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ON GRID TECHNOLOGY IN SCIENCE, MEDIA AND INDUSTRY

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ABSTRACT

In the past decade, several national programs for establishing Grid-infrastructures for computationally and data expensive scientific research fields were started. The understanding of the term Grid technology will be given first and the distinction in using this technology in science, media and industry/business is discussed.

The German E-Science initiative which started in September 2005 is presented in more detail. The project InGrid, in which the author is involved, for scientific, engineering applications, and collaboration in modelling, simulation and optimization is pointed out with its research goals.

For the use of Grid technology in industry the concept of business Grids is discussed and the state of the current research in this area based on value chain analysis is given. Here the focus is put on the use of Grid technology in small and meduim sized enterprises (SME). As an outlook the role of service-oriented computing is discussed.

Keywords: Grid technology, culture Grid, business Grid, SME, service-oriented architecture (SOA)

1. INTRODUCTION

In the past decade, several efforts for establishing Grid-infrastructures for both computationally and data-volume expensive scientific research fields were started (s. [1] and [2]). Most of the approaches in Grid-technology were mainly developed, studied and used in scientific communities (e-Science). These activities, in most cases nationally promoted, incorporate the "Cyberinfrastructure"-program of the United States (www.communitytechnology.org/nsf_ci_report/), e-Science in Great Britain (www.rcuk.ac.uk/escience/), NorduGrid in Sweden (www.norduGrid.org), DutchGrid and the Virtual Laboratory for e-Science in the Netherlands (www.dutchGrid.nl), GRID.it in Italy (www.Grid.it), in Japan (/www.jpGrid.org/english/), the activities of the European Commission (www.cordis.lu/ist/Grids/index.htm) or, since 2003, the D-Grid-Initiative in Germany (www.d-Grid.de).

In this context, the term "Grid-technology" is understood as consolidation of geographically distributed physical resources (computer, memory, networks), information resources (databases, archives, sensors), software services and human expertise, forming a holistic and uniformly accessable resource and using the internet as the carrier for communication. According to the use of the electrical power Grid for multiple purposes and – in this context – independence of location and time, the metaphor of computer power from the wall outlet is used. Since the major use of today's internet is the presentation, (re)calling and sharing of information which is embodied in documents, Grid-technology with its extended possibilities (e.g. service calls) is also referred as the "next-generation Internet".

2. GRID AND SCIENCE

The CERN in Geneva, Switzerland with its world spread networked research groups, their computers, analysis resources and the particle accelerator as an expensive research laboratory and measuring data source for high energy physics is considered as pioneer and demonstration example for holistic usage and development of the resource Grid. The world's largest Grid, the Large Hadron Collider Computing Grid (LCG), is currently built for experiments at CERN which are going to start in 2007. The LCG consists of more than 100 sites spread among 31 countries, using resources at the local institutions such as universities and research centres. The final Grid system will consist of 10.000 processing units (CPU's) and a total memory amount of approximately 10 million gigabytes. This Grid project is essentially promoted by the EU under the label "Enabling Grids for E-SciencE" (EGEE, http://public.eu-egee.org/).

As one can see in the LCG-project-example, the existing world wide research activities are mainly focused on improving and extending scientific possibilities by using Grid technology for fundamental research, assuming their cooperative utilization. Guided by British scientists, this vision emerged to a global collaboration, trying to achieve scientific research goals in computationally and data-volume expensive domains such as life science, biology, particle physics, astronomy, chemistry or material science, since the term "e-Science" (where *e* stands for "extended" or "enhanced") was established in the year 2000. As another root of Grid computing, multidisciplinary simulation and optimization as well as cluster computing has to be mentioned, originated by impulses from the aerospace and automotive industry.

