The Evolution of IT Standards in Academic & Commercial Communities: Grid Standardization

The Evolution of IT Standards in Academic and Commercial Communities: Grid Standardization

Raluca Bunduchi[1], Ian Graham[2], Robin Williams[3]

[1] Aberdeen University Business School, Aberdeen, Scotland

[3] Management School, University of Edinburgh, Scotland

[4] Research Centre for Social Sciences, University of Edinburgh, Scotland

Email address of corresponding author: i.graham@ed.ac.uk

Management School

University of Edinburgh

50 George Square

Edinburgh, EH8 9JY

Abstract.

This paper considers the emergence of institutions developing standards in a rapidly evolving area of information technology: Grid computing. Grid computing, with its aim of organizations sharing computer resources, inherently depends upon standardization. As grid computing as a technology has developed the community of actors involved has grown from a small homogeneous core of users in research institutes into a global constituency embracing large IT system vendors, leading to the formation of overlapping bodies outside the structures of formal international standardization to reconcile the needs of this diverse group. The study on which this paper is based formed one of a series of seven case studies exploring the social networks within which e-business standards are being negotiated, undertaken within the NO-REST research project, an EU research project studying the dynamics of e-business standardization (http://www.no-rest.org). This paper discusses the expansion of the Grid constituency, explores the tensions and alliances between the two major constituencies forming the global Grid community, industry and academia, and considers how standardization processes have evolved to accommodate these dynamics. It is found that with growing commercial participation, the future of the Grid is being shaped by three trends: strong competition between the large Grid industry actors, tight collaboration between industry and academia in standardizing the Grid, and the collaborative bodies formed to develop Grid standards increasingly becoming the arenas in which the technology is developed, alliances formed and conflicts resolved.

Introduction

Inter-operability in inter-organisational information technology depends upon standardization: the increasing benefits to users of adopting a technology shared amongst a wide community, in economic terms the existence of network effects or network externalities, creates an incentive for users to adopt a standard and join a wider community (Farrell & Saloner, 1985). Also, it is argued that the existence of network effects means that the standards which emerge will not necessarily be the most efficient, as argued by David (1985) in his analysis of the QWERTY keyboard, or lead to the emergence of competing standards, each trying to gain market dominance, the so-called "standards wars" (Shapiro & Varian, 1999), most famously seen in the competition between Betamax and VHS as the dominant design in video recorders (Besen & Farrell, 1994). The process of standardization itself influences the standards that become ubiquitous: through the ability of actors to build critical mass within their community and, most starkly, whether they decide to co-operate with other actors or try to impose their own vision of the technology, tempted by the possible income from intellectual property. This recognition of the importance of the processes and institutions of standardisation has coincided with a period of rapid change in these processes, most significantly in a movement away from national and international standardisation bodies, most notably ISO, towards standardization taking place within industry consortia. It has been argued that this change has occurred because the traditional formal standardisation mechanism are too slow to react to rapidly emerging technologies and that their structures, based on national representation, do not adequately represent the needs of users (David & Shurmer, 1996).

The EU-funded NO-REST project involved academic technologists, sociologists and economists from UK, Germany, Netherlands and Norway investigating the new dynamics of standardization in e-business. One element of this wider study was a series of studies of the institutional processes in which a range of inter-organisational IT standards are being negotiated. The studies built upon the insight that it should be possible to apply the conceptual frameworks of sociology of technology to standardization: a belief that standards are as much technological artifacts as mechanical devices are, shaped by the actors involved in their creation (Williams & Edge, 1996). These studies involved interviews with participants in standards bodies to uncover how they were shaping the emerging standards, with a particular interst in how they were collectively creating new institutions and organizations which could claim to be the legitimate body to develop standards in their area. The most rapidly evolving case studied was the emergence of processes for developing global standards for Grid Computing, which have had to accommodate a rapid growth in the number of interested actors and a movement out of academic computing, with its traditions for cooperation, into a constituency dominated by commercial enterprises, who have an interest in gaining competitive advantage from the standards.

