Industry involvement in Grid standardization

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Abstract. Originally developed to enable resource sharing within scientific collaboration, the evolution of the Grid technologies has gathered momentum during the last few years, with a significant increase in the range and complexity of Grid applications, as well as in the number of actors involved in Grid deployment. This paper discusses the expansion of the Grid constituency beyond universities to include significant commercial involvement, and explores the tensions and alliances between the two major constituencies forming the global Grid community –industry and academia. The interaction between the two Grid communities is illustrated through a discussion of the Grid standardization arena. The study finds that with growing commercial participation, the future of the Grid is shaped by three major trends: strong competition between the large Grid industry actors, tight collaboration between industry and academia in standardizing the Grid, and finally a dissipation of the boundaries that traditionally characterized the industry and academic efforts in technology (Grid) development.

Introduction

Grid computing emerged during mid 1990s as a form of distributed computing that involves coordinating and sharing resources across dynamic and geographically dispersed organizations. Grid applications make use of coupled computational resources that are not available at a single site, by pooling together resources that could not be coupled easily before (Laforentza, 2002). The goal is to create the illusion of a simple, yet powerful self managing virtual computing out of a large collection of connected heterogeneous systems sharing various combinations of resources (Berstis, 2002).

Originally developed to enable resource sharing within scientific collaboration, the evolution of the Grid has gathered momentum during the last few years, with a significant increase in the range and complexity of Grid applications, as well as in the number of actors involved in Grid deployment. The expansion of the Grid community beyond the universities raises a number of questions in terms of the outcomes that the growing industry involvement will have on the future of Grid development.

This paper discusses the expansion of the Grid community to include commercial participation, and explores the tensions and alliances between the two major constituencies forming the global Grid community –industry and academia. The paper explores the relevance that the growing industry involvement in Grid standardization has for the future of the Grid.

The Grid: technology and standards

Grid computing is often defined in relation to the different computing technologies that are supported. For example, Grid computing is seen as a form of distributed computing that involves coordinating and sharing computing, application, data, storage, or network resources across dynamic and geographically dispersed organizations (http://itmanagement.webopedia.com/TERM/G/grid_computing.html). Grid can be defined as a form of networking which, unlike conventional networks that focus on communication among devices, harnesses unused processing cycles of all computers in a network for solving problems too intensive for any standalone machine (http://searchcio.techtarget.com/sDefinition/0,,sid19_gci773157,00.html). Grid computing can also be thought of as distributed and large-scale cluster computing, and as a form of network-distributed parallel processing (http://dsonline.computer.org/0402/d/ o2004a.htm).

According to Foster and Kesselman (2004), the Grid is "a system that coordinates distributed resources using standard, open, general purpose protocols and interfaces to deliver nontrivial qualities of service" (pg. 46). Grid computing thus focuses on enabling flexible, secure and coordinated large-scale resource sharing in distributed systems (Joseph et al, 2004). Such resources include computing power, application, data, storage, and network resources. Unlike conventional networks that focus on communication among devices, Grid computing harnesses unused processing cycles of all computers in a network for solving problems too intensive for stand-alone machines.

The Grid environment is highly heterogeneous, incorporating different networks, machines, operating systems, file systems, as well as different versions of the underlying Grid infrastructure. Therefore, protocols and interfaces are required to address issues such as authentication, authorization, resource discovery and resource access. Like the World Wide Web, the Grid is relying on openness and standardization to achieve global interoperability. Standardization allows the Grid to establish resource-sharing arrangements dynamically with any interest party, so that both open source and commercial products can interoperate effectively in the heterogeneous and multi vendor Grid world. Grid is build on Internet standards such as TCP/IP, HTTP, SOAP, XML, and more recently web services standards such as WSDL (web service description language) and WSRP (web service for remote portals) developed within IEFT and W3C and OASIS. Over the years, a number of Grid specific standards have emerged such as OGSA (Open Grid Service Infrastructure) and OGSI (Open Grid Service Infrastructure) that specifying the Grid architecture and infrastructure developed within the Global Grid Forum (GGF), and lately the WSRF (Web Service Resource Framework) that replaces the OGSI standard and which is currently under development within OASIS (Berman et al, 2003).

