BUSINESS APPLICATIONS OF GRID COMPUTING: A REVIEW

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Abstract

This paper intends to discuss the business application of Grid Computing. Grids are very large-scale virtualized, distributed computing systems, which allow users to access the computing resources of many different machines distributed around the world. Until recently, grid computing was an academic tool, used as a cost-effective means for tackling computationally intensive problems. Though Grid Computing was not readily adopted by business and industry in the earlier phase of its development, but is now becoming a critical component of business, and industry. This paper briefly explores how this technology can be beneficially used by various sectors under business domain.

Keywords: Business Domain, Distributed Computing, Grid Computing,

I. INTRODUCTION

This paper looks at the application of Grid Computing in business domain. The term Grid Computing originated in the early 1990s as a metaphor for making computer power as easy to access as an electric power grid. Grid Computing is the creation of a computational infrastructure by coupling wide-area distributed resources such as databases, storage servers, high-speed networks, supercomputers and cluster for solving large scale problems (Foster *et al.,* 1999; Parashar *et al.,* 2005). This is analogous to the electrical grid that provides consistent, pervasive, dependable, transparent access to electric power irrespective of its source (Buyya *et al.,* 2005). Grid computing, which allows users to access the computing resources of many different machines distributed around the world, has been invaluable to science. However, much of the business world and the general public have had few ways to use it due to the complexity of installing and configuring grid software, accessing grid networks, obtaining permissions to use resource. Business sector, even though reluctant at first is increasingly adopting the technology to create innovative products and services, reduce time to market, and enhance business processes. Grids could allow the analysis of huge investment portfolios in minutes instead of hours, significantly accelerate drug development, and reduce design times and defects. With computing cycles plentiful and inexpensive, practical grid computing would open the door to new models for compute utilities, a service similar to an electric utility in which a user buys computing time on-demand from a provider. This paper is organized with the next section introducing briefly Grid Computing, followed by a discussion of the application of grid computing in business domain and various sectors under this domain.

II. GRID COMPUTING

Decades ago, when computers were rare and expensive, CPU time was scheduled and billed by the millisecond. But, now, CPU time is cheap, so much so that computers these days spend most of their time displaying your favorite photos or simulating an aquarium. These simple "screen saver" programs, which compute nothing and whose only purpose is to stir up pixels on the display screen, probably consume more of the world's computational capacity than any other kind of software. Go into almost any office and you will find machines busily saving their screens all night and all weekend. But even when a computer is in use, it is mostly idle and operating way below peak powers. The average office worker might produce 10 keystrokes a second; that is not much of a distraction for a processor that can execute 100 million instructions in that same blink of an eye. A lot of companies might have a great need for some of that unused computing power—and not just that being squandered by the PCs in your office. Imagine if the idle time of all PCs spread over a geographical area, could be focused on solving your company's latest global problem or on discovering a new source of oil or a new drug to cure diseases.

Grid computing has recently enjoyed an increase in popularity as a distributed computing architecture. The main concept of Grid Computing is to extend the original ideas of the Internet to sharing widespread computing power, storage capacities and other resources (Yang *et al.,* 2009). Grids are very large-scale virtualized, distributed computing systems, which allows users to access the computing resources of many different machines distributed around the world. Grid computing got its name because it strives for an ideal scenario in which the CPU cycles and storage of millions of systems across a worldwide network function as a flexible, readily accessible pool that could be harnessed by anyone who needs it, similar to the way power companies and their users share the electricity grid. This innovative approach of computing leverages on existing IT infrastructure to optimize computing resources and manage data as well as computing workloads. Grids are collections of heterogeneous computation and storage resources scattered along distinct network domains. Grids provide tools that allow users to find, allocate and use available resources (Amador *et al.,* 2009). They cover multiple administrative domains and enable virtual organizations. Such organizations can share their resources collectively to create an even larger grid. Fig. 1 shows a sketch of grid computing.

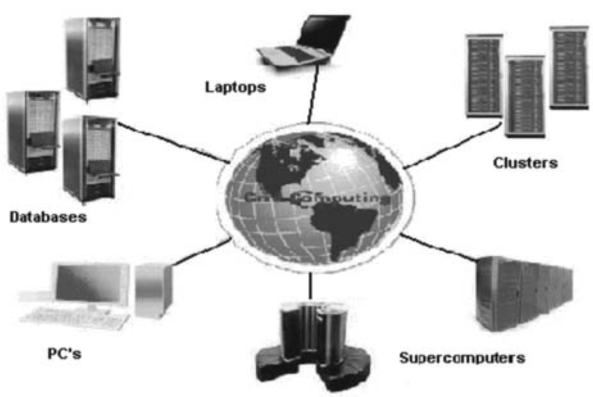


Fig. 1: Grid Computing

From the Search for Extraterrestrial Intelligent (SETI) to the Search for ways to utilize the unused computing power across the enterprise, grid computing has come of age. It promises to harness the spare clock cycle of all your computers and use this new found power to speed up the most complex of your computational or data processing demands (Asagba, et al. 2008). It also gives access to all the storage, all the data, of all those PCs and networked systems working on any processor-intensive task (Davey, 2003 & Foster, et al, 1999)