Grid Computing emerged during the 1990s as term describing the use of networks of computers, often geographically widely dispersed, to process computationally intensive calculations. Grid Computing applications can use computational resources that are not available at a single site by pooling together resources (Laforentza, 2002). The vision underpinning Grid Computing is to create a powerful self-managing virtual computer out of a large collection of connected heterogeneous systems sharing resources (Berstis, 2002).

The earliest users of Grid computing were academic researchers sharing resources for complex calculations in the natural sciences, building upon the institutionalized co-operations existing amongst academic researchers. From these academic roots, the application of Grid Computing has grown 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. In particular, commercial IT system suppliers have become interested in Grid Computing, seeing this as a technology that can be adopted within large dispersed users or open up the possibility of computing power being traded as a utility. However, commercial users of Grid Computing come from a very different institutional milieu to academics, with needs to differentiate their products and to gain competitive advantage, the widening of the actors interested in Grid computing may create tensions within the extended community of actors. As an interorganisational network technology, it would be expected that the forums in which Grid standards are being agreed will become the arena in which these conflicts are resolved.

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. This research was undertaken as part of the EU-funded NO-REST research project, an EU research project studying e-business standardisation (http://www.no-rest.org), as one of a series of nine case studies to uncover the social dynamics in e-business standardization. The study drew on interviews with academic and commercial participants in the emergent Grid standards bodies.

The Grid: a technology built on 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 Computing can be defined as a form of networking that harnesses unused processing cycles of computers in a network for carrying out calculations too intensive for timely completion on a single computer (http://searchcio.techtarget.com/sDefinition/0,,sid19_gci773157,00.html). Grid computing can also be thought of as distributed, large-scale cluster computing, or as a form of network-distributed parallel processing (http://dsonline.computer.org/0402/d/ o2004a.htm).

The Grid environment is highly heterogeneous, incorporating different networks, machines, operating systems, file systems, as well as different versions of the underlying Grid infrastructure. Achieving interoperability across these distributed networks, which may be using diverse operating systems, requires standards. According to Foster and Kesselman (2004, p46), the Grid is “a system that coordinates distributed resources using standard, open, general purpose protocols and interfaces to deliver nontrivial qualities of service”. 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, so that both open source and commercial products can interoperate effectively in the heterogeneous and multi-vendor Grid world.

The earliest institutionalization of standardisation in Grid computing, the Grid Forum, emerged from a meeting at Supercomputing 1998, a US academic conference bringing together supercomputing researchers in universities and the private sector. The Grid Forum adopted the democratic structures seen in the IETF, based on open processes and consensus. Equivalent bodies quickly emerged in the grid computing communities in Europe and Asia, but by 2000 they had merged with the Grid Forum to form the Global Grid Forum (GGF). In seven years GGF, now renamed the Open Grid Forum (OGF), has achieved a de facto position as the legitimate standards development body in grid computing.

The Grid's infrastructure is built on Internet standards, including TCP/IP, HTTP, SOAP, XML, and web service standards, such as WSDL (web service description language) and WSRP (web service for remote portals) developed within IEFT, W3C and OASIS. TO supplement these generic network standards, Grid-specific standards have emerged to facilitate Grid applications, including OGSA (Open Grid Service Infrastructure) and OGSI (Open Grid Service Infrastructure), that specify the Grid architecture and infrastructure and were developed within the Global Grid Forum (GGF), and the WSRF (Web Service Resource Framework) that replaces the OGSI standard and was developed 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].

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

The success of Grid applications in natural sciences opened the path for their commercial use. Grid computing has two main benefits in commercial deployment: more intensive and efficient use of existing resources and short-term access to 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 harnessed and managed in networks of users, it offers improved scope for collaboration, in areas such as the supply chain management or customer relationship management (Lloyd, 2005).

Seeing Grid Computing as a commercial opportunity, 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, Oracle's 10g database and Microsoft's Bigtop. Table I summarizes the approach to Grid of the largest IT vendors.

