D-Grid Future

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1 History

In 2003, German scientists and scientific organizations started the D-Grid initiative [German D-Grid Initiative, website www.d-grid.de], publishing a strategic paper in July 2003. This paper examined the status and consequences of grid technology for scientific research and recommended a long-term strategic grid research and development initiative. This resulted in the German e-Science Initiative initiated by the Federal Ministry for Research and Education (BMBF) in March 2004, together with a call for proposals in the areas of Grid Computing, e-Learning, and Knowledge Management. In November 2004, the BMBF presented the vision of a new quality of digital scientific infrastructure which will enable our globally connected scientists to collaborate on an international basis; exchange information, documents and publications about their research work in real time; and guarantee efficiency and stability of the resources and services even with huge amounts of data from measurements, laboratories and computational results. For this vision, the term 'e-Science' has been established internationally.

2. Current Status

D-Grid as part of the e-Science Initiative and started September 2005. BMBF is funding over 100 German research and industry organizations with 100 Million Euro over the next 6 years. The goal is to design, build and operate a network of distributed, integrated and virtualized high-performance resources and related services to enable the processing of large amounts of scientific data and information. The Ministry for Research and Education is funding the assembling, set-up and operation in several overlapping stages:

1. D-Grid-1, 2005-2008: IT services for scientists, designed and developed by the 'early adopters' of the computer science community. This global services infrastructure will be tested and used by so-called Community Grids in the areas of high-energy physics, astrophysics, medicine and life sciences, earth sciences (e.g. climate), engineering sciences, alternative energy, and humanities.

2. D-Grid-2, 2007-2010: IT services for scientists, industry, and business, including applications in industries such as automotive, aerospace, construction, finance, geo information, machinery, and IT services, among others.

D-Grid-1 consists of the DGI Integration project and the following seven Community Grid projects:

- AstroGrid-D (Astronomy)
- C3-Grid (Earth Sciences)
- HEP Grid (High-Energy Physics)
- InGrid (Engineering)
- MediGrid (Medical Research)
- TextGrid (Scientific Libraries)
- WISENT (Knowledge Network Energy Meteorology)

Short-term goal of D-Grid is to build a grid infrastructure prototype for the German scientific community, until the end of 2007. First test and benchmark computations will be performed by the Community Grids, to provide feedback to DGI. Then, climate researchers of the C3-Grid, for example, will predict climate changes much faster and more accurately than before, to inform governments about potential measures. Similarly, astrophysicists will be able to access and use radio-telescopes and

supercomputers remotely via the grid, resulting in novel quality of research and the resulting data and information.

2.1 D-Grid Integration Project

Scientists in the D-Grid Integration project DGI are developing and implementing a set of basic grid middleware services which will be offered to the other Community Grids. For example, services include access to large amounts of distributed data in the grid, the management of virtual organizations, monitoring and accounting. In addition, a core-grid infrastructure will be built for and provided to the community grids for testing and experimentation. High-level services will be developed which guarantee security, reliable data access and transfer, and fair-use policies for computing resources. This core-grid infrastructure will then be further developed into a reliable, generic, long-term production platform which can be enhanced in a scalable and seamless way, such as the addition of new resources and services, distributed applications and data, and automated "on demand" provisioning of a support infrastructure.

An important aspect in every grid is security, especially with the industry such as e.g. automotive and aerospace. Therefore, a large DGI work package is "Authentication and Authorization". It is important to know that a user is really the one she pretends to be, and that she is authorized to access and use the requested resources. While enterprise grids are mostly operating behind firewalls, global community grids use security technology like VOMS, Virtual Organization Membership Service. However, building and managing so-called Certificate Authorities is still a very cumbersome activity.

The following D-Grid DGI integration services are now available for the D-Grid-1 and for the D-Grid-2 community projects:

• The core D-Grid infrastructure offers central grid services. New resources can be easily integrated in the help-desk and monitoring system, allowing central control of resources to guarantee sustainable grid operation.
• DGI offers several grid middleware packages (gLite, Globus und Unicore) and data management systems (SRB, dCache und OGSA-DAI). A support infrastructure helps new communities and "Virtual Organizations" (VOs) with the installation and integration of new grid resources via a central Information Portal („Point of Information"). In addition, software tools for managing VOs are offered, based on the VOMS and Shibboleth systems.
• Monitoring und Accounting prototypes for distributed grid resources exist, as well as an early concept for billing in D-Grid.
• DGI offers consulting for new Grid Communities in all technical aspects of network and security, e.g. firewalls in grid environments, alternative network protocols, and CERT (Computer Emergency Response Team).
• DGI partners operate „Registration Authorities" to support simple application of internationally accepted Grid Certificates from DFN (German Research Network organization) and GridKA (Grid Project Karlsruhe). DGI partners support new members to build their own „Registration Authorities".
• Core D-Grid is offering resources for testing, via middleware systems (gLite, Globus and Unicore). The Portal Framework Gridsphere serves as the graphical user interface. Within the D-Grid environment the dCache system takes care of the administration of large amounts of scientific data.