Grid computing appears to be a promising trend for three reasons (Berman, 2003):

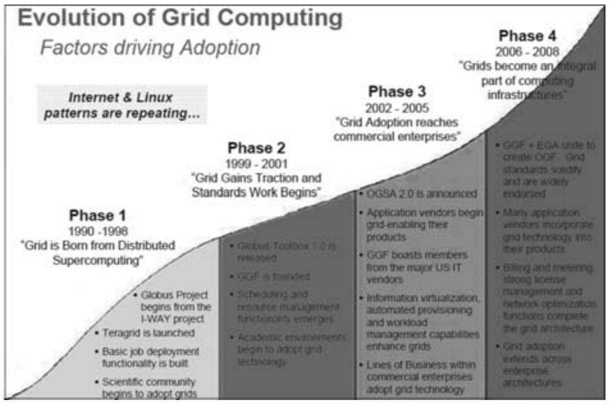
1. Its ability to make more cost effective use of a given amount of computer resources.
2. As a way to solve problems that cannot be approached without an enormous amount of computing power.
3. It suggests that the resources of many computers can be cooperatively and perhaps synergistically harnessed and managed as collaboration toward a common objective.

Until recently, grid computing was an academic tool, used as a cost-effective means for tackling computationally intensive problems. In disciplines like particle physics and meteorology, when problems involved computations that could run in parallel, grids provided what were essentially cheap supercomputers. Grid Computing is now becoming a critical component of science, business, and industry. Grids could allow the analysis of huge investment portfolios in minutes instead of hours, significantly accelerate drug development, and reduce design times and defects. Larger bodies of scientific and engineering applications stands to benefit from grid computing, including molecular biology, financial and mechanical modeling, aircraft design, fluid mechanics, biophysics, biochemistry, drug design, tomography, data mining, nuclear simulations, environmental studies, climate modeling, neuroscience/brain activity analysis, astrophysics (Kaufman , 2003).

III. BUSINESS APPLICATIONS OF GRID COMPUTING

Most enterprise applications, though, are designed for centralized processing, and could not easily be diced up and distributed. This partially explains why grids have been slow to take off in business applications, despite the hype. Grid computing looks to be the case of Internet and Linux history repeating itself (Fig.2). With Internet, it was first adopted by academics, then, it moved into large, leading-edge companies before finally gaining wider adoption. Grid Computing is slowly making its way from academia into large enterprises. Financial institutions, energy companies, and insurance firms have found that they, like academic institutions, have large problems that can be broken down into smaller computation problems and distributed.

Fig. 2: Evolution of Grid Computing (Watkins, 2006)



Grid technology is in a critical transition as it moves from research and academic use to wider adoption by business and enterprise. The use of Grid brings many benefits, such as the greater utilisation of IT resources and increased business flexibility. This consequently reduces overall cost for end users, including costs for security enhancements. Grid enables large, complex systems to be utilised effectively, promoting the sharing of networked resources and supporting new business processes across distributed administrative domains. The application of Grid computing will surely benefit the business domain. The following sections looks at some of these benefits that Grid Computing can provide to various sectors under the domain of business.

Manufacturing sector:

The manufacturing sector comprises a wide range of businesses, from aerospace and automotive engineering to electronics and chemical production. The needs across this broad range of industries are similar, companies must find ways to deliver superior designs as quickly as possible in order to get products to market faster (than the competition) whilst keeping development and production costs under control. Here, computational power is essential for the timely completion of these products. Companies are under extreme pressure to design, simulate and test in tight time scales that signify massive requirements for computing capacity. Traditionally, large companies have met these increasing demands for computing power through large, continual investments in hardware. This has resulted in huge data centres that are under utilised the majority of the time, but struggle with peak loads. Industry relationships are becoming increasingly complex. The trend is towards modular sourcing, which requires extremely close relationships between the manufacturer, the supplier and the lower-tier suppliers. As relationships grow ever more complex with increased interaction between participants of different tiers, players must have access to complex analyses involving massive data sets and e-business tools, to automate flows and speed up collaborative processes.