The extensions of scientific possibilities provided by Grid technology are based on the scientist's demand of being globally networked, having easy access to high performance computing centres for evaluating his theses efficiently and quickly while on the other hand having access to remote data sources and high end visualization systems. By utilizing simulation, the third pillar of science besides theory and experiment, considerably more complex model simulations and therefore scientific questions can be tackled. Model systems from various domains can be coupled and – on that account – virtualized problems can be studied inside a computer – in many cases more quickly and precise than in reality. In the majority of cases, the constantly increasing quantity and complexity of the needed knowledge, belonging to various domains, overextends scientists. This barrier can be vanquished by well-organized international collaboration, based on a Grid-infrastructure. For coordinating the activities on this field, researchers and scientists in computer science and the IT industry established international committees (e.g. the Global Grid Forum (GGF, http://www.Gridforum.org/)) and standardization approaches (e.g. the Open Grid Services Architecture (OGSA, http://www.globus.org/ogsa/)) for specifying fundamental and relevant Grid-functionalities.

In September 2005 the German Ministry of Education and Research (BMBF) started an initiative to set up a national D-Grid infrastructure (s. Fig. 1). It consists of six projects.

There is one generic Grid infrastructure project (DGI), developing fundamental Grid services based on middleware for access to computing resources and large amounts of data, management of virtual organizations, authentication and authorization, security, metadata catalogues, resource brokerage, network technologies, monitoring and accounting. In addition, there are five community Grids.

The Astro-Grid is bringing together astrophysical and astronomical scientists within a virtual, distributed, collaborative laboratory with integrated data archives, and access to scientific experiments and instruments.

The C3-Grid stands for Collaborative Climate Community. The C3-Grid`s goal is to develop a highly productive Grid-based research platform for the effective scientific analysis of high-volume Earth modelling and observation data.

The HEP-Grid focuses on high-energy physics and is closely collaborating with the already mentioned CERN Hadron Collider Grid community.

The InGrid (s. also Fig. 2) is developing a Grid environment for modelling, simulation and optimization of engineering applications in the areas of casting technology, sheet metal forming, groundwater transportation, turbine simulation, and fluid and structural mechanics.