---

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

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

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

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.

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 Computing is still an emergent technology, and many of the existing software and models are not yet fully tested against a commercial background. Therefore, Grid commercial applications have been limited, with only a few companies implementing Grid projects (Smith and Konsynski, 2004). Such commercial Grid projects range from applications in financial services to the automotive and pharmaceutical industries. For example, Charles Schwab piloted a project with IBM to use Grid technologies to calculate optimum investment portfolios[4] and GlaxoSmithKline has implemented a Grid solution to simulate the effects of drugs on the human body[5].

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. Clearly there is significant flexibility in the interpretation of the term Grid Computing, with the existing commercial actors associating a wide range of problems and solutions with the 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. 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 attempt to impose their own interpretation as the dominant, "true" Grid.

The competition between the IT vendors' Grid visions is reflected in the Grid standardization arena, which is characterized by a plethora of private, industry-driven standard consortia all

---

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

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

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)[6]	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)[7]	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	February 2004	IBM and Veritas;	To create interoperable and	The initiators for the UCWG announced their

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

7 http://www.dcml.org/

Working Group (UCWG)[8]	Cisco Systems, EMC, HP, IBM, Oracle, Sun	common object models for utility computing services within the DMTF's Common Information Model (CIM).	intention for collaboration with other Grid fora including GGF and OASIS.

8 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)[9]	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[10]	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 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), and thus the future of the Grid technologies. In a similar

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

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

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 led EGA versus the IBM influenced 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 themselves against the high market uncertainty that characterizes emergent technologies, but they are also able to widen the scope of their influence over negotiations involving Grid standards, and 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 OGF, 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 Grid projects include, in the EU for example, the D-GRID[11] initiative in Germany,

11 http://d-grid.de/

DEISA[12] and E-diamond[13], and together with HP and Oracle, IBM is also part of the CERN OpenLab[14] 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[15] 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

12 http://www.deisa.org/

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

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

15 www.globus.org

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 29th 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, a research community-driven standard consortium, created specifically for this purpose. The 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).

Grid standards within the GGF remit included, 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, extended 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. OASIS is an open standard body formed in 1993, initially to develop the guidelines for interoperability among products using SGML. Rather than an organization, OASIS is more accurately viewed as a process in which actors interested in developing a standard can set up a technical committee to develop a standard on the basis that they adopt OASIS's policies for openness and intellectual property. In March 2004 the WSRF Technical Committee was formed to work on the new Grid specifications. The WSRF Technical Committee included representatives from IBM, HP, Novell, Oracle and SAP.

This shift to development within OASIS marked a change in the development of Grid specific standards, which moved out of the academic oriented GGF consortium to the more commercially focused 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 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.

Although originally a scientific community-driven initiative, commercial involvement in GGF became increasingly significant. In September 2006 GGF merged with the Enterprise Grid Alliance (EGA), the commercially oriented collaboration facilitating grid computing in enterprises, further strengthening its position as the legitimate body for Grid standardization

Shifting the boundaries between industry and academia

The growth of industry involvement in the academic oriented 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 by the academic world has percolated 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.

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, Foster and Kesselman, to commercialize the Globus Toolkit (http://news.com.com/Grid+gurus+launch+a+start-up/2100 -7339_3-5488374.html?tag=nl). Univa 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 and the distinction between academia and industry further blurred.

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 more open OGF, which still involves significant academic involvement . 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 between the Grid commercial vendors, there is also tight collaboration between the commercial and the academic Grid developers and standardizers. Industry involvement in academic focused standardization – GGF - grew significantly, eventually leading to it being subsumed within OGF. 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. One effect of open standards processes, where influence is linked to the number of participants, is that as commercial interest increases the process will increasingly represent commercial requirements. Such a development questions the role that the academia will play in the future shaping of Grid standards.

