is the Austrian Grid where the local interests are in visualisation, and the middleware has been modified to incorporate the Grid Visualisation Kernel on which applications can be built.

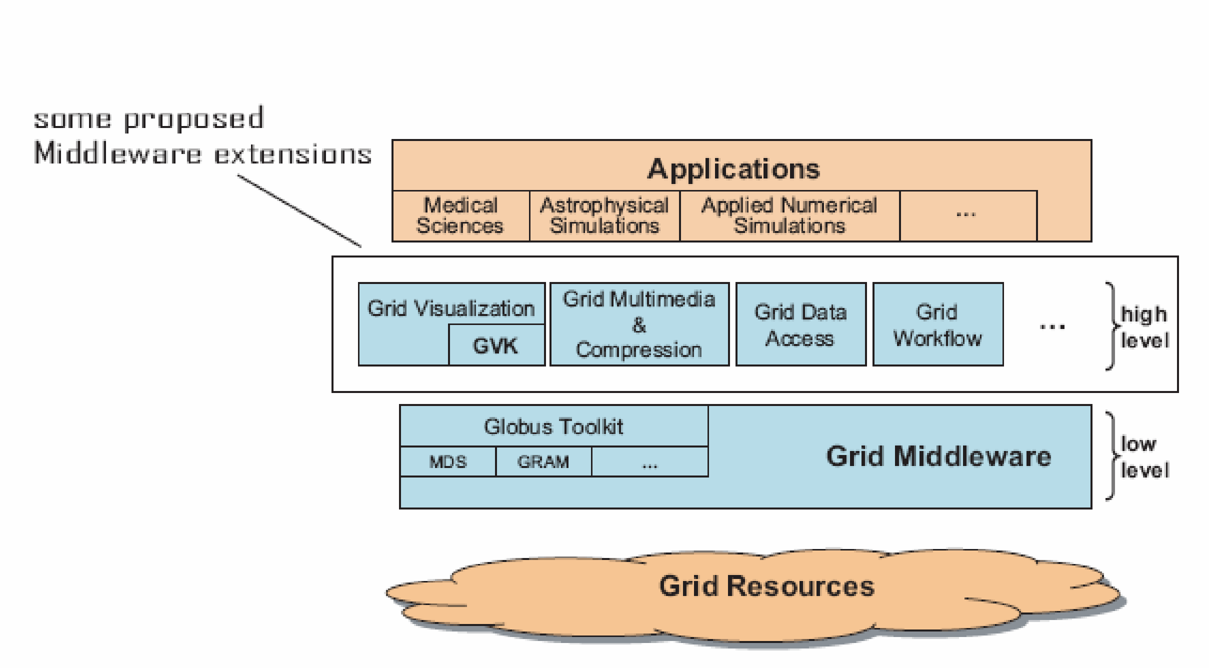

Figure: The Architecture of the Austrian Grid incorporating the GVK.

In Germany the D-Grid uses UniCore as its middleware, which it develops itself. The latest version of UniCore V6.0 is built on the latest Grid services standards such as WSRF, compliant with the Open Grid Forum's Open Grid Services Architecture (OGSA). Given this, it uses Clients, Gateway and UNICORE/X components all of which are compatible with MS-Windows as well as other operating systems. This portability, in principle, provides considerable advantages for interoperability over gLite used on EGEE. However, despite the principle the current version of the

Globus Toolkit uses an older version of the WSRF specifications, while UNICORE 6 uses the official OASIS standard (WSRF 1.2). Therefore, they are not compatible currently.

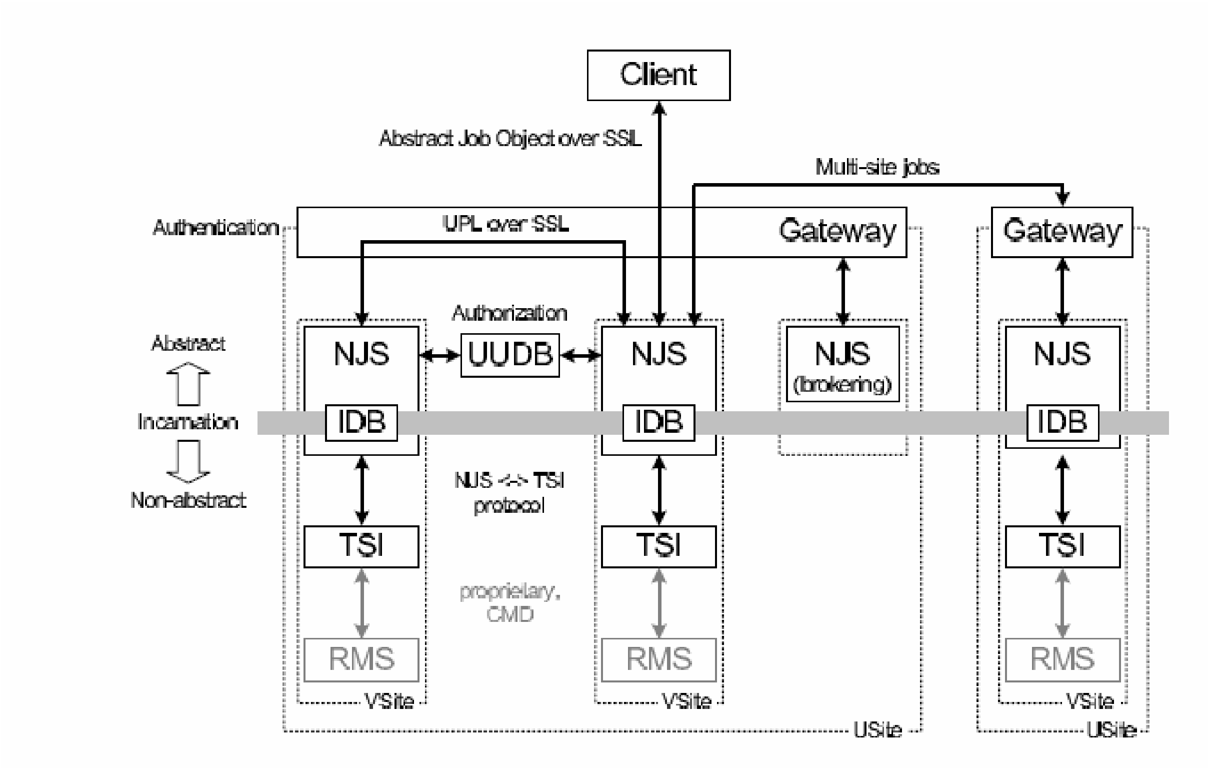

Figure: The UNICORE Architecture, 2006[54].

UNICore is important since it is used not only in Germany, but is the basic middleware for research and development used in Japan for the National Research Grid Initiative (NaReGI). To bring about the vision of a global computing Grid will require interoperability with Japan, therefore interoperability with UNICore is not just a European issue, but also an Asian and global one. Interoperability has been demonstrated between UNICore and both the Globus and Condor Grid middleware. UNICcore has also been very influential in the NextGrid project (see section 6.2.1.8) which is due to end in August 2007.

In the UK the main production Grid is the National Grid Service (NGS) operated by the STFC at the Rutherford Appleton Laboratory. Other significant Grid activities also include GridPP as a part of the CERN centered Global LHC Computing Grid (GLCG), the main GridPP GLCG Tier 1 computing resource is also hosted by the STFC at the Rutherford Appleton Laboratory. Both NGS and GridPP are built on VDT as the EGEE gLite is, so NGS and GriPP are both very similar to EGEE in their architectures. The software environment directly exposed to the end-user scientist in the NGS is the application hosting environment (AHE) which is a lightweight hosting environment that allows scientists to run applications on Grid resources in a quick, transparent manner. The AHE provides resource selection, application launching,

[54] http://www.unicore.eu/documentation/files/streit-2005-UFP.pdf

workflow execution, provenance and data-recovery, exposing a WSRF compatible interface to job management on remote Grid resource using WSRF::Lite as its middleware. WSRF::Lite is a Perl implementation of WSRF from the University of Manchester, first released in February 2004. Subsequent versions have performed well in WSRF interoperability tests, correctly interoperating with WSRF implementations written in Java, .NET, and Python.

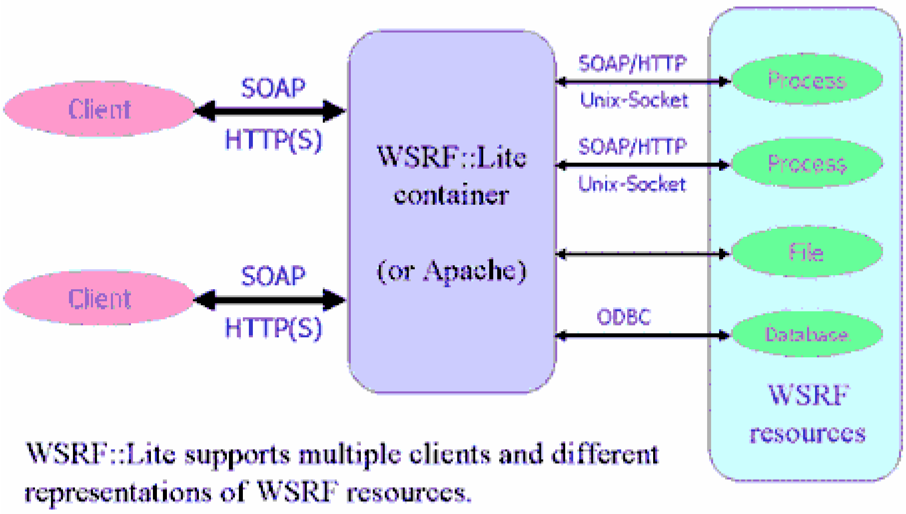

Figure: WSRF::Lite architecture

However, the UK also supports the OMII-UK[55] which certifies middleware and tools compatible with its own container. The Application Hosting Environment uses the OMII-UK MP component GridSAM to provide a JSDL compliant interface to a number of different Distributed Resource Managers (DRMs), including GT2, Sun Grid Engine and Condor. The objective of GridSAM is to let users execute applications onto existing distributed resource managers transparently and monitor their status. Transparency is achieved through the use of a common job description language, JSDL, and a uniform networked access interface, WS-I compliant Web Service. The core function of GridSAM is to translate the submission instruction into a set of resource-specific actions: file staging, launching and monitoring. The aim is to minimize user attention in the job launching process with a minimal overhead. The AHE on top of GridSAM provides a uniform interface to access both local campus based resources (for example running SGE) and Grid resources (for example running GT2). The AHE is currently deployed at several sites in the UK, and used to facilitate scientific access to the UK National Grid Service and US TeraGrid amongst others.