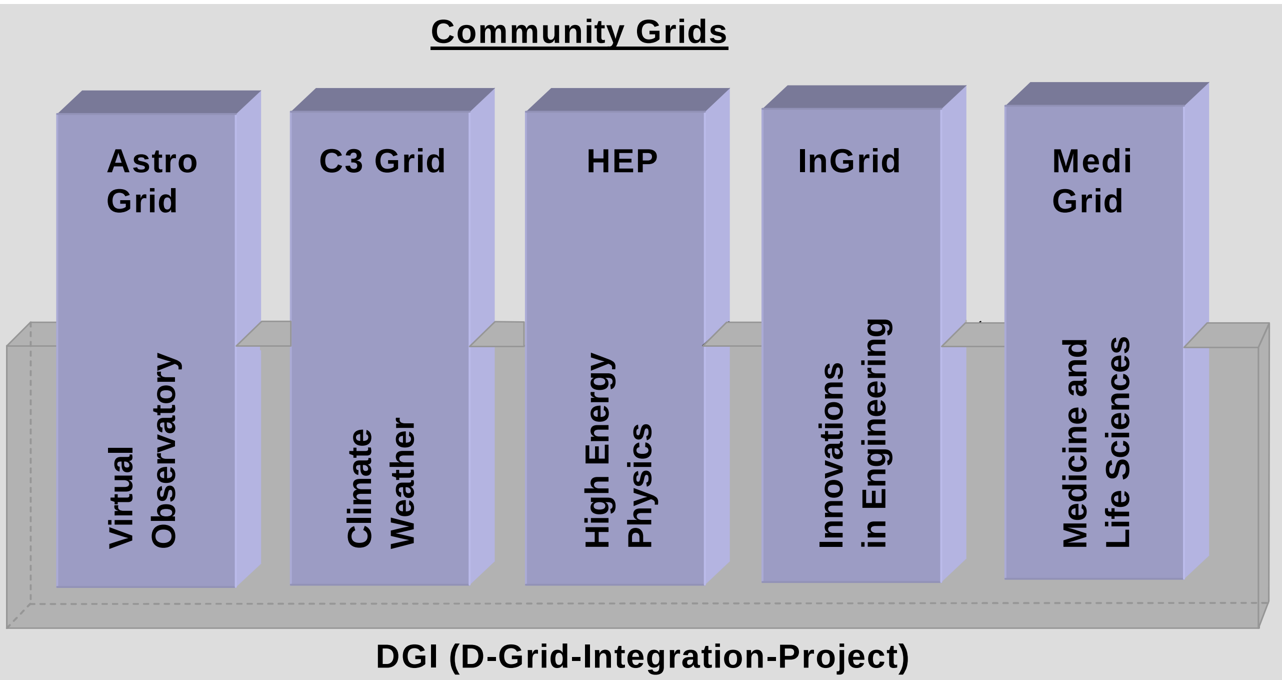

Figure 1: Structure of the German D-Grid/E-Science-Program

The Medi-Grid represents the German medical-bioinformatics community collaborating on image processing, bioinformatics and clinical research, and their intercommunication.

niques of various digital culture projects. This way, the mandatory necessity of a “Culture Grid” for extending possibilities in cultural science is brought into context. Among others, extensive multimedia data collections,