Using Grids can accelerate product development. It improves computing resource availability and maximises the utilisation of IT assets and expensive software application licenses. It also improves workload throughput for more simulations, better testing, and faster model development cycles. This leads to superior products offering new and improved solutions. Companies can take advantage of grid service providers to get flexible computing capacity on demand adapted to their requirements. Moreover, Grids can be used to provide the secure data storage required by distributed industrial partners in such groupings (Villasante, 2010).

Media Industry:

Media sector companies are involved in the creation, modification and/or distribution of media content, such as reports, images, motion pictures, video games and music. This sector groups a set of heterogeneous organisations that share a need to create, store and transfer massive amounts of data. They have access to a huge computing capacity to process these large volumes and deliver contents within real-time flows between geographically distributed points. Applications include film post-production and rendering, multimedia content provision, video on demand, multiplayer online games, virtual and augmented reality, vehicle and aircraft simulators, and e-learning. The media production process is often performed in a collaborative manner involving many parties. Companies need access to expensive server farms. High-end workstations and existing applications are not suitable for complex projects that require scalability. These solutions are unaffordable for SMEs. Grid computing can provide the following benefits to the media sector:

- Shorten time-to-market based on a scalable capacity that allows enhanced multimedia content to be produced in a more effective way

- Integration and automation of workflows and data management in the media product lifecycle, leading to substantial cost savings
- Efficient utilisation of resources: they are not tied to applications or customers, Grid can better cope with unexpected load and variable demand
- Increased resilience: load is distributed among all the servers with no dependence on a single group
- SMEs can focus on their core businesses: utility computing models offer needed capacity on demand.

Financial Sector:

The financial sector is composed of companies involved in activities such as banking, insurance, investment, brokerage and many related services. Financial markets have experienced great changes in the last decade and there is intense competition between financial organisations to sell new products. That has led to a complexity of products in order to grow revenue and market share while being surrounded by competition and hemmed in by regulations. Companies have turned to more risky instruments to gain more yield, and players now need better risk-assessment and management capabilities. One of the biggest challenges is the need to manipulate huge data volumes in real time. The Grid can deliver supercomputer performance capable of running orders of magnitude faster to transform overnight risk reporting runs into near real-time reports. This supports decision making better while delivering the results of complex value-at-risk calculations cost effectively and reliably. At the same time companies are aiming to lower the total cost of ownership of resources while becoming faster and more adaptable. The Grid provides access to a real-time infrastructure that enables financial organisations to speed up time to market and align with changing business demands by dynamically allocating computing resources to business applications. Companies can consolidate IT components and cut total cost of ownership within an environment where multiple users and applications share computing resources – hardware and software licenses – in virtual pools that adjust and scale to the company‘s needs. Grid solutions improve quality of service, lower IT operations costs and reduce application management complexity. They increase server and cluster utilisation. Grid computing can therefore benefit the financial sector with improved service levels, reduced costs and thus enhanced overall business performance (Villasante, 2010). These are achieved through:

- Running financial applications orders of magnitude faster, giving the business a competitive edge and ensuring that IT is never a bottleneck
- Rreducing operating and capital costs and securing a large reduction in purchases of new computing equipment
- Creating transformational opportunities through new products, new algorithms and new ways of doing business that are just not possible without deploying Grid technology

Retail & Logistics:

The Retail & Logistics sector includes companies whose activities are related to management of goods (acquisition, transformation, delivery, etc.). It is composed of a huge and heterogeneous set of companies that rely on a collection of suppliers to deliver the product they need to the right place when they need it. The activities in this sector are mainly concerned with the physical movement of goods, some of which may be perishable (e.g. fresh vegetables, meat) or have a limited shelf life for other reasons (e.g. fashion, seasonal items). Therefore, the movement of goods in a prompt and efficient manner is essential and should also minimise stock holding and wastage. The main products to be offered in this sector are services to improve the efficiency of the supply chain, and the resources and process planning. ICT systems have been shown to increase efficiency in supply chains, improve transaction efficiency and reduce waste. Most of the extended and popular solutions in the Retail & Logistics sector suffer from heavy performance problems. This forces final industrial customers to buy, rent or reserve space on very powerful yet expensive hardware and software platforms at service providers‘ server farms. Moreover, service providers implement customer-specific solutions that are difficult to maintain, evolve and reuse, and pose a hurdle for sharing information in the value chain. This has a direct negative consequence on business. There are hundreds if not thousands of enterprises (mainly SMEs) that need these services. But with traditional architectures, the high entry-level barrier of huge investments in hardware, software and maintenance are an almost insuperable obstacle for many potential users, SMEs in particular. In addition, it is extremely difficult for the existing solutions to meet more and more demanding performance requirements because of their traditional centralised architectures. Grid technology can overcome these technical and business hurdles by relieving end customers of heavy infrastructure investments, while preserving, if not improving, system performance to gain competitive advantage without increasing costs (Villasante, 2010).