At first, the Grid was targeted to support applications in natural sciences which required high computational power or access to large data sets. Grid academic applications range from life science applications such as the MCell in US to deploy Monte Carlo simulation to study microphysiology[1], to engineering applications including the NEESgrid developed at the University of Illinois to support earthquake engineering experiment and simulation[2] and to physical science applications like the UK GridPP used in particle physics analysis[3]. Most Grid applications are interdisciplinary, requiring collaboration between researchers from a number of disciplines such as scientific computing, engineering and physics, biology and medicine.

Commercial developments of the Grid: intersecting patterns of competition and collaboration

The success of the Grid applications in natural sciences opened the path for commercial usages. Grid computing has two main benefits which make possible a (potential) wide spread commercial deployment: increased utilization of existing resources in a cost-effective manner, and increased computer power (Smith and Konsynski, 2004). Grid computing could enable companies to share computing resources more effectively both within and outside organizational borders, hence supporting the emergence of the virtual organization (Foster et al, 2001). At the same time, as Grid computing enables the resources of many computers to be cooperatively and perhaps synergistically harnessed and managed, it offers improved scope for collaboration, in areas such as the supply chain or customer relationship management (Lloyd, 2005).

Competition between Grid industry players

As a result of the commercial potential of the Grid, during the last years, large IT vendors have become significant players in the development of Grid technologies. Commercial adoptions of Grid technologies, or at least the rhetoric of the Grid, include IBM's "World Community Grid", Sun's Grid vision, HP's Adaptive Enterprise, Oracles' 10g database and Microsoft's Bigtop. Table I summarized the approach to Grid of the largest IT vendors.

Table I. IT vendors and the Grid

Large IT vendors	**Grid vision**
IBM	In November 2004, IBM announced the development of the "World Community Grid" project to harvest unused processing cycles from underused PCs. The IBM's Grid vision is based on a tiers evolution beginning with intra-grids within the company, extra-grids with trusted partners to public or global grids that correspond to what industry calls utility or on demand computing.
Oracle	Oracle has adopted the Grid label for the latest version of its database software, 10g, which splits its database across a small but tightly linked network of servers.

1 http://www.mcell.cnl.salk.edu/

2 http://www.neesgrid.org/index.php

3 http://www.gridpp.ac.uk/

Large IT vendors	Grid vision
Sun	Sun has adopted a more bottom up approach in contrast with IBM, focusing its efforts initially on what they call cluster grids within an organization, based on the Grid Engine software. Sun sees such cluster grids projects gradually evolving into enterprise and global grids. Sun Microsystems' Grid vision is for a global Grid of computing power that users pay to make use of in the same way that they access the electricity distribution grid for electrical power.
HP	Hewlett-Packard has absorbed Grid computing within its Adaptive Enterprise effort to produce flexible corporate computing systems.
Microsoft	Microsoft has a project, Bigtop, developing tools to enable developers to create sets of loosely coupled, distributed operating systems components.

The Grid has thus become a central element in the product development strategies of IT systems suppliers, but each vendor has adopted an idiosyncratic approach and they diverge in their understanding of which technologies can be labeled as being part of the Grid.

The lack of cohesion within the Grid commercial market left many customers confused regarding the practical benefits of Grid applications. Additionally, Grid is still an emergent technology, and many of the existing software and models are not yet fully tested against a commercial background. Therefore, up to date, Grid commercial applications have been limited, with only a few companies daring to embark on Grid projects (Smith and Konsynski, 2004). Such commercial Grid projects range from applications in the financial services to the automotive and pharmaceutical industries. For example Charles Schwab piloted a project with the IBM to use Grid technologies to handle the recommendation of optimal portfolio[4], Magna Steyr has implemented a project with IBM to optimize the simulation of clashing time between overlapping components of a model[5] and GlaxoSmithKline has implemented a Grid solution provided by the United Devices for modeling and simulation of drug effects on the human body[6].