The Scandinavian countries (Norway, Sweden, Finland and Denmark) operate a joint Grid called the Nordic DataGrid Facility where sites use either the gLite or the NorduGrid ARC middleware[56], which is also used at sites in the Estonia, Latvia, Lithuania, Russia, Switzerland, Germany, USA, Australia, Sri Lanka and China (Nanjing). The middleware builds upon standard Open Source solutions like the OpenLDAP, OpenSSL, SASL and Globus Toolkit® (GT) libraries. ARC does not use

[55] http://www.omii.ac.uk/index.jsp
[56] http://www.nordugrid.org/

most of GT services, such as GRAM, job submission commands, the WUftp-based gridftp server, the gatekeeper, GRAM job-manager scripts, MDS information providers or schemas. Moreover, ARC extends Globus RSL and makes the Globus MDS functional.

6.2.3 Other non–funded efforts

To support the process of preparation of the first FP7 Work Programme a consultation workshop was organised in Brussels by the European Commission, Information Society and Media Directorate-General on the technology pillar "SOFTWARE, GRIDS, SECURITY and DEPENDABILITY".

Some of the workshop's objectives were:

- To take stock on the technology base in the light of the advances in the different research areas addressed by the workshop;
- To identify synergies between the three core areas of the technology pillar namely software technologies, Grids and security & dependability and possibly with areas such as embedded systems and knowledge technologies;
- To provide suggestions on the way forward in view of the preparation of the FP7 and its eventual execution by means of identifying and involving the appropriate stakeholder constituencies.
- The basis for discussion on this technology pillar is based on a high level vision for that pillar: "Europe needs to strengthen its capability to develop, manage and deploy dynamic and trusted knowledge-intensive software and services including their provision as a utility. This challenge will leverage the Grid-like virtualisation of resources, ubiquitous access as well as the trusted and dependable integration and interoperability of mobile, fixed, personal and corporate heterogeneous resources and applications".

6.2.4 Industrial Status in Europe

Grid computing has definite momentum in the scientific and academia worlds, but is still in its early stages of adoption in the enterprise world.
In this section we have surveyed the European industrial Grid environment. This study is based on the direct experiences of selected companies on the basis of their familiarity with Grid computing.

A questionnaire has also been prepared and circulated within the project to gather useful information known to EchoGRID partners about the adoption of Grid-related technology in the EU. This has also stimulated the discussion on Grid open issues within the project participants. The questionnaire is annexed to this document.

The study reports in detail how the Grid computing technology is used within the various industries/companies. Some organizations are IT companies customers (the majority of them), while others are companies who have considered implementing Grid computing technology in their IT environment.

Grid-shaped organizations is also an emerging issue in the field, as organizations are starting to use Grid applications to re-shape their non-core processes as well, such as HRM, administration, finance and control processes. In general, some of the advantages of Grid computing to IT managers with responsibilities in the progress of their organisations include:

- Immediate, tangible ROI (return on investment)
- Increased asset utilization
- No more scalability limitations
- Reduced capital investment and ongoing expenses
- Capacity on demand
- Increased application speed
- Web services support
- Increased application reality
- Enhanced model sophistication
- Accelerated time to deploy
- Increased IT resources
- Enterprise integration
- Greater application up-time

The adoption of Grid is described in the following sections with a segmentation by industry sector; each experience is presented in detail, with a focus on the specific industry/company requirements and the solutions adopted.

In general, early adopters of Grid technology in the commercial sector are:

- ☑ the Financial services industry, which is usually an early adopter of new technology (and big IT spender) where the applications need to function as quickly as possible, especially in the world of trading, with so much money riding on decisions;
- ☑ the manufacturing industry (car and aircraft manufacturing industry) where the Grid technology is used for complex computer modelling and simulations;
- ☑ the life science industry (pharmaceuticals and medical science) where Grid computing technology is used to accelerate and streamline the discovery of new drugs and treatments.

In conclusion, the European industrial Grid environment consists of a large number of stand alone projects, apparently without commercial collaborations between them. Differently for the US experience, where most industrial projects have a worldwide importance and are exported worldwide, the European initiatives are often local to the birthplace or at most to Europe itself.

Industry Name	Project type	Verticals
AUDI	Virtual car design and various analysis	Manufacturing - Cars
BMW	Crash analysis	Manufacturing - Cars
Liverpool Women's hospital	Creation of a connected Trust.	Healthcare
UK e-Science Centre (coming soon)	SimCity for real	Government
BBC	GridCast and PRISM	Media
Autotrader – UK	Care sales	Sales services
Credit Suisse	Credit where it's due	Financial services
Liquid Computing Corp.	LiquidIQ	IT Industry

Airbus	Air designing	Manufacturing - Aerospace
GridSystems	Many projects	IT Industry
Data Systems and Solutions & Rolls Royce	-	Aerospace
MPS	-	Financial services
CDO2	-	Financial services
ING direct	Use of Dollar Universe Solutions	Financial services
Deutsche Bank	One of the first case of Grid using in bank applications	Financial services

6.2.4.1 The Audi experience

An important European success in the use of the Grid technology within the industrial environment is the experience of the German best known automobile manufacturer: Audi.

The most important result of Audi's use of Grid is that the German company is taking a big advantage over the competition by cutting costs and having results in less time. Essentially Audi uses Grids in two sectors:

- Cars designing.
- Crash testing.

The use of its 1000 CPUs-made system Audi has the opportunity:

- To create communication and collaboration between its different design groups located in different countries.
- To create virtual cars and test them for all required testing cases by simulations (noise, comfort levels etc.).
- To execute crash testing simulations.
- To support rapid modifications (e.g. new regulations).

For example, using its Grid network Audi can execute car tests with the objective of optimizing the weight of the cars. These tests involve very complex systems consisting of one hundred design variables, seven typologies of crash tests and some other general tests.

Some Grid tests currently reduce 80 times the time required for equivalent mainframe tests.

6.2.4.2 The BMW experience

BMW is one of the leading automobile and motorcycle companies in Germany. BMW is a pioneer of crash analysis: it executed the first test on 1997 with a over weekend simulation (consisting of many Monte Carlo simulations). Currently BMW is using Linux clusters thanks to the reduction in time to do the same jobs. For example the simulation executed in 1997 as of today requires only one day.

Pointing to accurate simulations, BMW technicians represent each piece in the structure of the car using a series of polygons associated with mathematical and physical descriptions of its properties.

The importance of Grid is in the high increasing of performance during these simulations which give the company many advantages, ad example, the first BMW's simulation saved about 15Kg in vehicle weight and $36 million per car model over five years.

Currently BMW is developing a database to enclose all the simulation data and re-use them in the future to contribute to new designs. In addition, BMW staff is searching for data mining and cluster algorithms and decision trees to analyze historical data.

6.2.4.3 The Liverpool women's hospital experience

The Liverpool women's hospital started the re-engineering of its IT system in parallel with the advent of a new director of Information Management and Technology.
Before then, many applications were running on single PC used as a server and were running all day all the time.

The expert director proposed to use the virtualization to have improved access to resources and a better management of all of them.

The Network structured was build up using Dell machines: nine Dell PowerEdge 2850 and 1850 servers and tro Dell EMC CX500 storage area networks and a PowerVault 132T LTO tape library. Data is mirrored to a disaster recovery site.

Once the staff were properly trained, the work had been relatively easy at the hospital.
The organisation's effort results are (1) the capability to manage the environment from home, (2) a better problem solving capabilities thanks to VMware interface and (3) the possibility to storage a big quantity of data in a distributed way.

In addition, all these functionalities are transparent to the users, while helping the hospital to give a better service to the community.

6.2.4.4 The UK e-Science Centre experience

The UK e-Science Centre proposes a most interesting way to use the Grid technology: "SimCity for real".

SimCity is a videogame that allows the player to create his own city and manage it. The player's actions are the basis of the city destiny. So, for instance, if the player make mistakes in the organization of the city, it will not be able to recover disaster and to maintain a good feeling with citizens.

Using Grid computing and a real model of the population, the UK e-Science Centre will be soon able to test the consequences of their policies in a simulated real UK city.

The reference model starts from the year 2001 census and it is composed by attributes such as cars, house prices, use of health, education, forecast, employment etc.

6.2.4.5 The BBC experience

The BBC is currently involved in two Grid-related projects, Gridcast and PRISM. Both are carried out in collaboration with the Belfast e-Science Center with the aim of changing the way people watch television.

The BBC project idea is to give users the access to its programs database consisting of 80 years of archive. Moreover, BBC wants to allow control of broadcasting by regional authorities and viewer control over what is on and when.

