BACKGROUND PAPER ON GRID COMPUTING
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Introduction

Increased network bandwidth, more powerful computers, and the acceptance of the Internet have driven the on-going demand for new and better ways to compute. Commercial enterprises, academic institutions, and research organizations continue to take advantage of these advancements, and constantly seek new technologies and practices that enable them to seek new ways to conduct business. However, many challenges remain. Increasing pressure on development and research costs, faster time-to-market, greater throughput, and improved quality and innovation are always foremost in the minds of administrators - while computational needs are outpacing the ability of organizations to deploy sufficient resources to meet growing workload demands.

On top of these challenges is the need to handle dynamically changing workloads. The truth is, flexibility is key. In a world with rapidly changing markets, both research institutions and enterprises need to quickly provide compute power where it is needed most. Indeed, if systems could be dynamically created when they are needed, teams could harness these resources to increase innovation and better achieve their objectives.

World Information Technology and Services Alliance

The World Information Technology and Services Alliance (WITSA) is a consortium of 60 information technology (IT) industry associations from economies around the world (list attached). As the global voice of the IT industry, WITSA is dedicated to:

- advocating policies that advance the industry's growth and development;
- facilitating international trade and investment in IT products and services;
- strengthening WITSA's national industry associations through the sharing of knowledge, experience, and critical information;
- providing members with a vast network of contacts in nearly every geographic region of the world; and
- hosting the World Congress on IT, the only industry sponsored global IT event.

Founded in 1978 and originally known as the World Computing Services Industry Association, WITSA has increasingly assumed an active advocacy role in international public policy issues affecting the creation of a robust global information infrastructure, including:

- increasing competition through open markets and regulatory reform;
- protecting intellectual property;
- reducing tariff and non-tariff trade barriers to IT goods and services; and safeguarding the viability and continued growth of the Internet and electronic commerce.

Grid Overview

Grid Computing delivers on the potential in the growth and abundance of network connected systems and bandwidth: computation, collaboration and communication over the Advanced Web. At the heart of Grid Computing is a computing infrastructure that provides dependable, consistent, pervasive and inexpensive access to computational capabilities. By pooling federated assets into a virtual system, a grid provides a single point of access to powerful distributed resources.

Researchers working to solve many of the most difficult scientific problems have long understood the potential of such shared distributed computing systems. Development teams focused on technical products, like semiconductors, are using Grid Computing to achieve higher throughput. Likewise, the business community is beginning to recognize the importance of distributed systems in applications such as data mining and economic modeling.

With a grid, networked resources -- desktops, servers, storage, databases, and even scientific instruments -- can be combined to deploy massive computing power wherever and whenever it is needed most. Users can find resources quickly, use them efficiently, and scale them seamlessly.

The *Grid* Concept

The term ‘grid’ is variously used to describe a number of different, but related, ideas, including utility computing concepts, grid technologies, and grid standards. In this paper the term ‘*Grid*’ is used in the widest sense to describe the ability to pool and share Information Technology (IT) resources in a global environment in a manner which achieves seamless, secure, transparent, simple access to a vast collection of many different types of hardware and software resources, (including compute nodes, software codes, data repositories, storage devices, graphics and terminal devices and instrumentation and equipment), through non-dedicated wide area networks, to deliver customized resources to specific applications.

At the most general level *Grid* is independent of any specific standard or technology. Any practical grid is realized through specific distributed computing technologies and standards that can support the necessary interoperability. Today, there are no universally agreed grid standards, but there are freely available, open source and proprietary grid technologies that implement emerging standards recommendations. Separate web services standards are also emerging which have many grid-like capabilities. Indeed grids are already being built by integrating and enhancing web standards technology.

Practical Realizations

Practical grids are generally described in terms of layers (see Fig 1). The lowest layers (the ‘platform’) comprise the hardware resources, including computers, networks, databases, instruments, and interface devices. These devices, which will be geographically distributed, may present their data in very different formats, are likely to have different qualities of service (e.g. communication speeds, bandwidth) and are likely to utilize different operating systems and processor architectures. A key concept is that the hardware resources can change over time - some may be withdrawn, upgraded or replaced by newer models, others may change their performance to adapt to local conditions - for example restrictions in the available communications bandwidth.