2.2 Community Grid Projects

A detailed description of each of the following community grid projects can be found in [Heike Neuroth, Martina Kerzel, Wolfgang Gentzsch (Eds. 2007). German Grid Initiative D-Grid. Universitaetsverlag Goettingen and http://webdoc.sub.gwdg.de/univerlag/2007/D-Grid_en.pdf] and on the D-Grid website. The High-Energy Physics Grid community (HEPCG) is developing applications and components for evaluating terabytes of data from large high-energy physics experiments, including the Large Hadron Collider at CERN. AstroGrid combines research institutions in astronomy and astrophysics into a single, nationwide virtual organization for distributed collaboration and integration of distributed astronomical data archives, instruments and experiments.

MediGRID represents the medical and bio-informatics community in Germany. It focuses on application scenarios in medical image processing, bioinformatics, and clinical research, and their interaction. C3Grid for the Collaborative Climate Community develops a highly proficient grid-based research platform for the German earth-system research community to efficiently access and analyze distributed, high-volume scientific data from earth-system modeling and observation. For In-Grid, the Industry applications grid project, a grid environment will be developed to enable modeling, optimization, and simulation of engineering applications from areas such as foundry technology, metal forming, groundwater flows, turbine simulation, and fluid-structure interaction. The TextGrid project is developing tools and standard interfaces for publication software, modules for scientific text processing and editing, and administration and access to distributed data and tools on the grid. Finally, WISENT is developing tools and methods in the area of energy meteorology to accurately forecast energy usage to be matched with energy provisioning on demand.

In D-Grid-2 there is a stronger focus on grids with industry participation, with more than 40 companies involved. The new grid projects will all be using the D-Grid core infrastructure developed during the first years of D-Grid. The AeroGrid project aims at providing an efficient grid-based working environment for the national aerospace research community. BauVOGrid develops an extensible Construction-Community-Solution as the basis for next generation VO grid services. The BIS-Grid project intends to realize a horizontal Service Grid for business information systems, by developing and providing organizational and technical extensions based on the current state of the art in grid technologies, EAI, and SOA. The main objective of Biz2Grid is to provide foundations for an effective application of grid technologies in enterprises. Two case studies from commercial scenarios within the automotive industry gain specific attention as “best practice” for future business grid solutions. D-MON’s vision is to realize a D-Grid wide monitoring architecture across several underlying, heterogeneous systems taking in consideration multiple resource providers, virtual organizations. The F&L-Grid project has the goal to set up a service grid for IT services for research and education, on the base of the German Research Network (DFN). The concept is open also to small and medium enterprises. FinGrid strives to identify services and processes in the financial services sector and to develop grid-based systems that enable financial service providers to reorganize their processes efficiently and to realize applications that have been impossible so far in terms of computational requirements. The GDI-Grid project is integrating geo-information technologies with grid technologies in order to establish a Spatial Data Infrastructure Grid. Evaluation is with three scenarios: spatial simulation of flood disasters - flood hazard; noise dispersion simulation for noise pollution predictions; and real-time route optimization for disaster management. IVOM aims at designing a D-Grid wide management infrastructure for Virtual Organizations, ranging from PKI-based VOMS to Shibboleth-based my-Vocs. IVOM will also identify remaining gaps on the way to an interoperable and integrated VO management in D-Grid. PartnerGrid develops a platform for the co-operation of companies on the basis of D-Grid, with special focus on small and medium enterprises. Main objectives of the ProGRID project are to utilize grid technology for collaborative product development and to demonstrate benefits by means of use cases for virtual product development. Finally, SuGI’s major task is to disseminate the knowledge of grid technology and to spread its use, addressing small and medium academic computing centers as well as small and medium enterprises.

Potential next steps, within the D-Grid-3 phase, will extend the D-Grid infrastructure with a business layer (including work on Service Level Agreements), and a knowledge management layer (including maintenance, utilization, and preservation of digital data and objects), encouraging and connecting global service-oriented architectures in the industry, and using this grid infrastructure for the benefit of our whole society.

3. The D-Grid Company

On January 1 2008, the D-Grid Company (D-Grid Development and Operation GmbH) has been founded. The main objective of the D-Grid GmbH is to support development, operation and maintenance of a sustainable Grid Infrastructure for German research, industry and commercial users, in a professional way. This includes implementation and usage of accounting tools, operational procedures and consulting and training for the users. In more detail, main tasks of the company are:

- Coordination of all D-Grid projects funded by the German Government
- Development and implementation of Grid-Economy models for financing a sustainable operation of the open grid infrastructure
- Support of research projects to investigate new technology developments in grid and grid-related fields
- Collaboration in national and international standards organizations
- Planning of a Grid Operation Center to coordinate operation of grid resources
- Consulting and training for grid users
- Implementing a set of maintenance and support services (GERT – Grid Emergency Response Team)
- Organization of technical workshops and conferences in the grid field
- Marketing communications to create awareness and attract new user communities.