Both projects are currently ongoing and more information will be made available by BBC in the next future.

6.2.4.6 The Autotrader experience

Autotrader.co.uk is one of the most visited UK sites, and Internet accesses are growing to a very high rate. Autotrader is a leader company in the cars sales industry. By reducing problems related to new required services and to the growing number of daily accesses, the organization has build up a SMP multiway server with a stack of CPUs; chosen technology has been SunFire V20z and V40z Opteron processor based server with Oracle 10g RAC for the database. Combined with existing network, this configuration has given the capability to use a flexible and resilient computing Grid.

The system is running since the end of 2004 and is working with a good performance level. The company believes to achieve a ROI of over 50% in the future by using such Grid network.
It also needs to be said that the organization has experienced initial problems due to the fact that Grid technology was new to this environment and it needed much training on the job to be used in the best way, and to exploit its full potential.

6.2.4.7 The Credit Suisse experience

Credit Suisse manages its infrastructures and products using innovative ways. Since 2003 the organization has been moving towards a Grid architecture taking benefits from the distributed and parallel computing power.

Looking at open source solutions Credit Suisse chose a proprietary system due to its specific requirements in features and support.

As usual in the financial industry, the organization’s IT systems are not revealed in details for security reasons, however, the bank’s manager says that they have reached a strong computation capacity and that they are thinking to even sell it outside the organisation. The organization also says that the Grid network is the cheapest part of their infrastructure to run and that it is relatively simple to manage.

6.2.4.8 The Airbus experience

Airbus is one of the two leader companies in Europe in designing and producing Aircrafts and has a long history in the adoption of Grid technology.

In fact, crash and design tests need intensive computing due to analytical issues: parallelizing them decrease of a step the computation time by taking hours instead of days.

The Grid practice to make crash tests is a reality within the Airbus company. It is also trying to take advantage from Grid to improve the design performances by increasing collaborations between different groups in different places, and by coordinating the work with external partners.
In each of the main centers dedicated to aircraft design, the growing of CPUs number is incredible: from hundreds to thousands for every design center, this is due to the need of increasing the computational power for crash tests and design collaborations.

The creation of new Airbus required the running of finite element analyses, fluid dynamics tests and evaluations about components, engines, wings, and fuselage. In this view, processes' optimization by using the lowest computational time is a major goal.

6.2.4.9 The GridSystems experience

GridSystems is a Spain headquartered company that develops Grid solutions for all of the most important sectors of the industrial world.

The variety of their solutions ranges from the telecommunications sector, to the health industry, having between them also finance, oil and energy, pharmaceutical, and government industry.

The most important experiences are reported in detail in the following paragraphs:

Telecommunications

Telecommunications are full of processes which require data intensive computing. An example can be the analysis of all the data regarding the use of the services that a provider offers. Grid technology can provide solutions which give the capability to have better performances, robustness, profits, scalability for volume-growing processes and cheaper expenses.

GridSystems has got many customers from this industrial sector. As an example, it has worked in a project for Telecom Italia (the biggest Italian TLC operator) to re-engineer a system developed to manage all CDRs (Calla Data Records) with the objective of having a Grid enabled version of the system.

Telecom Italia is experiencing faster processes and more scalable and reliable systems, as well as the reduction of infrastructure costs.

Finance

The Financial services industry is a continuously growing industry. In this context there is a strong increase in the volume of complex trades and in the number of operators involved in the provision of financial services.

The financial institutions has to support many new complex computational processes and amount of data, while maintaining at the same time the level of service required and improving the systems' performances and reliability.

As example of Grid projects in this sector, we report Santander Central hispano bank (SCH). The organization has adopted GridSystems technology to build an infrastructure for risk analysis, as a fundamental process in all financial environments. They run Monte Carlo simulation to have statistical valuation of risks. The Grid based solution gave them a big reduction of computational time, optimizing the resources, removing dead times, and showing flexibility, scalability and robustness of systems.

Oil & energy

Monte Carlo simulations are of much use also in the Energy and Petroleum Industries that require accurate risk analysis and exploitation simulations to help decision making process.
These kind of simulation are easy to be integrated in a Grid network, and are optimal to be increased in their performances by the employment of grids.
GridSystems and Agenium Technologies (a French company) are helping EDF Energy in Paris with Grid-enabled Nuclear risk analysis processes, resulting in optimal results in terms of reliability and fastness.

The developed platform consist of OpenPBS-managed clusters accessed with IG V graphical interface and optimized with the delivery services of IIG V. The result is a full virtualized platform with hundred of Grid resources that can be exploited by Grid services in a transparent way to the user.

Pharmaceutical sector

With the term pharmaceutical we intend the sector consisting of pharmaceutical bioinformatics and chemical sectors. All of them requires specifically high calculation capacity and parallelization of many computational processes. So they are excellent users for Grid networks.

The Japanese Taisho Pharmaceutical, as an example, have chosen GridSystems to install IG V to run in-silico docking experiments covering many proteins and compounds. This is done in a most efficient way with a dramatic reduction of computing time and, as a direct consequence, a strong reduction of the time-to-market for new drugs.

Government

The government is a relatively new client for the Grid IT industry. At present, public institutions are in need of managing very complex interactions between citizens and governments, thus they urge to manage a growing amount of digital data.

As an example, the Spanish Ministry of Defense has asked GridSystems to make available a thousand nodes Grid network with special services that can be used in crypto-logical applications.

As usual in the case of national defense organizations, the details of the implementations are confidential, and no more information is available to our survey.

Healthcare

It can be noted that the healthcare industry is getting more technology-oriented every day. Also in this sector, the solutions need large processing power due to the huge amount of digital data available.

Drug design, medical imaging, medical simulations are some of the most “Grid-oriented” areas which analyze 3D images, clinical trials, medical simulations.

The Hospital Clinico in Barcelona, for example, has combined the university and industrial support to have better distributed calculations, thus reducing the time of performances of simulations from months to hours.

6.2.4.10 The MPS experience

Monte dei Paschi di Siena (MPS), which was founded in 1472, is believed to be the oldest bank in the world. Today, it is leader of one of the top five Italian banking groups. It has significant market shares in all the sectors in which it operates. MPS is the flagship of the MPS Group leading the domestic market in terms of market share. The MPS Group was one of the first institutions in the world to implement an SOA architecture & provide web services to their customers.

Typical operations include millions of online transactions and many batch procedures on mainframes of other banks within the group. The first production environment for a spectrum of compute-intense applications was first set up in 2005. CRM and reporting applications need large amounts of computing power in order to comply with the new regulations, such as IAS and Basel-II.

The mainframe, which was already in production, did not provide sufficient compute power or speed, making it incompatible with business needs. To overcome this obstacle, the solution currently used is the Intel application ion AGA (Avanade Grid Based Architecture), With this solution, the required speed and cost savings have been achieved. In 2006 MPS adopted a Grid solution for financial reporting using Murex. MPS is now testing the porting of many different batch processing from the IBM mainframe to their AGA Grid solution in order to lower computing effort on the central machine using idle resources.

The original target was to perform statistics from web sites. The consortium has estimated that the elaboration of data would necessitate 2 servers with 4 processors each working for approx. 8 hours. Today, the work is carried out in around 2 hours on non-dedicated machines. A similar approach was adopted regarding the data processing for compliance with BASEL-II, market risks in particular. In utilisation terms, the distributive processing capacity was under-utilised during the day and almost zero throughout the night. Beneficiaries – Company cost reductions and significant increase in processing; Client services improved with faster data processing, e.g. official customer communication documents like account statements, reporting statements, etc.

The departmental Grid allows MPS to apply the product on as many machines as needed. Processes typically taking about 6 days, can now be processed in one day.

In the following list some other benefits are showed:

- Increased compute power and processing speed for a range of computationally intense tasks; compliance with regulations and improved customer services. Transactional and process interaction are key components of both an internal and external architecture.. Grid is considered to be a very important paradigm for the evolution of Service Oriented Architecture (SOA).
- Used a product on the mainframe, the time for elaborating data for the bank statements was in the region of 6 days for all the banks managed: Banca MPS, Banca Toscana, Banca Agricola Mantovana and MPS Banca Personale. MPS bought the departmental license, DOC1, substituting the mainframe whilst paying the same price. For example, the elaboration for the Banca Toscana would take up around 7 hours using computers on Saturday, which are not in use. On the Grid, it takes around 1 hour and 20 minutes, including transfer time for data, mainframe and periphery, fanning on the Grid, re-grouping data and uploading them on the mainframe. These are significant examples, which have led to others that are emerging today, such as Murex product's usage of server farm Grids for the elaboration of financial data, whilst not having them run on SUN machines.
- Recently a product has been bought to categorise the clients addresses. IT was acquired on the departmental and quickly adapted to use on the Grid. Advantages:
    1. The mainframe is an excellent architecture, but is becoming too expensive. In particular the cost of the software mainframe increases as power increases. Since power is continuously increasing, costs are inevitably rising.
    2. There is a significant increase in elaboration. The examples given above are an indication of this.

6.2.4.11 The CDO experience

CDO2 is a London-based software provider for pricing and risk technology to banks, hedge funds and investment firms involved in trading structured credit products. CDO2's financial risk simulation software, CDOSheet, is used to accurately calculate the value of complex investments and conduct risk analysis.