Consequently, the existing market for Grid commercial applications is highly fragmented, the largest IT vendors pursuing different visions of what Grid commercial applications look like: IBM and Sun emphasize the outsourcing of computing power, HP uses the Grid to facilitate data storage, while for Oracle, Grid represents an extension of clustering capabilities in its databases to allow several instances of the database to work in tandem and to share the processing load across different machines. Grid computing thus still possesses significant flexibility in its interpretation, with the existing commercial actors associating a wide range of problems and solutions to the "same" concept[1]. This diversity in the meanings associated with the Grid results from a divergence in the major players' interests who aim to fit the Grid within their current product strategies, while at the same time it reflects a wide range of customer (potential) requirements that these vendors address with their "Grid" offerings.

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4 http://www.informationweek.com/story/IWK20030131S0031

5 http://www-306.ibm.com/software/success/cssdb.nsf/CS/DNSD-652H2J?OpenDocument&Site=

6 http://www.ud.com/rescenter/files/cs_gsk.pdf

What becomes the predominant meaning of the Grid concept in the commercial arena will emerge from the competition between the large IT vendors who each attempts to impose its own interpretation as the dominant, “true” Grid.

The competition between the IT vendors’ Grid visions reflects in the Grid standardization arena, which is currently characterized by a plethora of private, industry driven standard consortia all addressing specific areas of the Grid standard development. A primary objective of these private consortia is to support the commercial adoption of the “Grid”, as understood by the community represented in that consortium, and not necessarily to work together towards the development of industry wide Grid standards. Table II provides an overview of the major consortia addressing Grid specific standards:

Table II. Private Grid standard consortia

Name	**Date**	**Founders**	**Objective**	**Collaboration with other consortia**
New productivity initiative (NPi)[7]	April 2000	HP, Compaq, Platform Computing	To develop common approaches for the implementation of distributed resource management.	In April 2002, NPi merged with GGF to bring commercial direction to the GGF, and to accelerate the work on interoperability.
Data Centre Markup Language (DCML)[8]	October 2003	smaller IT vendors like Computer Associated, EDS, Opsware and TIBCO	To develop a standard data format for sharing information between IT management systems and codifying management policies to enable automation and utility computing.	In an industry-wide effort to support the convergence of web services and the grid, in August 2004, DCML announced the movement of its technical and marketing activities to OASIS.
Utility Computing Working Group (UCWG)[9]	February 2004	IBM and Veritas; Cisco Systems, EMC, HP, IBM, Oracle, Sun	To create interoperable and common object models for utility computing services within the DMTF's Common Information Model (CIM).	The initiators for the UCWG announced their intention for collaboration with other Grid fora including GGF and OASIS.

7 http://www.pulsipher.org/npia

8 http://www.dcml.org/

9 http://www.dmtf.org/about/committees, part of the Distributed Management Task Force (DMTF).

Name	Date	Founders	Objective	Collaboration with other consortia
Enterprise Grid Alliance (EGA)[10]	April 2004	Oracle, Sun, HP, Network Appliance	Focuses on Grid within enterprise data centers, within and between trusted and secure enterprises, but it does not address virtual organizations.	According to EGA, the alliance collaborates with other forums including GGF, OASIS, W3C and DMTF.
Globus Consortium[11]	January 2005	IBM, HP, Sun and Intel	To accelerate the commercial development of Grid computing.	They are not focused at the present on developing standards.

As seen in the table above, these private standard consortia are characterized by overlapping membership and jurisdiction, often representing divergent interests between dominant Grid players and/or groups of smaller IT vendors. For example, the creation of DCML was the response of smaller IT vendors to what they saw as the attempts of the large IT players such as IBM, to control the Grid standardization arena (for example through their strong involvement in the Globus Alliance), an thus the future of the Grid technologies. In a similar way, there is strong competition between some of the largest Grid players – IBM and Oracle – who occupy different, opposing areas within the Grid standardization arena (for example the Oracle driven EGA versus the IBM driven Globus Consortium) – while a range of other players (like HP and Sun) position themselves in different consortia, thus apparently supporting different interests. By participating in different standard consortia, such players manage not only to protect against the high market uncertainty that characterizes emergent technologies markets such as the Grid, but they are also able to widen the scope of their influence over negotiations involving Grid standards, and maybe also to obstruct their rivals from getting their exclusive interests translated into the process.