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"

References

Berman, F., Fox, G. and Hey, T. (2003): 'The Grid: past, present, future', in F. Berman, G. Fox, and T. Hey (eds.) *Grid Computing: Making the global Infrastructure a Reality*, John Wiley & Sons, Chichester, 2003, pp. 9-50.

Bertis, V. (2002): *Fundamentals of Grid Computing*, RebBooks paper, IBM, **www.ibm.com/redbooks**

Besen, S. M. and Farrell, J. (1994) Choosing how to compete: Strategies and tactics in standardization. *Journal of Economic Perspectives* 8: 117-31.

Catlett, C., Foster, I., and Johnston W. (2003): *GGF Management*, GDF-C.3 Community Practice Document, GGF, **http://www.ggf.org/documents/final.htm**

Czajkowski, K., Ferguson, D., Foster, I., Frey, I., Graham, S., Maguire, T., Snelling, D. and Tuecke, S. (2004): 'From Open Grid Services Infrastructure to WS-Resource Framework: Refactoring & Evolution', version 1.1, 3/05/2004, **http://globus.org/wsrf/OGSI%20to%20WSRF%201.0.pdf**

David, P. A. (1985) Clio and the economics of QWERTY. *American Economic Review* 75: 332-37.

David, P.A., and Shurmer, M. (1996) "Formal standards-setting for global telecommunications and information services. Towards an institutional regime transformation?," *Telecommunications Policy*, 20:10, pp 789-815.

De Roure, D., Baker, M. A., Jennings, N. R. And Shadbolt, N. R. (2003): 'The evolution of the Grid, in F. Berman, G. Fox, and T. Hey (eds.) *Grid Computing: Making the global Infrastructure a Reality*, John Wiley & Sons, Chichester, 2003, pp. 9-50.

Farrell J. and Saloner, G. (1985) Standardization, compatibility, and innovation *Rand Journal* 16: 70-83.

Foster, I. and Kesselman, C. (2004): 'Concepts and Architecture', in: I. Foster and C. Kesselman (eds.): *The Grid: Blueprint for a New Computing Infrastructure*, Morgan Kaufmann Publishers (Elsevier), San Francisco, 2004, pp. 37-64.

Foster, I., Kesselman, C. and Tuecke, S. (2001): 'The anatomy of the Grid. Enabling Scalable Virtual Organizations', *International Journal of High Performance Computing Applications*, vol. 15, no. 3, Fall 2001, pp. 200-222.

Foster, I., Kesselman, C. and Tuecke, S. (2004): 'The Open Grid Service Architecture', in: I. Foster and C. Kesselman (eds.): *The Grid: Blueprint for a New Computing Infrastructure*, Morgan Kaufmann Publishers (Elsevier), San Francisco, 2004, pp. 215-257.

Joseph, J., Ernest, M. and Fellenstein, C. (2004): 'Evolution of grid computing architecture and grid adoption models', *IBM Systems Journal*, vol. 43, no. 4, pp. 624-645

Laforenza, D. (2002): 'Grid programming: some indications where we are headed', *Parallel Computing*, vol. 28, no. 12, December 2002, pp. 1733-1752.

Lloyd, A. (2005): 'The Grid and CRM: from 'if' to 'when'?' *Telecommunications Policy*, vol. 29, no. 2-3, pp. 153-172.

Shapiro C., Varian H.R. (1999) The Art of Standard Wars, *California Management Review*, 41, 2, 8-32.

Smith, H. and Konsynski, B. (2004): 'Grid Computing', *MIT Sloan Management Review*, vol. 46, no. 1, Fall 2004, pp. 7-9

http://itmanagement.webopedia.com/TERM/G/grid_computing.html

http://searchcio.techtarget.com/sDefinition/0,,sid19_gci773157,00.html

http://dsonline.computer.org/0402/d/o2004a.htm

http://news.com.com/Grid+gurus+launch+a+start-up/2100-7339_3-5488374.html?tag=nl

http://www-unix.globus.org/toolkit/docs/development/4.0-drafts/GT4Facts/index.html