The targets of the company were: Delivering pricing and risk analysis computations faster to gain competitive edge, increase market share, provide affordable and secure software service to customers – banks, hedge funds, and investment firms. The main objectives were to find a solution that would increase market share adding value by delivering results faster to customers without the need to invest heavily in the IT infrastructure. CDO2 saw an opportunity to offer its software as a service on a utility infrastructure. Key adoption drivers were: affordable and convenient access to intensive computing power; robust security and high availability due to the sensitive nature of financial data and the constant change in financial markets. The two main beneficiaries are: the company's growth and ability to offer value-add to customers by enhancing software as a solution that rapidly delivers complex analyses; the company's customers - banks, investment firms and hedge funds, who are able to strengthen their negotiating position with larger banks from whom they purchase complex credit derivatives, called collateralised debt obligations (CDOs).

Company has achieved main goals: meet technical and market needs, ensuring return on investment. ISV solution brings a number of advantages: no expensive start-up fees; pay-per-use; flexibility: add power as needed; low barriers to entry. The company is able to grow business incrementally on the ISV's (Sun Microsystems' Sun Grid) utility as customers build up their businesses; completely scalable business model without the constraints of having to invest large amounts of money to create our own IT infrastructure.

The solution implemented is Sun Microsystem's pay-per-use 'Sun Grid Compute Utility', an access data centre-on-demand, delivering computing power and resources over the Internet (www.network.com.). This utility is designed to enhance business performance and speed up processing. Utilises the SunFire dual processor Opteron-based servers with 4 GB of RAM per CPU, Solaris 10 OS, and Sun N1 Grid Engine 6 software. Cost: $1/CPU-hr. According to this ISV, no hidden costs involved.

In the finance sector, market-edge basically means getting business by getting data to market faster. CDO2's mission is to help its customers make better financial deals by giving them access to the same capabilities and information as their larger counterparts. With access to the latest pricing algorithms and risk methodology, CDO2's customers can independently and accurately assess the fair value of these investments, a capability formerly available only to larger banks with in-house Grid computing capability.

Delivering results faster to customers and enabling customers to make their analyses more quickly. Both reap the rewards as customers increase competitive edge and expand, leading to business growth for CDO2.

CDO2 software has increased its value within the financial services market. The company believes the solution is easy to use and offers immediate access. Main benefits include: Computation time significantly reduced strengthening customers' negotiating power, Easy-to-use utility with immediate access to low-cost computing resources, Meets high security demands of the finance sector; does not require high investment costs, Target market has increased tenfold due to affordable computing power.

6.2.4.12 The Data Systems and Solutions & Rolls Royce experience

Rolls Royce is today best known for its aerospace solutions and it currently serves about 500 airlines, 4000 corporate & utility aviation operators, and approximately 160 armed forces. In 1999 Rolls-Royce (UK) and US information systems developer

Science Applications International Corporation (SAIC) established their joint venture company: Data Systems and Solutions. Is has the mission of developing enterprise asset management systems making the best use of predictive maintenance technologies for an enterprise's complex or expensive assets. Today their monitoring systems are highly advanced. This case study regards the development of Grid for Equipment Health Monitoring.

The main objectives were: improve the predictive maintenance process (analysing asset data so that operators have the right data to avoid potential problems), increase the quality and speed of fault detection as well as the frequency of data sampling to real-time, continuous streams of data, initially involving full spectrum, vibration and speed data. This to have more efficient predictive maintenance processing of large amounts of data, costs reduction, tackling the bottleneck of storing and transmitting data. .

Grid computing technology allows for dynamic processing locally, with support for more complicated and in-depth analysis to be performed on-demand. In addition, Grid provides methods for dealing with large datasets, data access, data caching, replication, and transport.

Maintenance on all Rolls Royce aircraft engines needs to carried out on time to an optimised build standard to avoid extra costs, unplanned repairs, and maintain company image. The solution has been to collect as much data as necessary on each engine in operation so that its condition, performance, configuration, and state of maintenance can be established in near real time. A full range of information is required, generating large amounts of data.

The EHM system improves as more data is supplied to it, increasing the system's efficiency. Grid technology has been proposed as a solution to solve the bottleneck of transmitting and subsequently storing data.

This case study illustrates one of the top-level challenges for the automotive/aerospace industries – massive amounts of data are generated for design, engineering and maintenance purposes. In the EU automotive firms, are required to store and preserve data for a number of years. In this particular case, the predictive maintenance process is used across the board to include assets from diverse types of transportation and power plants. The wide diversity of assets and geographic distribution makes a distributive solution a viable alternative.

Privacy of data and bandwidth restrictions (particularly in military environment), along with security are all issues that need solving. The Grid addresses the issue of sharing resources across organisational boundaries.

The Grid also offers the means to deal with large datasets, data access, data caching, replication and transport.

Cost optimisation means reducing the time span between arrival and departure of aircraft as much as possible. During this narrow timescale, engine performance in flight must be analysed. This process is repeated in different locations at different times of the day, and synchronised with centrally held data. Grid technology enables dynamic processing locally alongside more in-depth analysis on demand.

The above mentioned data can later be downloaded into a GSS computer where it can analysed to support maintenance planning and further asset management activities.

24/7 service is an inherent feature of the Grid paradigm.

The more engines running equals more revenue generated as Roll Royce leases out engines and customers pay a fee for each hour the engine is in operation.

6.2.4.13 The ING Direct experience

With respect to what has been reported so far, ING is essentially a customer of Grid solutions, rather than a manufacturer. However, it is interesting to notice how they have selected a Grid solutions to have a better job schedule within the organisation.

Using Dollar Universe Solutions they could decrease the needs of operators in parallel to the increase of the elaborations volume. In other words, when the organization experiences a growth in elaboration volumes (e.g. when a new project is launched) DUS can easily manage the variation of production operations by optimizing the available resource. This is done through the architecture Automation Power Grid.

6.2.4.14 The Deutsche Bank experience

Deutsche Bank’s Securities Custody System is one of the oldest Grid success in the bank industry: it is one of the earliest results of lower costs and better performance and higher return on investment using Grid clusters.

In 1996 the bank expanded its reporting capabilities for its Global Custody business. The existing system was quite old and without any user interface, without centralized control and application security. The previous system was inefficient and not reliable or scalable.
DB turned to Base One and contracted for custom software design and support, and used a Grid computing based solution that evolved every year.
The experience has been successful because DB obtained reliability, performance in its systems.

6.2.4.15 Grid Market Situation in Europe

The market analysis for Europe and China will be produced in September 2007 in Deliverable D1.2. This short summary gives an overview in prospect of that longer analysis.

Grid technology evolution

For many years, big businesses have been using Grid to speed up compute-intensive applications and handle huge volumes of data. Since Grid began its evolution, enterprises have been finding more everyday uses for Grid technology, focusing more on Grid's inherent flexibility and distributed nature than on its brute processing power. One way in which they have been using Grid is to handle transactional applications, a technology trend Gartner has labelled "Grid-based application platforms," which, as of July of 2006, sat on the "Technology Trigger" area of Gartner´s Hype Cycle.

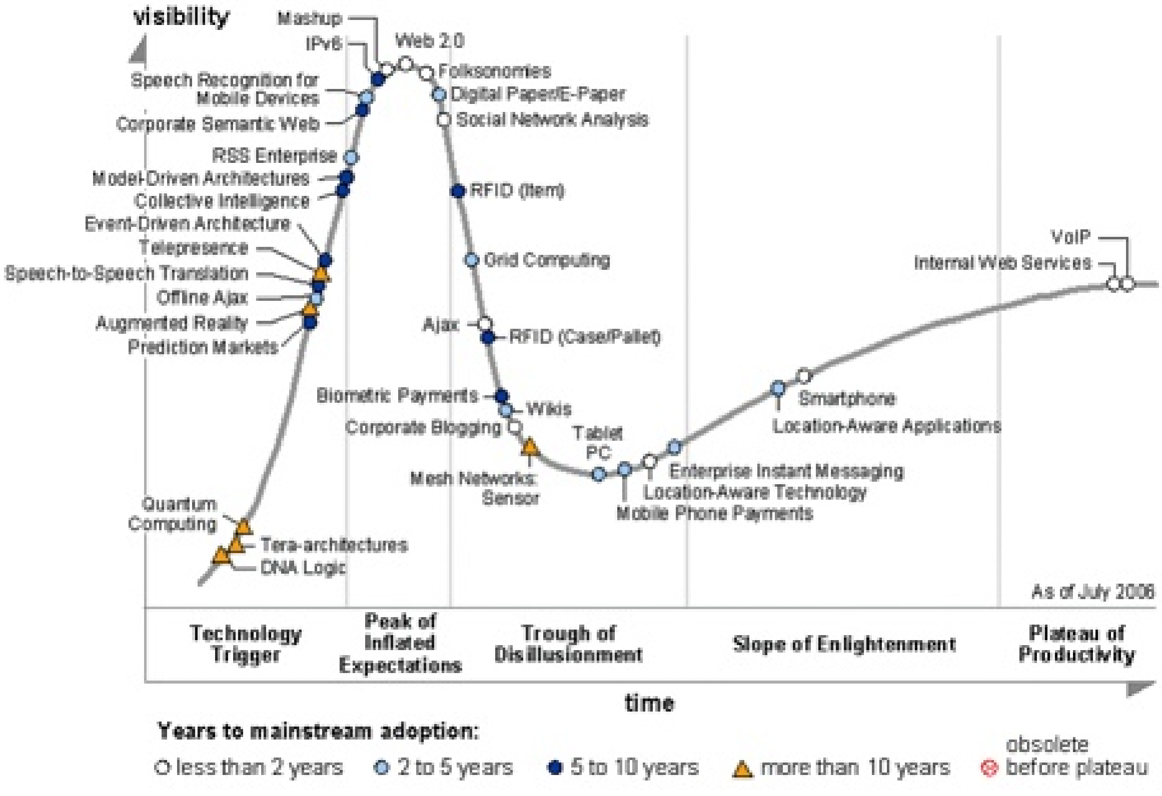

Figure: The positioning of Grid technology adoption expectations among other technologies

According to Gartner, while there are similarities between traditional Grid deployments and Grid-based application platforms, and while the underlying technologies even can be the same, the target, from an application perspective, is different. "In traditional Grid, the problem is allocating processing power and you don't really care about availability of the overall system, if one box is available you don't care. You need to have that server," he said. "In transactional applications, it is not that simple. With transactional applications, you have to deal with databases, you have to deal with maintaining the transactional integrity of the thing that you are doing. It´s a bit more complicated."