At the same time, the consortia's collaboration announcements, even if genuine, refer not to collaboration between themselves – i.e. collaboration between different consortia addressing Grid standardization in specific areas of application – but to collaboration with higher level standard bodies such as GGF, Oasis and W3C which develop generic Grid standards that constitute the foundation for these specific area standards.

Collaboration between industry and academia

Despite the fierce competition that characterizes Grid commercial developments, most of current academic Grid developments are emerging through tight collaboration between a number of industry players and academic partners. Most of the largest Grid commercial players are involved in a number of Grid projects in close collaboration with the academia and with each other to advance the development of Grid technologies. IBM's collaborative

10 http://www.gridalliance.org/en/index.asp

11 http://www.globusconsortium.com/index.html

Grid projects include, in the EU for example, the D-GRID[12] initiative in Germany, DEISA[13] and E-diamond[14], and together with HP and Oracle, IBM is also part of the CERN OpenLab[15] project.

Such industry-academia collaborations are particularly strong in Grid standardization, with the industry players becoming strongly represented in the standardization arenas not only through establishing private Grid consortia, such as EGA (Oracle) and Global Consortium (IBM), but most importantly through their involvement in the academic driven standardization initiatives such as the Globus Alliance and later the GGF.

Globus Alliance was established in 1995 as the Globus Project[16] by the Argonne National Laboratory, the University of Southern California's Information Sciences Institute and the University of Chicago to support the development of an open source software for Grid management – the Globus Toolkit. In 1997, the open source Globus Toolkit version 1 (GT1) emerged as de facto standard for Grid computing, followed in February 2002 by the release of GT2. The majority of the GT "standards" were neither formal, nor subject to public review. However, some elements of the GT1 were codified in formal technical specifications and reviewed within standards bodies such as elements of the Grid Security Infrastructure and the GridFTP data transfer protocol which were proposed as extensions of existing standards (GSS-API and FTP standard) to the IETF. By 2003, the now called Globus Alliance added two European members as key partners: the University of Edinburgh in Scotland and the Swedish Center for Parallel Computers, launched an academic affiliate program, and gained large industry involvement, including IBM, Microsoft and Cisco Systems. The enlargement of the initially US based university project both internationally and in what concerns the area of application (from academic to commercial partners) enabled Globus Alliance to gain access not only to other kinds of expertise required in developing the Grid but also to essential funding for Grid projects that would normally not be funded from national research agencies, such as software hardening projects.

Significant industry involvement into the Globus activities led to changes in the Globus Toolkit to address the industry concerns. As such, Globus has been retooling its Globus Toolkit Grid management software to use Web-services standards which have wide industry support (for example the GT3 and GT4 which show an increasing convergence with the web services) in an attempt to make the technology more business friendly. GT is moving to the web service standards so the software will more easily integrate with business computing infrastructure. GT2 was already using web services specification, and with the release of the GT3, Globus supports "real" standards, developed within standard consortia which are preferred by industry partners to non-standard solutions. GT3 supports OGSI standards developed within the academic driven GGF, while GT4, whose first release is expected in 29^{th} of April this year (http://www-unix.globus.org/toolkit/docs/development/4.0-drafts/GT4Facts/ index.html), will support WSRF developed within the IT vendor driven OASIS.

Since 1998, the development of Grid standards has moved under the auspices of the GGF, research community-driven standard consortium, created specifically for this purpose. The

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12 http://d-grid.de/

13 http://www.deisa.org/

14 http://www.ediamond.ox.ac.uk/

15 http://openlab-mu-internal.web.cern.ch/openlab-mu-internal/

16 www.globus.org

researchers from Globus Alliance were one of the key founding members of the GGF. The creation of the GGF came as a realization that a number of Grid efforts are replicated across the world due to a lack of communication between Grid researchers, which also leads to a lack of interoperability between the various Grid developments. Therefore, GGF was created to (1) support an open process for the development of agreements and specifications regarding the Grid; and (2) to serve as a forum for information exchange and collaboration between Grid researchers. GGF is deliberately modeled after the IETF, with similar working groups, documentation processes and workshop structure, as well as open participation and transparent distribution of information (Catlett et al, 2002).