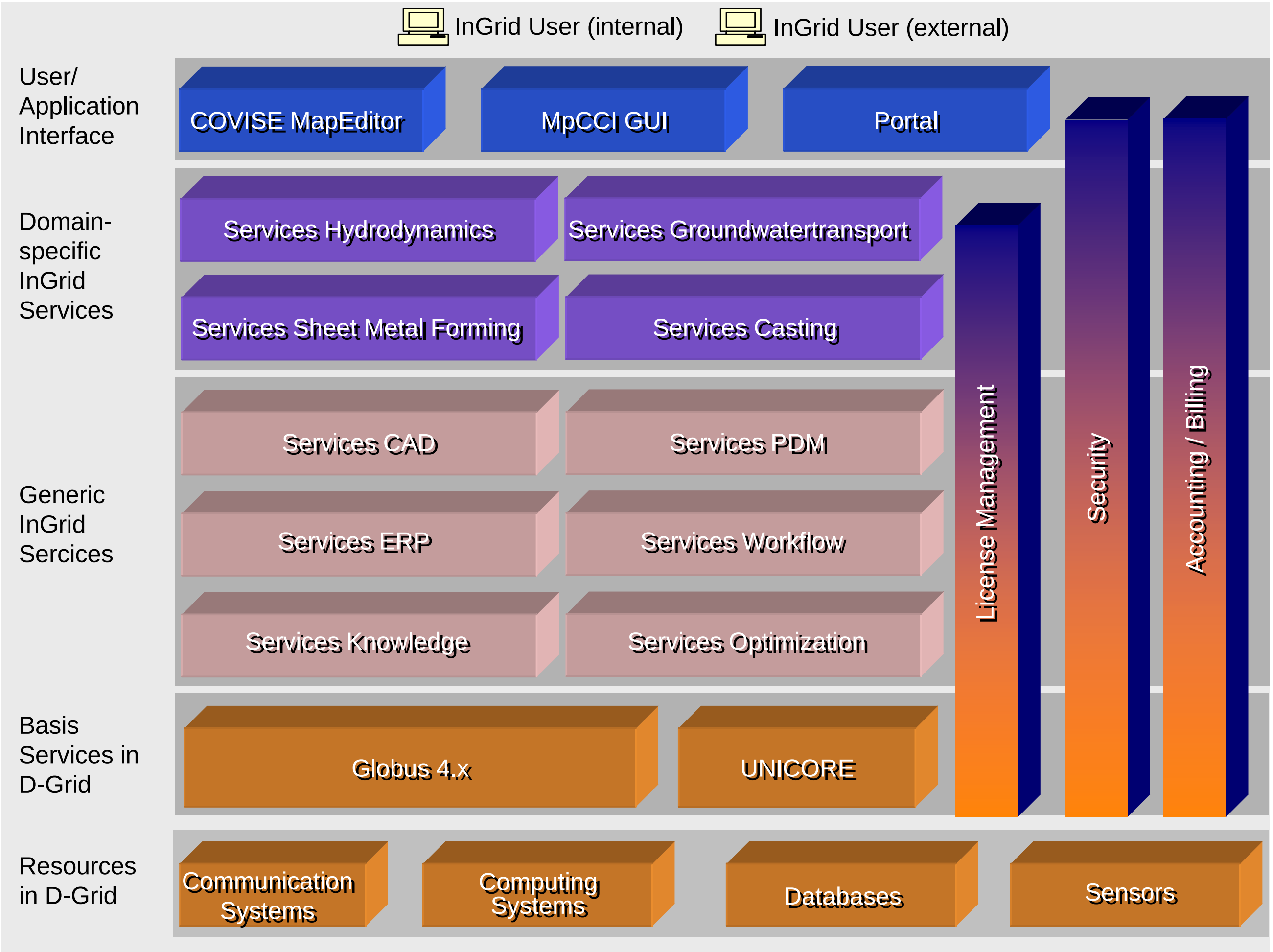

Figure 2: Structure of the InGrid project in the erman D-Grid initiative

brought into existence because of conservation and restoration of works of art, are referred. Furthermore, compute intense applications are mentioned, dealing with different subjects e.g. virtual reconstruction of objects of fine art like sculptures or buildings as well as the possibility of spatiotemporal contextualisation dedicated to subjects of cultural science.

The role of Grid technology in media research can be shown by a project in developing a Media Grid for the analysis of audiovisual media. This project belongs to the research which is supported by the national German science foundation DFG (www.fk615.uni-siegen.de/).

3. GRID AND MEDIA

Besides the described utilization of Grid technology in natural sciences and engineering, a comparable concept is promoted since the 5^{th} EU Framework Programme; the project “e-Culture Net” (www.mmi.unimaas.nl/eculturenet/) aims on the digital availability of the cultural assets of Europe for every EU-citizen. The creation of a “Distributed European Electronic Resource” is planned, providing a distributed virtual repository for European cultural resources and being accessible via portals for EU citizens. Furthermore, the basis for innovative scientific work in the domain of cultural science shall be created, which is only possible because of the novel networking tech-

4. GRID AND INDUSTRY

The exploration of the benefit of Grid technology for economic, value-added processes under market-economy conditions (non-cooperative usage of Grid technology) – as it is subject to applied sciences like engineering or economics – is actually in its initial stage. The use of Grid-technology in such scenarios require not only the research in Grid-economy and adequate corresponding business models; they are challenging computer science in terms of scalability, security, standardization, resource management, software engineering and system design and architecture. But it is also assumed that the creation of such an economic benefit has a feedback on the optimal configuration and adaptation to changing business conditions (reengineering) of engineering and economic-organizational value-added networks.

The use of Grid-technology under the terms of the aforementioned economic competitive conditions provides a set of economic benefits and potentials for enterprises. Predominantly, virtual prototyping supports the engineering divisions of an enterprise to reduce the amount of time needed for design, development and production for innovative products – the so called "time-to-market". The Grid concept provides access to IT technology, which a single enterprise (particularly with regard to small and medium sized enterprises, SME) can not afford. The approach therefore of course offers the possibility to reduce the total costs for the IT systems of the particular enterprise (the so-called "Total-Cost-of-Ownership"). Another benefit exists in the reduction of intra- and inter-enterprise transactional costs of business processes. These transactional costs can be designed more efficiently in all their appearances, like initiation, bargaining, execution, controlling, adaptation and achievement. Furthermore, the continuity and persistency of the engineering – as well as the economic-organizational business processes and workflows – are contributing in the reduction of transactional costs. Another economic benefit is a higher availability and reliability of highly specialized IT systems and infrastructures accessed by utilizing Grid technology in contrast to company-owned ones. In consequence, utilizing the IT infrastructure has to be dynamic and it has to meet the demands of the user, combining and recombining it like utilities, which was not possible even with state of the art application service providing approaches.