The middle layers (sometimes referred to as ‘middleware’) provide a set of software functions that ‘buffer’ the user from administrative tasks associated with access to the disparate resources. These functions are made available as services and some provide a ‘jacket’ around the hardware interfaces, such that the different hardware platforms present a unified interface to different applications. Other functions manage the underlying fabric, such as identification and scheduling of resources in a secure and auditable way. The middle layer also provides the ability to make frequently used patterns of functions available as a composed higher-level service using workflow techniques.

The highest layers contain the user 'application services'. Pilot projects have already been carried out in user application areas, such as life sciences (e.g. computational biology, genomics), engineering (e.g. simulation and modeling, just in time maintenance) and healthcare (e.g. diagnosis, telematics). These services could include horizontal functions such as workflow (the linkage of multiple services into a single service), web portals, data visualization and the language/semantic concepts appropriate to different application sectors.

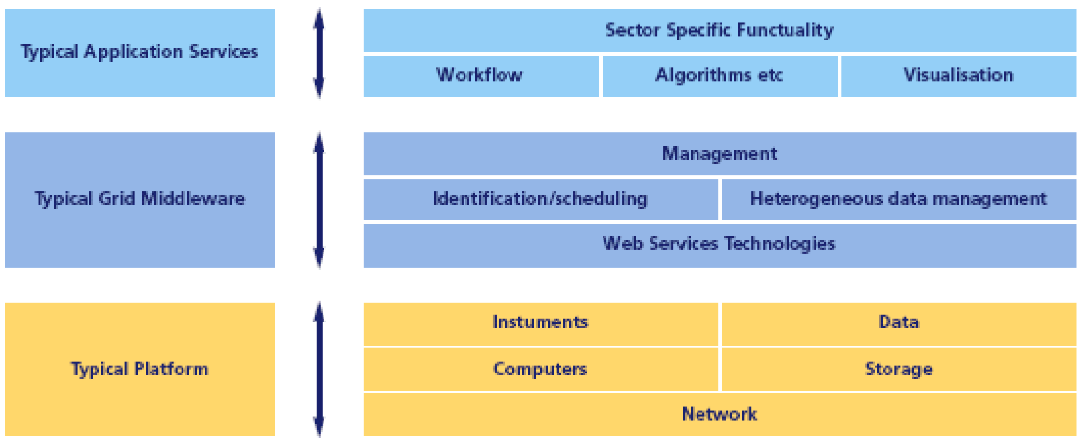

Figure 1 : Simplified *Grid* Architecture

Grid Developments and Deployment

A key issue facing the industry is the timing and mode of deployment of *Grid* technology to ensure that it is sufficiently mature to deliver the expected business benefits. There is emerging evidence that the technology can achieve significant operational benefits (e.g. in telemedicine), improvements in performance (e.g. in climate modeling and genomics) and a significant reduction in costs. Nevertheless, current grid technologies are not yet viewed as sufficiently mature for industry scale use, and remain largely unproven in terms of security, reliability, scalability, and performance.

Short term

For the short term (within the next two years), *Grid* is most likely to be introduced into large organizations as internal 'Enterprise grids', i.e. built behind firewalls and used within a limited trust domain, perhaps with controlled links to external grids. A good analogy would be the adoption into business of the Internet, where the first step was often the roll out of a secure internal company 'Intranet', with a gradual extension of capabilities (and hence opportunity for misuse) towards fully

ubiquitous Internet access. Centralized management is expected to be the only way to guarantee qualities of service. Typically users of this early technology will be expecting to achieve IT cost reduction, increased efficiency, some innovation and flexibility in business processes. At the same time the distinction between web services and grid services is expected to disappear, with
the capabilities of one merging into the other and the interoperability between the two standards being taken for granted.

Medium Term

In the mid term (say a five year timeframe) expect to see wider adoption - largely for resource virtualization and mass access. The technology will be particularly appropriate for applications that utilize broadband and mobile/air interfaces, such as on-line gaming, 'visualization-on-demand' and applied industrial research. The emphasis will move from use within a single organization to use across organizational domains and within Virtual Organizations, requiring issues such as ownership, management and accounting to be handled within trusted partnerships. There will be a shift in value from provision of computer power to provision of information and knowledge. At the same time open standards based tooling for building service oriented applications are likely to emerge and *Grid* technology will start to be incorporated into off-the-shelf' products. This will lead to standard consumer access to virtualized compute and data resources, enabling a whole new range of consumer services to be delivered.