Although originally a scientific community-driven initiative, over the years, commercial involvement in GGF has increased significantly. Presently, over 25% of the GGF participants represent industry members. GGF brings together all the major players in Grid computing including IBM, Computer Associates, Platform Computing, HP, Sun, Oracle and Microsoft.

Grid standards within the GGF remit include, for example, the OGSA and OGSI standards describing the Grid architecture and infrastructure released in July 2003. OGSA standards on which the GT3 implementation is based, extends GT2 standards and web service standards such as WSDL and XML Schema definitions, addressing at the same time the issues of transient and stateful services[3] (Foster et al, 2004). The development of OGSA/I standards was an attempt to align Grid standards with the broader industry initiative in the area of web services (de Roure et al, 2003; Laforenza, 2002). However the wide adoption of OGSI within the web service (industry) community proved to be problematic. Four major technical problems were associated with OGSI: the specifications were too complex, there was poor interconnection with existing web service and XML tooling, the standard was too object oriented and it used concepts from the unsupported WSDL 2.0 specification (Czajkowski et al, 2004). Following feedback on OGSI from the web service community, work on a new specification started during the summer of 2003.

In March 2004, IBM and Globus Alliance submitted to OASIS a new Grid specification – the WSRF - that replaces the former OGSI standard. WSRF represents a refactoring[2] of the OGSI to ensure a stronger alignment between Grid and web services standards. In contrast with the GGF, OASIS is and industry driven standard consortium formed in 1993 initially to develop the guidelines for interoperability among products using SGML. In 1998 SGML Open changed its name to OASIS to reflect the broadening range of its standardization activities, including XML and related standards including web service standards[17]. In March 2004 the WSRF Technical Committee was formed to work on the new Grid specifications. The WSRF Technical Committee includes companies such as IBM, Computer Associate, HP, Novell, Oracle and SAP.

This shift marked a change in the development of Grid specific standards, which moved out of the academic driven GGF consortium to the commercial driven OASIS standard forum. According to Ian Foster, one of the founders of the Globus Alliance and GGF, the change in the standard was primarily driven by the web service vendors who indicated that they would not adopt OGSI as it was then defined (http://dsonline.computer.org/0402/d/o2004a.htm). Globus and IBM justified the submission of WSRF to OASIS rather than GGF by the fact that WSRF is not a Grid standard alone, but a set of web services standards which are highly

17 Whereas W3C attempts to create robust standards for web services in a bottom-up style, e.g. SOAP, XML, and WSDL, OASIS' ebXML initiative focuses on providing an open SOAP/XML based infrastructure which comprehensively enables the global use of electronic business information. OASIS also develops the standard for directory service (UDDI).

relevant to the Grid. It was felt that such web services standards should be developed within organizations that focus on generic web service standard development, such as OASIS or W3C, and not in Grid specific standard organizations. Consequently, OASIS was selected to handle the development of the WSRF.

Shifting the boundaries between industry and academia

The growth in the industry involvement in the academic driven Grid consortia during the last years not only indicates an intensification in the collaboration between the two domains, but it also shifts the boundaries between the academic and the industry efforts in Grid standardization. Both Globus Alliance and GGF have started as academic initiatives to support Grid development based on open standards. Both consortia now include significant commercial participation, Globus in the form of sponsors, and GGF in the form of members. Such involvement has significant outcomes for the nature of academic driven Grid standards and technologies. For example, it is due to the strong IBM support of the Globus Alliance that the GT standards were incorporated into the IBM Grid tools and what was a standard developed for an by the academic world has pervaded into the commercial world. Currently, GT standards are included in a number of commercial products, for example Platform Computing has already incorporated the GT into its Platform Globus Toolkit, and SAP showed intention to integrate Globus within some of its business software modules. In a similar way, academic consortia team up with commercial actors and become involved in industry driven private standard consortia (Globus Alliance and IBM proposing the new Grid in OASIS).