Typically, these Grid-based application platforms address two main problems that are not always for traditional grids to solve: scalability and availability. When it comes to scalability, it's all about adding more and more hardware resources, and availability is crucial because users need to be able to maintain transactional integrity, which generally requires as close to 100 percent availability as possible - even while adding or removing resources from the Grid.

And it is here, where vendors believe they have the advantage over traditional Grid vendors. Whereas Grid-based application platforms can be applied to straight computational applications, the same cannot be said for traditional Grids and transactional applications. Grid has a lot of advantages to offer the enterprise for business-oriented types of applications, and that process of migrating from Grid middleware/scheduler to Grid-based application platforms is really the key.

So, from a commercial point of view Grid is moving in the following directions: Service-oriented Architecture, virtualization and transactional applications. The marketing messages that used to deal with Grid or even Web services, have been rewritten to speak about SOA and/or virtualization. Even traditional Grid companies such as Data Synapse, now define themselves as providers of application virtualization software.
Grid technology is moving into the arena of transactional applications. As transactional applications such as e-commerce applications, trading, and real-time analytics generally demand 100 percent availability and are seeing exponential growth in the transaction workload, there are several initiatives to study ways to integrate Grid technology and transactional applications support.

Platform Computing and GigaSpaces announced (Jan 2007) a partnership to make transactional applications work over a compute Grid. Other vendors trying to exploit this different approach are Appistry, Paremus, Aumega Networks and Majitek.

The idea of bringing together Grid resource virtualization and management solutions and the end-to-end linear scalability of transactional and data-intensive applications will create a single platform capable of addressing the data, messaging and processing bottlenecks present in high-throughput, low-latency transactional and data-intensive applications.

From discount travel sites to airline company sites or shopping sites like Amazon, businesses need to reduce the cost of processing each transaction. Grid platforms with their ability to utilize commodity hardware can bring a solution to these businesses.

State of the discussion

One of the goals of the European BEINGRID project is to materialise Grid into concrete solutions that satisfy the business needs of industry, enabling new and more demanding applications and services to take the lead, going beyond the borders of the academic world. There are 18 business experiments –coming 5 or 6 more in a 2nd wave- that are running in different industry verticals, exploiting different business cases in order to come up with best practices that would foster the commercial uptake of Grid technologies.

However, we recognize that there is a fundamental gap between the technology and its users, as the technology is still too complex and requires too much knowledge to utilise it and too much effort to manage it. We also believe that the emphasis is not on selling the Grid, but on selling an integrated solution to the customer that involves the Grid. In a general outline, we can say that Grid middleware might be only a niche product in the future, while many functionalities will be taken over either by operating systems or applications and be nicely combined with other technologies. When entering the market, we have found four main focuses to consider:

- Focus on gridified applications
- Focus on Grid services (software as a service)
- Focus on commercial Grid middleware
- Focus on open source Grid middleware

In order to propose market opportunities we can also have a look at two other approaches: the Next Generation Grids expert group approach and the SCF Associated Ltd report, written by Simon Forge and Colin Blackman, titled "Commercial Exploitation of Grid Technologies and service".

Concerning the first approach, in the last quarter of 2005 the Next Generation Grids expert group was involved to identify the gaps between the leading-edge of Grid technologies and the end-user.
In the NGG report come out that the popularity of Grids has been growing very rapidly, driven by the promise that they will change dramatically the life of individuals, organisations and society as much as the Internet and the Web have done in the past decade. Grids can give new drives to the IT market and foster growth and competitiveness in many industrial and business sectors, thanks to the knowledge and computing resources to be delivered to and used by citizens and organisations as traditional utilities or in novel forms.

The complexity of software applications is growing rapidly under the time-to-market pressure. In this view, mainly for cost reasons, it is foreseeable that no single company or organisation would be interested in creating by itself very complex and diverse software applications. Future business and scientific applications will be built as a complex network of services offered by different providers, on heterogeneous resources, constrained by administrative problems when crossing the borders of different organisations, well-known as SOA (Service Oriented Architecture).

The NGG vision consists of three complementary dimensions: the end-user perspective where the simplicity of access to and use of Grid technologies is exemplified; the architectural perspective where the Grid is seen as a large evolutionary system made of billions of interconnected nodes of any type; and the software perspective of a fully programmable and customisable Grid.

End-users will require personalisation techniques that allow the services and infrastructure to be tailored to their individual needs, including the creation of information and knowledge as well as its delivery.

The socio-economic aspects also demand investigation. Issues of ethics, privacy, liability, risk and responsibility will arise which will impact future public policies. Economic and legal issues will emerge from combining open shared systems with other systems, and new forms of business models will emerge. These studies will require interdisciplinary research.

Concerning the second approach, Simon Forge and Colin Blackman think that the established European exploitation mechanism, in which industrial partner in EC projects invest in the pre-competitive research and then invest in their own commercial products development and support, is unlikely to succeed for Grid commercialisation of products and services. They say that it tends to produce a range of competing results rather than one model. It fragments any effort to build a single model.

In order to bridge the gap they propose to have a look to other country experience. An example is the Korean Grid programme. Korea is interested in Grid technology as a way of introducing computing technology to an industrial environment which is strong in semiconductors, telecommunications and display technology but weaker in computing technology, especially software. Grid computing is one important direction for its declared goals of national competitiveness in advanced IT services and the business grids projects have concentrated on quite practical application, often linked to telecommunication. Korea is also interested in taking the Grid to the level of the ordinary population and has plans on usage of a Grid from home. One experiment is the Kore@Home project.

Naturally, the Korean and other Asian models such as Japan are not identically replicable in Europe. So the SFC Associates have proposed the scheme presented in the following picture:

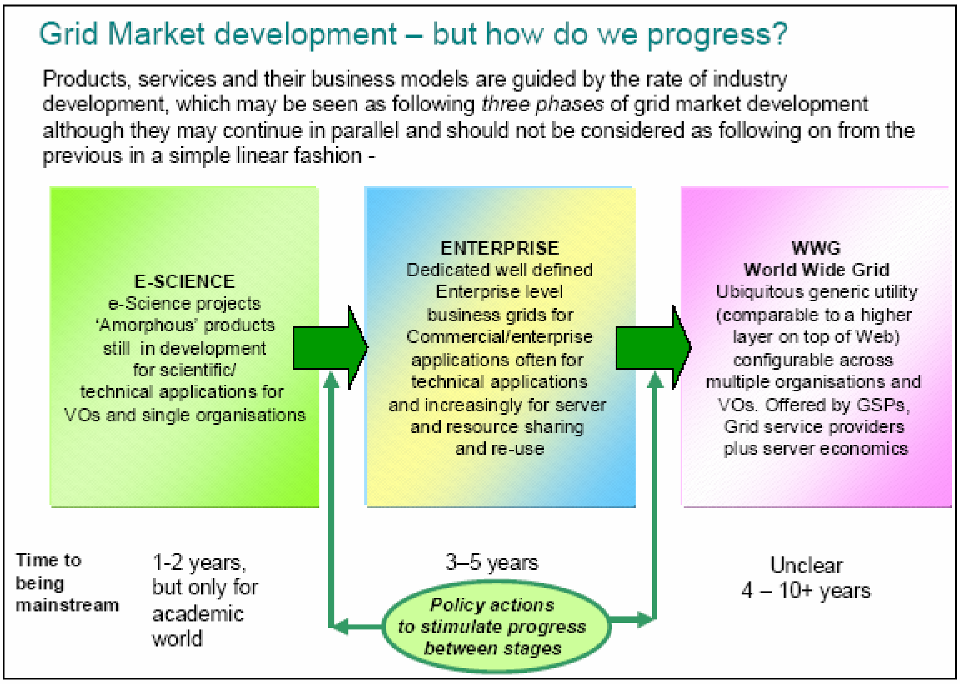

Figure: Policy actions to seed the next phase of Grid market development[57]

At the end of this approach, we could summarize some issues for the discussion:

- In order to create a European market it could be useful the creation and the

[57] Source: Simon Forge and Colin Blackman, titled "Commercial Exploitation of Grid Technologies and service"

promotion of a standard toolkit and a reference model with support service. It could be chosen among the best technologies/middleware available at the moment. This common toolkit can be diffused to the European software industry, which may use it as a basis for Grid technology commercialisation in product and services and to the user/enterprise /consumer market that may use it directly. In this model the spread of Grid technology is left to the market, to create a offshoot of the software and internet services industry in derived product and services which can run over the Internet, or in more secure infrastructure.

- From the Policy point of view, it could be possible to build an open Grid infrastructure for Grid application services.

- From the end user point of view a European Agency for Grid technology and a core set of market support unit could be useful for the market.