Environment:

The Environment and e-Science sector comprises organisations whose products and services are based on the processing of geophysical data. Examples include seismic data to support decisions in drilling for oil and gas field exploration, or atmospheric data captured by satellites to produce daily particulate matter maps. Other organisations use science applications that perform complex algorithms based on optimizations and simulations with large amounts of data. Examples of such applications include bio-informatics and particle physics.

The main characteristic of this sector is the use of complex algorithms to process massive amounts of data obtained from sensors and other devices. These devices are normally located remotely, necessitating the transfer of data over large distances. Therefore, the products and services required by the sector are data intensive and need large communications capacity to transfer the captured data. In order to meet these requirements, large investments must be made in data processing centres. Typically, these centres are placed as close as possible to the data source to reduce the amount of long distance communications. Despite their high cost these data centres often fail to meet peak load. For many years, academic environments have been using cluster and Grid computing to perform these kinds of calculations. These solutions often have the ability to dynamically add distributed computing resources owned by associated organisations. This provides a scalable solution, which can increase capacity when required to allow mission-critical work to be completed in a fraction of the time it would take at a stand-alone dedicated data centre with limited resources. The key advantages that Grid technology provides are:

- Increased computing capacity, reducing the time to process and analyse data. Accurate operational and production decisions can be made earlier, product development is accelerated and higher quality results are achieved.
- More effective management of IT assets: optimised use of computing resources and application licenses reduces total cost of ownership.
- New business models, such as SaaS (Software as a Service), allow small organisations access to resources that were previously beyond their budgets.

Telecomunications:

The firms in this sector provide telecommunications and related services, such as transmitting data, sound, text, voice and video via different channels (fixed line, mobile and wireless, cable, etc.). They can be classified into network operators or carriers (which own their own networks or resell acquired transmission capacity), and service providers (which provide products and services over networks) or both (often the larger companies). Network operators can also be divided into incumbent and alternative network operators. The former are usually long established and offer their customers a wide range of products and services. The latter are often newer and may focus on one particular market segment as a niche player. Competition in the sector is intense. firms are under strong pressure because of falling prices for core transmission services and the arrival of new competitors due to the convergence of telecommunications, IT and media. Many of the older companies in the sector have legacy systems and they may not have the speed and flexibility to compete head-on with the new entrants in niche markets.

The telecommunications industry has a double role with ICT, as both user and supplier. Core business processes and most product and process innovations are enabled by ICT. Therefore, an important part of investment is spent on ICT. Telecommunications carriers have to process massive amounts of data and part of this processing has real-time constraints. These processes, such as network management, traffic control and analysis and billing, consume vast quantities of computing power and lead to sharp increases in demand at peak times. Therefore, they are clear candidates for the internal implementation of Grid technology. Grid technology can significantly increase the performance of intensive computational systems. Other potential applications of Grid are business intelligence applications to analyse customer profiles and support decision-making processes. Because of the traditional incompatibility of different solutions, the continuous pace of technological innovations, and the high costs of platform investments, operators can find themselves with a diversity of disparate systems. Some of these are under-utilised because they are dedicated to a specific service or application and there is no capability to balance load and easily exchange information across the disparate systems to optimise the use of available resources. If done according to well-defined policies and SLAs, virtualising business-critical applications across a Grid with shared resources can cut costs, achieve greater scalability and flexibility, and increase business agility without losing reliability (Villasante, 2010).

Tourism:

Tourism is the provision of products and services for people travelling and staying outside their usual environment for business, leisure or other purposes. These services include: transportation (airlines, trains, ships, etc.), accommodation (hotels, resorts, etc.), entertainment (galleries, museums, parks, theatres, etc.) and intermediaries (tour operators and travel agencies). The tourism industry contains a large number of SMEs that need a wide range of local support services usually provided by other SMEs. In the tourism sector the Internet has had two effects. It has enabled service providers to interact directly with consumers, bypassing traditional intermediaries, such as travel agencies and brokers (disintermediation). On the other hand, it has also provided new opportunities for traditional players to offer value-added services and foster new intermediaries that operate exclusively online. The tourism sector has been one of the first to make large-scale use of ICT to reduce costs and generate value. Its application has been focused on reservation and distribution systems to create, develop and globalise the availability of basic tourist services. In the aviation sub-sectors, ICT has been heavily adopted to reduce costs: e-ticketing to avoid paper tickets, customer selfservice check-in and RFID for luggage handling. Airlines can track sales for each service very efficiently and define pricing strategies to maximize revenues. Only a minority of tourism businesses uses other applications, such as ERP, CRM, SCM and knowledge management solutions. This is because most of these solutions are costly and tailored for larger companies, and require maintenance skills small companies lack. Therefore, most SMEs in the sector still perform their internal operations manually. Despite this low usage, such solutions offer high benefits for the industry. For instance, business intelligence applications can help discover client behaviour patterns, then adjust marketing strategies to their needs and tailor offerings to improve customer satisfaction. Grid technology can help SMEs in the tourism sector (where the outsourcing trend is strong) to adopt these solutions to automate internal business processes, using flexible and cost-effective business models such as SaaS (Software as a Service). Bigger enterprises can also implement internal Grids to create new infrastructures or consolidate existing ones, lowering IT operations costs and reducing application management complexity.

Agriculture:

Agriculture comprises the production, processing and marketing of food for human consumption and animal feed. The value chains in the agriculture sector are static and highly diverse, with many SME primary producers as well as large enterprises in industrial food production. The emerging field of

e-agriculture focuses on the improvement of agricultural processes by applying ICT in innovative ways. It faces the problem of distributed systems, high data asymmetry and non-existing standards. The goal is to help stakeholders perform their activities more efficiently by providing them with the tools to manage, process and exchange information and knowledge in a cost effective way. The main ICT application areas in the agriculture sector are (Villasante, 2010).

- The automation of internal processes aiming at reducing the resources required to perform tasks and at improving service quality.
- Information systems to manage the creation, storage and distribution of knowledge to the stakeholders (for instance, through e-commerce services or e-learning platforms).
- Decision-making tools to gather information from heterogeneous sources and help

farmers decide, for instance, the best use of land, what crop to plant and when, the right amount of fertiliser to use and when, and the best time to harvest the crop. These systems gather data from external sources (weather data, aerial images), internal sources (crop data, soil data, topography, etc.) and sensors (rainfall, climate conditions, etc.).

Grid technologies can provide players in this sector with a high capacity solution for storing and processing information, while preserving data access policies. In agriculture, data resources are normally heterogeneous, smallscale, site-specific and stored in different locations with different owners. This prevents centralisation. Grid maximises data and application usage without data centralisation and eases its update and integration, resulting in time and cost savings.

Health:

The health, or medical, sector deals with the detection and treatment of illness. ICT plays a key role in reducing treatment delays and improving service quality and affordability. eHealth services are cost-effective solutions for prevention and continuity of care, supporting mobility and patient autonomy. In the medical and health sector, the most important areas of ICT application are information systems, imaging systems, biomedical research, and treatment planning. The information systems are applied in managing and administrating health centres and other services, as well as for clinical usage. These systems must acquire and handle huge amounts of data and provide channels to share this information. Examples of use are: supporting tools for medical decisions, information transfer and collaboration; and medication management. The better availability of patient data can significantly improve workflows and business process efficiency. The imaging systems are the basis for diagnosis and offer enhanced visualising, archiving and communication methods. The analysis and simulation of medical treatments and research on diseases and drugs requires high-performance computing and extensive scalability to run computationally intensive applications. On top of these basic areas, added services can be provided. These include telemedicine, 24/7 monitoring and diagnostic services in the field, and exchanging information between centres, researchers and others. The health sector, in particular, should benefit from Grid. Grid technologies are already being used in many areas including (GridTalk, 2009):

- Researchers can use grid computing's processing power to hunt for new viruses, search for new drugs, model disease outbreaks, image the body's organs and determine treatments for patients
- Doctors can gain access to relevant health data regardless of where it is stored
- Patients can receive a more individualised form of healthcare
- Healthcare workers are better able to collaborate and share large amount of information

IV. CONCLUSION

This paper has briefly discussed about Grid computing and its application in the business domain. Grids are very large-scale virtualized, distributed computing systems, which allow users to access the computing resources of many different machines distributed around the world. We have seen about the huge potential of this technology and how academics including science and research have been able to harness the potentials of this technology for their benefit. Though the business sectors have adopted this technology slowly, but have been lately using it to increase their performance both effectively and efficiently. Grid technology proves to be one that could give leverage to the business sectors to increase their productivity at reduced costs. In future Grid Computing is expected to play a bigger role in the competitive business domain.

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