At the same time, there is a shift from academia to industry, as academic driven Grid efforts are transported into the commercial world. In December 2004, a new company – Univa – was launched by the academic founders of the Globus Alliance (Kesselman and Foster) to commercialize the Globus Toolkit (http://news.com.com/Grid+gurus+launch+a+start-up/2100_-7339_3-5488374.html?tag=nl). The company is selling support and services for those who want to integrate Globus with their own products. The academic expertise is thus brought into the commercial world to enhance the development of commercial Grid applications.

Conclusions

The Grid is fast emerging as one of the most significant technologies today, and the commercial potential for Grid applications seems enormous. What started in 1995 as a North American academic project to test the network architectures and to explore their usefulness for end users, has now become a global phenomenon spanning geographical and disciplinary boundaries. The discussion of the Grid standardization arena has identified three trends that influence the role that the industry plays in shaping the evolution of the Grid:

First, large Grid commercial players compete not only for customers and markets, but also for defining the meaning of the “Grid” in a way which is compatible with their products strategies, and with their own customers (potential) requirements. Such competition reflects in the Grid standardization arena which is characterized by a plethora of private standard consortia, each addressing different, often overlapping areas of Grid standardization. Such consortia are driven by the commercial interests of their industry members, and are in general more opaque and less transparent than the largely academic driven GGF. At the same time, while the movement of WSRF to OASIS might ensure that Grid standardization remains open and transparent, it does bring to fore the interests of the industry (in particular IT vendors) rather than those of the academic community who had previously driven Grid standards development within GGF.

Second, whereas there is strong competition within the Grid commercial vendors, there is also tight collaboration between the commercial and the academic Grid developers & standardizers. Industry involvement in academic driven standardization – GGF - has grown significantly during the last years. The collaboration serves both parties: universities receive larger funds to pursue research into Grid development, whereas the industry is benefiting from the academic expertise. However, there are potential tensions between the different constituencies involved. Industry and academia have different requirements and different priorities, for example the importance of data security when deploying Grid technologies across organizational boundaries, or the emphasis on compliance with the web services. The industry seems to gain higher control over standard development with the move of the new Grid specification out of the remit of the GGF into the IT vendor driven OASIS. Such a development questions the role that the academia will play in the future in shaping Grid standardization.

Finally, as the originally academic driven Grid consortia (Globus Alliance and GGF) gain a growing industry support and involvement, the boundaries between the commercial and the academic Grid worlds become blurred. At the same time, the academia is finding new ways of shaping the development of Grid technologies, by going outside the university boundaries into the commercial world. The creation of Univa by the academic initiators of the Grid to support the commercialization of the Globus Toolkit suggests a new role that could be played by the academic researchers in influencing Grid development once the Grid becomes widely adopted into the commercial domain.

Notes

1. A significant distinction can be made between the flexibility in the interpretations of Grid technology definitions – distributing computing, networking, cluster computing – and in the concepts that commercial players use to market their Grid computing offerings. Where the former may influence the latter (i.e. different players emphasize different components of the Grid, focusing on the distributing computing or on cluster computing, which influences their approach to Grid computing and their meaning of what “the Grid” is). Though, this is not the only factor that influences the commercial actors’ approach to Grid computing.

2. Refactoring means improving a computer program, or in this case a standard, by reorganizing its internal structure without altering its external behavior. Refactoring is a collection of techniques that enable programmers to restructure code so that the design of a program is clearer. It allows programmers to extract reusable components, streamline a program, and make additions to the program easier to implement. Refactoring is usually done by renaming methods, moving fields from one class to another, and moving code into a separate method.

3. Web services are not transient, i.e. web services outlive their clients which means that data available to one client is potentially viewable and modifiable by another, and stateless, that is they do not remember from invocation to invocation what a client has requested or received. OGSA attempts to address these two problems by using extended WSDL and XML schema definitions to introduce the concept of stateful and transient web service through the introduction of the concept of “Grid services”

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