- Market –oriented R&D: on the model of EUREKA programme, that aims to enhance Europe competitiveness trough its support to business, research centres and universities who carry out pan-European projects to develop innovative products, processes and services. The federation's charter should be set with a long-term programme of focused targets, producing projects, standards negotiation support, analysis and promotional material following the strategic direction for the development of EU Grid middleware and its commercial exploitation. This "Group Special Grid" could later have a global extension.

7 Annex 2: EU-China Collaboration

This chapter is intended to describe the collaboration on a research level for specific scientific and industrial issues. It describes joint projects which exist to encourage collaboration and to exchange best practices and experiences at the research and industrial levels.

In comparison with the large number of organizations involved in national projects in China, and EU projects in Europe, only a small number of organizations are involved in these collaborations. Many of the major players at the national and continental level are not involved in these activities.

It is also clear from the previous chapter that whereas the European scientific grids are structured at a national level in Europe and then brought together at a European level by the EGEE projects, there are three major Grid systems in China which are independent and funded by different parts of government. These collaborative activities do not proportionately represent organizations active in the major grids in China.

A third observation is that these collaborative activities are funded by the EU or European national bodies, and very little of the collaborative effort is funded by China.

7.1 EU funded Grid projects related to China

Under FP6 the EC has funded several projects to facilitate interaction of European Grid researchers with those in China, which complement the present project ECHOGrid.

7.1.1 EC-GIN

EC-GIN[58] is a FP6 project with partners from Europe and China. The project's objectives are summarized following:

- Development of Grid-specific network management mechanisms that enable Grid applications to use their resources more efficiently or in other words, "make the Grid faster".
- Development of a secure incentive-based solution for economic management of Grid and network resources
- Cause of a "snowball effect" in the European and Chinese research community, convincing other networking/Grid computing researchers to jump on the bandwagon.

[58] http://www.ec-gin.eu/corpsite/display/main.asp

- Promote global adoption of Grid environments and tools particularly in a pan-European and pan-Chinese environment to achieve a realistic and long-distance demonstrator case.

Chinese Partners:

BUPT - Beijing University of Posts and Telecommunications[59]
ISCAS - INSTITUTE OF SOFTWARE, CHINESE ACADEMY OF SCIENCES[60]
CTTL - CHINA TELECOMMUNICATION TECHNOLOGY LABS[61]
CMDI - CHINA MOBILE GROUP DESIGN INSTITUTE CO. LTD[62]

7.1.2 EUChinaGRID

EUChinaGRID[63] is an initiative that extends the European Grid infrastructure for e-Science to China. The first aim of EUChinaGRID will be to facilitate scientific data transfer and processing in a first sample of application areas that have already strong collaborations between Europe and China. Three pilot applications (in the areas of Astrophysics, High energy Physics and Biology) will immediately profit of the new infrastructure, and will be subsequently regarded as the driving force to test and deploy an effective Grid infrastructure between Europe and China.

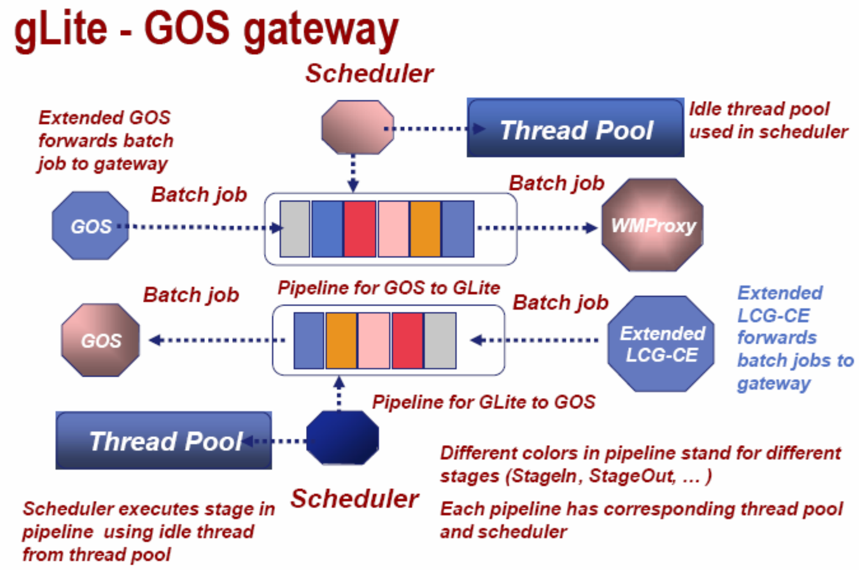

Figure: The gateway developed in the EUChinaGrid project between the gLite middleware used in the European EGEE project and the GOS middleware used in CNGrid in China.

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59 http://www.bupt.edu.cn
60 http://www.iscas.ac.cn
61 http://www.iscas.ac.cn
62 http://www.bcdi.com.cn

63 http://www.euchinagrid.org/

Chinese Partners:

Beihang University, Beijing[64]
CNIC
IHEP, Bejing[65]
Peking University, Beijing

7.1.3 Grid@Asia

Grid@Asia[66] is a FP6 project that was signed to foster collaboration in Grid research and technologies between the European Union and Asian countries with a particular focus on China and South Korea.
The project is implemented through three principle steps:

- Identification of Chinese and South Korea key players in Grid research and technologies
- Organisation of focused workshops around EU/Asia research and industrial agendas
- Establishment of sustainable cooperation and dissemination activities.

Relying on a core of leading European Grid research institutes Grid@Asia defined a joint research agenda to address international Grid priorities. This initiative was relying on the local support of the Asian partners to ensure on-site organisation, enhanced visibility and participation of high-profile industrial and scientific delegations.
By strengthening cooperation between both communities, Grid@Asia provided Europe with a clear picture of the Grid community in those two Asian countries and prepared a reliable ground for sustainable and long-term collaboration. The project supported long term international cooperation, in particular through the integration of Asian expertises with leading European Grid initiatives within the 6th Framework Programme of the European Union (such as Networks of Excellence, Integrated Projects, STREPS, etc.).

7.1.4 GridCOMP

GridCOMP main goal is the design and implementation of a component based framework suitable to support the development of efficient Grid applications. The framework will implement the "invisible Grid" concept: abstract away Grid related implementation details (hardware, OS, authorization and security, load, failure, etc.) that usually require high programming efforts to be dealt with.

Objectives

[64] http://www.buaa.edu.cn/

[65] http://www.ihep.ac.cn/english/index.htm
[66] http://www.gridatasia.net/

The GridCOMP project will have the following objectives:

- be able to interoperate with existing standards, such as Web Services, WSRF, Unicore, EGEE gLite;
- become a "de facto" standard for big industry and SMEs specifying and implementing all the features usually expected from an actual Grid programming framework;
- address both scientific computing and enterprise computing;
- reach a world wide audience thanks to the involvement of non European partners from South America, Australia and China.

GridCOMP will take the Grid Component Model (GCM, CoreGRID Network of Excellence) as a first specification, and use the ObjectWeb ProActive Open Source implementation as a starting point. ObjectWeb ProActive Grid middleware ensures interoperability with other standards: EGEE gLite, UNICORE, NorduGrid, Globus, Web Services. Coordination with the NESSI initiative is also a strong priority, with the involvement of ObjectWeb, Atos Origin, IBM.

Expected results in the scientific domain are accelerations in developing new simulations, and as such new discoveries. The impact on the EU economy can be foreseen by analogy to the GSM standard. GSM has changed the way mobile telecommunication infrastructures were built, bringing EU at the leading edge of the technology. Similarly, GCM should stimulate the domain of IT infrastructure management and application development, reinforcing Europe leadership in the sector.

Consortium
The GridCOMP Consortium gathers **11 Partners** for a period of 30 months : from 1 st June 2006 to 30 November 2008. The budget allocated by the European Commission for the GridCOMP projects amounts 1 750 000 EURO.

For more information see: http://gridcomp.ercim.org

7.1.5 XtreemOS

The overall objective of the XtreemOS project is the design, implementation, evaluation and distribution of an open source Grid operating system (named XtreemOS) with native support for virtual organizations (VO) and capable of running on a wide range of underlying platforms, from clusters to mobiles.

The approach we propose in this project is to investigate the construction of a new Grid OS, XtreemOS, based on the existing general purpose OS Linux. A set of system services, extending those found in the traditional Linux, will provide users with all the Grid capabilities associated with current Grid middleware, but fully integrated into the OS. The underlying Linux will be extended as needed to support VOs spanning across many machines and to provide appropriate interfaces to the Grid OS services.

Installed on each participating machine, the XtreemOS system will provide for the Grid what an operating system offers for a single computer: abstraction from the hardware, and secure resource sharing between different users. It would thus considerably ease the work of users belonging to VOs by giving them (as far as possible) the illusion of using a traditional computer, and releasing them from dealing with the complex resource management issues of a Grid environment. By integrating Grid capabilities into the kernel, XtreemOS will also provide a more robust, secure and easier to manage infrastructure for system administrators.

The XtreemOS consortium composition is a balance between academic and industrial partners interested in designing and implementing the XtreemOS components (Linux extensions to support VOs and Grid OS services), packaging and distributing the XtreemOS system on different hardware platforms, promoting and providing user support for the XtreemOS system, and experimenting with Grid applications using the XtreemOS system. Different end-users are involved in XtreemOS project, providing various test cases in scientific and business computing domains.