Long term

In the longer term, *Grid* is likely to become a prerequisite for business success - central to business processes, new types of service, and a central component of product development and customer solutions. A key business change will be the establishment of trusted service providers, probably acting on a global scale and disrupting the current supply chains and regulatory environments.

Conclusions

- The Grid -- the IT infrastructure of the future -- promises to transform computation, communication, and collaboration. Over time, these will be seen in the context of grids -- academic grids, enterprise grids, research grids, entertainment grids, community grids, and so on. Grids will become service-driven with lightweight clients accessing computing resources over the Internet. Datacenters will be safe, reliable, and available from anywhere in the world. Applications will be part of a wide spectrum of network-delivered services that include compute cycles, data processing tools, accounting and monitoring, and more.

- Grid computing and related technologies will only be adopted by commercial users if they are confident that their data and privacy can be adequately protected and that the Grid will be at least as scaleable, robust and reliable as their own in-house IT systems. Thus, new Internet technologies and standards such as IPv6 take on even greater importance. Needless to say, users of the Grid want easy, affordable, ubiquitous, broadband access to the Internet.

- Similar to the public policy issues raised by the development of electronic commerce and electronic government, Grids raise a number of public policy issues: data privacy, information and cyber security, liability, antitrust, intellectual property, access, taxes, tariffs, as well as usage for education, government, and regional development.

- WITSA continues to address public policy issues likely to affect the future development and deployment of the Grid. WITSA works with governments and international organizations to ensure that appropriate government policies address legitimate concerns of users in such a way as to facilitate rather than hinder technological developments of the Grid.

Appendix: WITSA Members

Argentina
Cámara de Empresas de Software y Servicios Informáticos (CESSI)
URL: http://www.cessi.org.ar

Armenia
Armenian Union of Information Technology Enterprises (UITE)
URL: www.uite.org

Australia
Australian Information Industry Association (AIIA)
URL: http://www.aiia.com.au

Bangladesh
Bangladesh Computer Samity (BCS)
URL: http://www.bcs-bd.org

Brazil
Sociedade de Usuários de Informática e Telecomunicações - Sao Paulo (Sucesu-SP) URL: http://www.sucesusp.org.br

Bulgaria
Bulgarian Association of Information Technologies (BAIT)
URL: http://www.bait.bg

Canada
Information Technology Association of Canada (ITAC)
URL: http://www.itac.ca

Chinese Taipei
Information Service Industry Association of Chinese Taipei (CISA)
URL: http://www.cisanet.org.tw

Colombia
Colombian Software Industry Federation (FEDESOFT)
URL: www.fedesoft.org

Costa Rica
Costa Rican Chamber of Information and Communication Technologies
URL: http://www.camtic.org

Czech Republic
Association for Consulting to Business (Asociace Pro Poradenství v Podnikání - APP) URL: http://www.asocpor.cz

Ecuador
Association Ecuatoriana de Tecnologia de Informacion y Servicios (AETIS)
URL: http://www.aetis.org.ec

Egypt
Egyptian Information Technology, Electronics and Software Alliance (EITESAL) URL: http://www.eitesal.org

Finland
Federation of the Finnish Information Industries (TIETOALAT)
URL: http://www.finnishinformationindustries.net

France
Syntec Informatique
URL: http://www.syntec-informatique.fr

Greece
Federation of Hellenic Information Technology and Communications Enterprises (SEPE) URL: http://www.sepe.gr

Hong Kong
Hong Kong Information Technology Federation (HKITF)
URL: http://www.hkitf.org.hk

Hungary
Hungarian Association of IT Companies (IVSZ) URL: http://www.ivsz.net/

India
National Association of Software and Service Companies (NASSCOM)
URL: http://www.nasscom.org

Indonesia
ASPILUKI - Indonesian Telematic Software Association
URL: http://www.aspiluki.or.id