To obtain a leading position in the international competitive scene, the D-Grid GmbH has to be the link between research organizations and the industry, to account for the need and to support the grid usage of the industry and the applied research, and to transfer the research results from the universities to the applied research organizations and the industry, in a timely manner.

To this end the D-Grid GmbH is aiming at a close collaboration with the German universities, research centers, and the industry, starting with the currently funded D-Grid projects and their participating partner organizations. In addition, the company intends to closely collaborate with other national and international grid projects, grid initiatives and organizations.

4. D-Grid Future

How will the Internet evolve under the influence of the new grid technologies? It will certainly take another few years until we see the next-generation Internet which allows access to compute resources and services as easy as the access to billions of Web sites today. For this to happen we have to continue to improve the new e-science infrastructure in projects such as D-Grid, to fully benefit from the availability of and access to vast amount of resources and services in a transparent way. Here are a few thoughts on a roadmap for research, industry and society to achieve this goal:

Research:

- Development of user-friendly and automated grid infrastructure building blocks with standard interfaces for easily building local and special grids (e.g. campus grids in universities) and of global grids for international research projects, to collaboratively use resources distributed in the Internet, such as computers, storage, applications, and data.
- Adaptation of application software for grid infrastructure and services, in areas like physics, chemistry, biology, weather, climate, environment, bioinformatics, medicine, aero- and fluid mechanics, oil and gas, economy, finance, and so on.
- Participation in and contribution to standardization organizations such as OGF, OASIS, and W3C, and to European organizations such as ESFRI and e-IRG.
- Development of training material and organization of training course to learn how to build, operate and use grid infrastructures.
- Encourage independent grid resource and application service providers, developing new operational and accounting models, utility computing, and service level agreements.
- Integration of local, national, and community grids into national, European and international grid infrastructures.
- Overcome mental, legal and regulatory barriers, via case studies, demonstrators, and pilot projects.

Industry and Business:

- Development of new enterprise IT infrastructures based on OGSA (Open Grid Services Architecture) and SOA (Service Oriented Architecture), with SLOs (Service Level Objectives) and SLAs (Service Level Agreements) to mapping business processes to resource and application usage in an enterprise.

- Global enterprise grids to network all resources of globally distributed branches, partners and suppliers, and for seamless integration of new companies after merger or acquisition.
- Close collaboration with research to efficiently transfer reliable global grid technology to the industry.
- Partner grids for close collaboration with business partners and suppliers, to optimize distributed product development, complex workflows for multi-disciplinary processes and applications, productivity and quality improvement through global "Six Sigma" processes.
- Sensor Grids, Wireless Grids, and RFID Grids to enable communication and interaction of electronic devices e.g. for safety reasons in airplanes, cars, bridges, skyscrapers, and for consumer products logistics optimization.
- Evaluate and operate new forms of distributed computing business models such as utility computing, cloud computing, service subscription, etc.
- Development of local and global training grids to support active and interactive, flexible and dynamic education of enterprise personnel .

Society:

- Development of grids for the masses, in areas such as healthcare (illness, fitness, sensor-based monitoring of bodily functions), leisure (multi-player games, digital entertainment, sports), education (life-long learning, school grids, digital interactive laboratories), and work (Internet-based courses, online training, global teamwork, collaboratories).
- Starting with pilot projects in these areas, partnering with end-users (consumers), application service providers, and resource providers.
- Utilization of grid resources and services for education in schools, universities, and in enterprises. Integration of grid resources and interactive applications and simulations into existing curricula will dramatically improve motivation and creativity of the learners (and teachers).
- Development of personal digital assistants including technology and service infrastructure for the mass market.
- Integration of these new applications for the masses into user-friendly browser-based web portals.

In the near future, on an enhanced Internet, all kinds of service providers will offer their services for computing, data, applications, and many other services. On an enhanced World Wide Web, via secure Web Portals, we will access grid components and services like Lego, which enable us to dynamically build grids 'on the fly', according to our specific application needs. We will rent or lease the resources required and pay for what we use or based on a subscription fee. We still might have our own resources, to fulfill a certain basic or average need, or for highly proprietary applications, which can seamlessly be extended 'on demand' with resources from service providers, available on the grid. But, as already said, this will still take a few years.

As with any new infrastructure, development and deployment of the next-generation Internet will require vision and endurance. We have to work continuously on strategic, long-term projects on a national and international scale which demand collaboration of research and industry on complex inter-disciplinary projects and which will enable and improve the tools of our scientists, business people, and educators and strengthen our position in the international competition.