The main objectives of the XtreemOS project are:

- To build a reference open source Grid operating system based on Linux for PCs, clusters and mobile devices;
- To provide a simple Grid API compliant with Posix while adding new functionality and supporting Grid-aware applications;
- To identify fundamental functionalities to be embedded in Linux for secure application execution in Grid environments;
- To develop a set of self-healing OS services for secure resource management in very large dynamic grids;
- To aggregate cluster resources into powerful Grid nodes by integrating single system image mechanisms in Linux;
- To build an XtreemOS flavour for mobile devices enabling ubiquitous access to Grid resources;
- To validate the design and implementation of the XtreemOS Grid operating system with a set of real use cases in scientific and business domains on a large Grid testbed,
- To promote XtreemOS software and create communities of users and developers.

Partners' Role

The consortium for this IP project is made of a significant number of industrial partners as well as leading research centers and universities.

On the industrial side, several partners (Edge-IT, NEC, RedFlag Software, Telefonica and Xlab) are strongly committed to take part in the implementation, packaging and distribution of the XtreemOS software; others (EADS, EDF, T6, and SAP) will provide real important test cases.

Regarding the academic side, partners with important background on operating system, distributed system and Grid computing domains (INRIA, CCLRC, CNR, BSC-CNS, ULM, VUA, ZIB) are involved in the XtreemOS IP project.

This combination of partners is a good mixture between top-level research activities, industrial experience, and end-user needs.
The high involvement of industrial partners in this project will also help to end-up with a final and usable product as well as to have real end-users able to use the new technology right away.

For more information see: http://www.XtreemOS.org

7.1.6 European & Chinese Cooperation On The Grid (EchoGRID)

EchoGRID will foster collaboration in Grid research and technologies by defining short-, mid-, and long-term vision in the field.

- **Establish** a common Grid research agenda, relying on European and Chinese experts, both from academia and industry
- **Consolidate** this vision and promote cross-fertilisation between Grid-related projects and initiatives in Europe and China by interacting with the Grid research and industrial communities
- **Exchange** experiences and best practices by selecting Grid Open Standards for Grid middleware and applications interoperability and by promoting the identification of guidelines for building a Standard Quality Assurance Process
- **Support** lasting cooperation and establish tangible partnerships in the field through support activities and tools, ranging from a mobility programme for researchers, to a dedicated partner search engine.

For more information see: http://echogrid.ercim.org/

7.1.7 Bilateral Research and Industrial Development Enhancing and Integrating Grid Enabled Technologies (Bridge)

Bridge is a project funded by the EC under the FP6-IST programme. The project will start in January 2007 and is scheduled for 2 years.

It will demonstrate the benefits of Grid technology for international cooperation, in particular between Europe and the target country China.

By joint research efforts of European and Chinese research teams, the BRIDGE project aims at enhancing the Grid technology for both scientific and industrial applications. Bridge is based on previous research and development achievement of European and Chinese projects. It addresses major technical issues, which result from the far distance of the collaboration partners as well as from the conflicting goal of intense collaboration and protection of intellectual property rights.

For more information see:http://www.scai.fraunhofer.de/bridge-Grid.html

7.1.8 Business Experiments in Grid (BEinGRID)

BEinGRID runs eighteen business experiments designed to implement and deploy Grid solutions in industrial key sectors. Complementing this work, a knowledge and toolset repository will be developed consisting of Grid service components and best practices to support European businesses with the take-up of Grid.

The main objective of the Business Experiments in Grid project, which has recently been selected for funding by the European Commission's Grid Technologies F2 Unit, is to foster the adoption of the so-called Next Generation Grid technologies by the realization of several business experiments and the creation of a toolset repository of Grid middleware upper layers.

Grid technology is at a critical transition as it moves from research and academic use to wider adoption by business and enterprise. The use of Grid technology brings many benefits such as the optimisation of IT resources and increased business flexibility with consequent reductions in overall cost and risk for end-users. Grid enables large complex systems to be utilised effectively, allows the sharing of networked resources and also supports new business processes across distributed administrative domains. The lack of business reference cases to persuade potential users to explore the business benefits of this important new technology is leading to weak commercial exploitation of Grid solutions across the EU. Increased general deployment of Grid technologies into the market will strengthen the EU´s competitiveness and leadership in this key area. The mission of BEinGRID is to establish effective routes to foster the adoption of Grid technologies across the EU and to stimulate research into innovative business models.

China partner: Beijing Water Authority

For more information see: http://www.beingrid.eu

7.1.9 OMII Europe[67]

The OMII-Europe project is funded by the EU, within the framework of the Sixth Framework Programme for Research and Technological Development (FP6), as part of the specific programme 'Structuring the European Research Area', within the 'Research infrastructures' activity.

The OMII-Europe vision is to harvest open-source, Web-Services-based, Grid software from across Europe and to supply these key Grid services in a form that will enable them to inter-operate across heterogeneous infrastructures, in particular gLite, UNICORE and Globus. The OMII-Europe project is providing a number of computer/computer clusters at sites throughout the Europe and China. Each of these

[67] http://omii-europe.com/wiki/attach/JRA1ChineseComponents/D-JRA1-14.doc

sites has a different middleware stacks deployed - they will later contain components from the OMII-Europe repository. An Evaluation Infrastructure is currently deployed at Edinburgh (with Globus 4.0.3), FZJ (Unicore 5) and at PSNC (gLite 3.0). Smaller Evaluation Infrastructure systems are provided at Southampton (OMII-UK Distribution 3.2), INFN (gLite 3.1 preview release) and Beihang and Tsinghua Universities (CROWN Grid 2.6). The creation of accounts process has not been determined as yet.

The goal of the Components Exchange activity under JRA1 of OMII Europe is to promote the exchange of software components amongst the European and the Chinese Grid middleware providers. It is a two year project and OMII-China[68] are not funded, lead by BeiHang University also includes three other institutions: Institute of Computing Technology (ICT), The Computer Network Information Center, and Tsinghua University. OMII-China is seen as one of the major Chinese Grid research and development forces in China developing both the CROWN Grid middleware[69] and the Vega GOS middleware[70] used in CNGrid[71]. All the activities are led and coordinated by OMII-UK, based at Southampton University.

In the 12 months to April 2007 the project has achieved:

- Analysis of the platforms to identify the suitable components for exchange
- Define different exchange and integration plans and carry out the integration work
- Built demonstrators to prove the feasibility of our integration plan
- Participate in UK AHM and OGF meetings and demonstrate our systems
- Host OMII-China working visits.

The most recent workshop was held at National e-Science centre in Edinburgh with Guangwen Yang, Department of Computer Science, Tsinghua University in June 2007[72].

OMII-China decided to take four prime components as their direct integration targets, which will be integrated one by one as man power permits. The integration order will be GridSAM, OGSA-DAI, GridSphere and finally VOMS.

IMII-Europe evaluated the job scheduler, hot-remote service deployment and the Grid Process (Grip) from the CROWN middleware, and has identified the first exchange of components to enable the CROWN Grid Scheduler to work on the OMII stack.

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[68] http://www.omii-china.org/cn/index.htm

[69] Hailong Sun at. el. CROWN Node Server: An Enhanced Grid Service Container Based on GT4 WSRF Core Available at http://doi.ieeecomputersociety.org/10.1109/GCCW.2006.30

[70] Guojie Li at. el. The Vega Grid and Autonomous Decentralized Systems. Available at http://ieeexplore.ieee.org/iel5/8499/26870/01194641.pdf

[71] X. Xie et. al. CNGrid Software 2: Service Oriented Approach to Grid Computing. Available at http://www.allhands.org.uk/2005/proceedings/papers/577.pdf

[72] http://www.nesc.ac.uk/action/esi/contribution.cfm?Title=790

A demonstration system built around the OMII meta-scheduler has shown the interoperability between the CROWN and OMII platforms. It also shows the way towards resolving the interoperability problem among any Grid platforms. That is the need for a unique web service interface for creating, monitoring and controlling the job execution and computation activities on any job execution end points. The Basic Execution Service (BES) schema has been developed and evolved particularly for this purpose. Both Components Exchange partners have heavily involved in the BES specification development and verification. We expect that BES will become a standard web service schema in the near future.

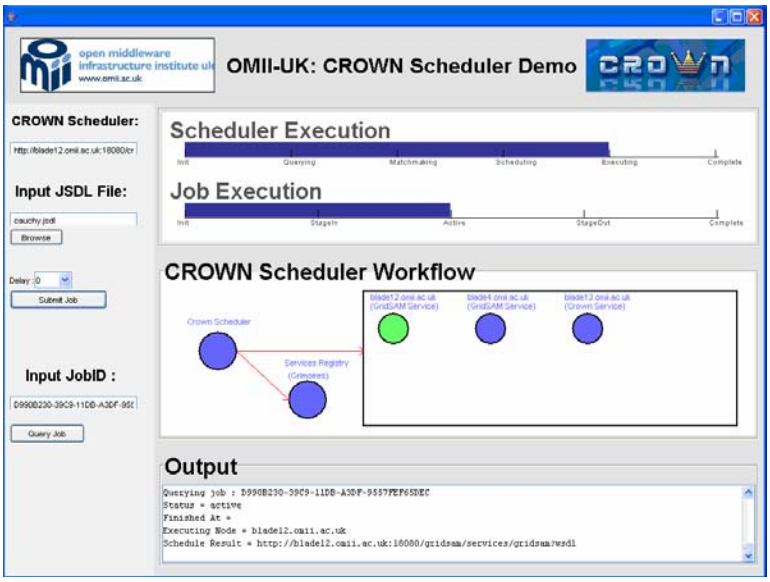

Figure: Screen capture of the OMII CROWN scheduler

In the year from April 2007 OMII Europe will continue to develop the CROWN BES meta-scheduler and convert it from a demonstration system into a product that will become a key contribution to the OMII-Europe repository. Taking advantage of the software engineering and integration expertise at OMII-UK Southampton, it will go through the OMII-UK integration process and becomes a component of the OMII-UK Software Release prior to release into the OMII-Europe repository.