To raise the potential, a simple, secure and transparent access to the distributed computing power of the Grid is needed, crossing enterprise- and state borders, bringing on demand of security, integrity and confidentially of all data and applications for both simultaneous cooperative utilization (along the value creation chain) and non-cooperative utilization of the distributed resources (as competitors on the open market). The used IT-systems within the scope of such a value creation have to be liable to a pre-concerted and guaranteed service level agreement, incorporating corresponding sanctions due to a non-fulfilment. The accounting of utilized distributed Grid services should be possible with powerful automatic pricing mechanisms – like auctions with intelligent software agents – rather than extensive economic or juristic efforts.

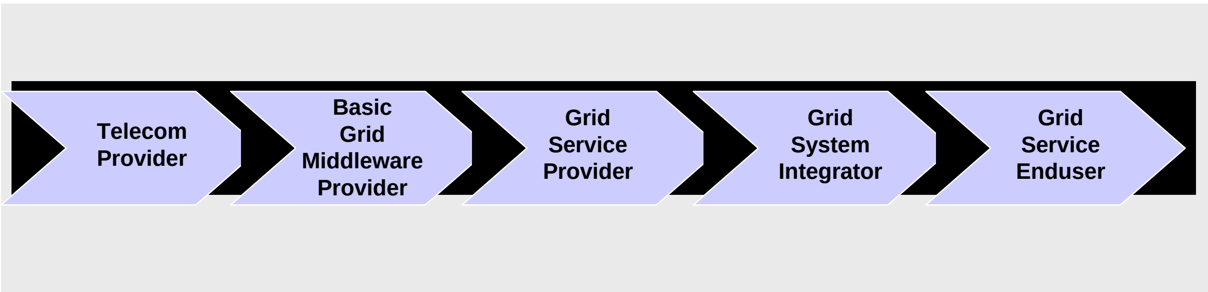

Figure 3: Value chain in a business Grid experiment under research

As an example based on current experiments the value chain for SME`s using Grid services will be presented (s. Fig. 3). One can identify three potential roles inside such a value chain: Grid services end-users, Grid service providers and Grid system integrators.

In order to make end users realise the benefits of Grid services, they need to be integrated in appropriate projects. This integration can only take place by utilizing prerequisite resources, e.g. a telecommunication infrastructure to connect and use a network as well as a middleware to integrate different software systems across institutional boundaries. According to this observation, two other roles in the value chain have to be considered: the telecom operator as well as the basic middleware provider.

Figure 3 shows an exemplary value chain for such integration projects. Starting at the left side of the value chain, the telecom operator provides the necessary network/internet connectivity for low value and ubiquitous communication. The computing service, which the Grid end user receives, results from the cooperation of a basic Grid middleware provider and one or more Grid service providers. The basic middleware provider integrates possibly heterogeneous devices and resources of the service providers. This way both the basic middleware provider and the service providers employ Grid technology for the realization of service oriented computing. As mentioned before, the Grid service provider hosts the computing devices and resources. In addition to that, the specific applications have to be employed to address the Grid end user's problems. Then the combination of software, hardware and middleware is wrapped up as a Grid service.

This ongoing experiment in using Grid technology with five SME`s from the field of automotive supplier industry is led by the author. This research is supported by the state ministry of science and research of Northrhine-Westfalia (s. http://www.miGrid.de/). The focus is on using Grid computing facilities for simulation and optimization in sheet metal forming and casting processes in these small and medium sized enterprises.

5. CONCLUSION

According to [3] we have to deal with the solution of complex problems in every sector, from traditional science and engineering domains to such areas as national security, public health, and economic innovation. It seems that Grid technology using advances in computing and connectivity gives the chance to address problems previously intractable. These future problems are predominantly multidisciplinary, multi-agent, multi-objective, multi-scale and collaborative.

For the future the Grid computing model and service-oriented architecture (SOA) is seen to be highly complementary (s. [4], [5], [6]). In a combined Grid and SOA approach, applications are deployed as loosely coupled Web Services to be consumed and reused by different users and applications with Grid management tools.

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