Israel	Israeli Association of Software Houses (IASH) URL: http://www.iash.org.il
Italy	Associazione Nazionale Aziende Servizi Informatica e Telematica URL: http://www.anasin.it
Japan	Japan Information Technology Services Industry Association (JISA) URL: http://www.jisa.or.jp
Jordan	Information Technology Association - Jordan (int@j) URL: http://www.intaj.net
Kenya	Computer Society of Kenya (CSK) URL: http://www.csk-online.org
Lebanon	Professional Computer Association of Lebanon (PCA) URL: http://www.pca.org.lb/
Lithuania	Association of the Information Technology, Telecommunications and Office Equipment Companies of Lithuania (INFOBALT) URL: www.infobalt.lt
Malaysia	Association of the Computer And Multimedia Industry Malaysia (PIKOM) URL: http://www.pikom.org.my
Mexico	Asociación Mexicana de la Industria de Tecnologías de Información (AMITI) URL: http://www.amiti.org.mx
Mongolia	Mongolian National Information Technology Association URL: http://www.ict.mn/midas
Morocco	l'Association des Professionnels des Technologies de l'Information (APEBI); URL: http://www.apebi.org.ma
Nepal	Computer Association of Nepal (CAN) URL: http://www.can.org.np
Netherlands	Federation of Dutch Branch Associations in Information Technology (Federatie Nederlandse IT - FENIT) URL: http://www.fenit.nl
New Zealand	Information Technology Association of New Zealand (ITANZ) URL: http://www.itanz.org.nz
Northern Ireland	Momentum - The Northern Ireland ICT Federation URL: http://www.momentumni.org
Norway	ICT Norway (IKT Norge) URL**:** http://www.ikt-norge.no
Palestine	Palestinian IT Association (PITA) URL: http://www.pita-palestine.org/
Panama	Asociación Panameña de Software (APS) URL: http://www.aps.org.pa
Philippines	Information Technology Association of the Philippines (ITAP) URL: http://www.itaphil.org
Poland	Polish Chamber of Information Technology and Telecommunications (Polska Izba Informatyki i Telekomunikacji - PIIT) URL**:** http://www.piit.org.pl

Portugal	Associação Portugesa das Empresas de Tecnologias de Informação e Comunicações (APESI) E-mail: apesi@treal.pt
Republic of Korea	Federation of Korean Information Industries (FKII) URL: http://www.fkii.or.kr
Romania	Association for Information Technology and Communications of Romania (ATIC) URL: http://www.atic.org.ro
Russia	Russian Information & Computer Technologies Industry Association (APKIT) URL: http://www.apkit.ru
Senegal	Senegalese Information Technology Association (SIT'SA) URL: http://www.sitsa.sn/
Singapore	Singapore infocomm Technology Federation (SiTF) URL: http://www.sitf.org.sg
South Africa	Information Industry South Africa (IISA) URL: http://www.informationindustry.org.za
Spain	Spanish Association of Electronics, Information Technology and Telecommunications Companies (AETIC) URL: http://www.aetic.es
Sri Lanka	Sri Lanka Information and Communications Technology Association (SLICTA) E-mail: Ict@tci.lk
Sweden	The Association of the Swedish IT and Telecom Industry (IT-Företagen) URL: http://www.itforetagen.se
Tanzania	Tanzania Information and Communication Technologies Association (TICTA) URL: http://www.ticta.org/
Thailand	The Association of Thai Computer Industry (ATCI) URL: http://www.atci.or.th
Turkey	Turkish IT Services Association (TUBISAD) URL: http://www.tubisad.org.tr
Uganda	The Private-Sector ICT Association of Uganda (PICTA) URL: http://www.picta.or.ug/
United Kingdom	The Information Technology, Telecommunications and Electronics Association (Intellect) URL: http://www.intellectuk.org
United States	Information Technology Association of America (ITAA) URL: http://www.itaa.org
Uruguay	Uruguayan Chamber of Information Technology (CUTI) URL: http://www.cusoft.org.uy
Venezuela	CAVEDATOS - Venezuelan Chamber of IT Companies URL: http://www.cavedatos.org.ve/
Vietnam	VINASA - Vietnam Software Association URL: http://www.vinasa.org
Zimbabwe	Computer Suppliers' Association of Zimbabwe (COMSA) URL: http://www.comsa.org.zw