OMII-Europe started in May 2006 with 16 established partners.

- University of Southampton, UK
- Fujitsu Laboratories Europe, UK
- Forschungszentrum Juelich, Germany
- Kungl Tekniska Högskolan, Sweden
- Istituto Nazionale di Fisica Nucleare, Italy
- Poznan Supercomputing & Networking Center, Poland
- University of Edinburgh, UK
- CERN, European Organisation for Nuclear Research, Switzerland
- University of Chicago, USA
- NCSA, University of Illinois, USA
- University of Southern California Los Angeles, USA
- University of Wisconsin-Madison, USA
- Beihang University China
- China Institute of Computing Technology, China

- Computer Network Information Centre, China
- Tsinghua University China

7.2 International Grid activities linking to China

As well as funded projects, several international standards bodies and NGO include Chinese collaboration on issues relating to the Grid.

7.2.1 OGF GIN (Grid Interoperability Now)[73]

GIN has 5 current focus teams working on describing a few islands of basic interoperable services on participating production Grids. The GIN are collecting a set of "How-TO" descriptions of recommendations for people trying to use resources from multiple grids.

After an introductory workshop, planned by representatives from nine Grid projects, in February 2006 the OGF GIN have formed sub-groups as outlined below and have expanded to roughly 20 Grid projects actively involved and/or tracking progress.

Information Services - led by Laura Perlman (ISI) and Satoshi Matsuoka (TIT). This group has been identifying a subset of information items that can be used as a common minimum set, and has been working on translation of these to and between GLUE and CIM.

Job Submission - led by Steven Newhouse. This group has been identifying commonly used job submission mechanisms with the goal of identifying a common mechanism, in some cases involving a translation between the native job submission scheme of a Grid facility and the common mechanism. They have identified Globus GRAM and JSDL, with potential for BES in the longer term.

Data Movement - led by Erwin Laure. This group is focusing on interoperation within two "islands" of technology, with parallel efforts in the SRM and SRB communities. In addition, the groups are working together to finalize an SRM interface to SRB, allowing for interoperation. Interoperation of GridFTP has also been exercised and documented.

Authorization and Identity Management - led by Dane Skow. This group is developing policy and experimenting with cross-domain authorization using VOMS technology.

Applications - led by Cindy Zheng (Pragma). This group has used one application to help the technical sub-groups to verify interoperation. Based on this experience additional applications will be added (see next steps).

There is no identified participation in the OGF GIN by China.

[73] `http://forge.ogf.org/sf/go/projects.gin/wiki`

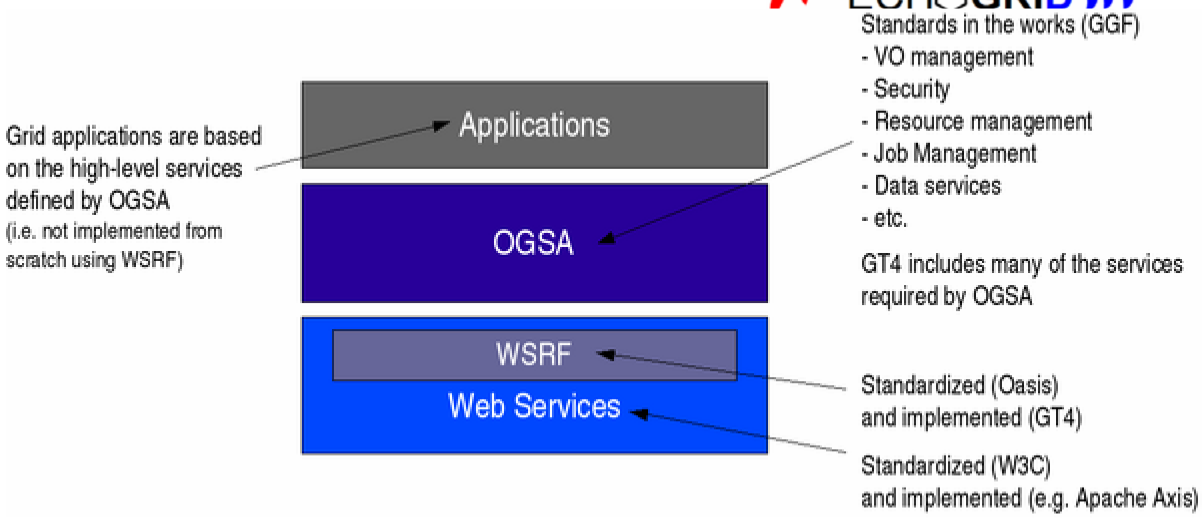

Figure: The Globus Toolkit 4 OGSA stack

7.2.2 ICANN

ICANN, which oversees the DNS (Domain Name System) at the heart of the Internet's operation, is an independent organization but is based in Marina Del Rey, California, and has close ties to the U.S. government.

It has been at the centre of a recent heated debate over control of the Internet. Representatives of China and other countries have voiced concerns about disproportionate U.S. power over the Internet. One of the main reasons for the creation of the IGF was to address these concerns.

ICANN calls China the greatest source of 'instability' on the Internet because of Chinese censorship introducing deviations from a fully hierarchical root which creates the possibility that there will be name collisions, leading to inconsistent results.

The Chinese Internet Network Information Center (CNNIC), oversees the country's .cn top-level domain.

7.2.3 IGF[74]

The Internet Governance Forum (IGF) is run by the IGF Secretariat. Its purpose is to support the United Nations Secretary-General in carrying out the mandate from the World Summit on the Information Society (WSIS) with regard to convening a new forum for multi-stakeholder policy dialogue - the Internet Governance Forum (IGF).

Issues addressed by the IGF[75] include internationalization of domain names and diversity, access and telecoms liberalization, security and privacy, openness of content, and other issues of governance. At present the IGF does not explicitly address Grid issues, although it will need to if the Grid develops as expected.

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[74] http://www.intgovforum.org/

[75] http://www.intgovforum.org/Substantive_2nd_IGF/Updated%20matrix%20of%20issues%20related%20to%20the%20Internet%20May%202006.pdf

There is no identified participation in the IGF or the WSIS by China.

7.2.4 W3C

W3C is a consortium which develops standards for core web technologies. These include the core technologies for Web Services (e.g. SOAP, WSDL, WS-Addressing, WS-Policy) which are the heart of the OGSA Grid architecture on which many of the Grid activities are based. The membership of W3C includes developer and vendor companies, government bodies, universities and research organizations as well as large and small user organizations. It operates through establishing working groups which develop specific standards. W3C has representation on the ICANN board of directors and the IGF advisory group.

W3C is structured with the regional hosts to cover the globe, with responsibility for Europe is based in France, responsibility for China is based in the US. W3C also operates national or regional offices, which are represented in both Hong Kong[76] and Beijing[77]. The role of W3C offices is to attract members to join the standards generation process, and to promote standards within the region they address. The W3C offices are performing the second role in their local areas, but there are a negligible number of active members in China, whereas about a third of members are European organisations. The impact of offices within the W3C organization depends very much on the individuals involved.

The host of the Hong Kong office is the The Hong Kong University of Science and Technology where the manager is Prof Vincent Yun SHEN who was Founding Head of the Computer Science Department and has been science advisor to the Government of the Hong Kong Special Administrative Region.

The host of the Beijing office is Beihang University where the manager is Prof.Huai Jinpeng who holds positions and titles of Vice president of Beihang University, Leader of computer division of China's 863 projects, Leader of China's e-government standardization, Syndic of China Computer Federation and Member of Consultative Committee of China's Information Construction and Committee of Chinese Journal of Computers.

The WWW conference and one of the two W3C Advisory committee meetings in 2008 will be held in Beijing.

7.3 Obstacles to Future Collaborations

There exist several non-technical obstacles to future collaborations which must be considered in developing the roadmap and recommendations for action.

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[76] http://www.w3c.org.hk/index.html.hk
[77] http://www.chinaw3c.org/

The need for strong English communication skills, both oral and written, among Chinese graduate students is paramount. Many graduate students speak reasonably fluent English, many computer science textbooks used in classes are in English and some courses are now taught in English. This suggests that communication will be less of a problem as time goes on.

Several major corporations as well as SME and research laboratories have established links with China. The downside of these collaborations is that the Western organizations such as Google, Microsoft and Yahoo have received bad publicity in the Western media[78] as a result of the perception that they are supporting values not generally held in the West. It is necessary for Western organizations to assess the risks of such perceptions, and balance them against the potential long term gains of establishing relationships in China.

The Chinese emphasis on publication in journals rather than in conferences – a result of the emphasis on SCI and EI indexing and differences between SCI/EI publication driven research and impact driven research more common in the U.S. and Europe – may pose obstacles to collaboration with European researchers working in the major/core computer science fields where publication in highly competitive conferences leads to greater visibility and attention from the community[79].

Many funded projects in Chinese universities are now closely related to the economic development of the country. These would not be defined as basic research projects in the U.S. or Europe, and that may pose another obstacle to collaboration with European academic researchers. However, the Chinese funded research projects are aligned to the applied level of EU funded Framework Programme IST and ICT programmes of DG INFSO & Media so researchers who gain benefit from these programmes, are likely to be aligned to the level of Chinese research.

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78 http://www.amnestry.org.uk/china

79 Based on, Report to National Science Foundation: Insightful Understanding of China's Higher Education and Research in Computer Science and Information Technology. U.S. Senior Computer Scientists Delegation Visit to China, May-June 2006; http://dimacs.rutgers.edu/Workshops/China/

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