Enterprise Grid computing: State-of-the-Art

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Oct 2005

Introduction

The term “grid” as used today means many different things to different people. It is often used to refer to various forms of distributed systems, such as Cluster-based systems, P2P networks, wide-area distributed storage solutions, and the like. To add to the confusion, various big companies such as IBM, Sun, HP and Oracle liberally use the term “grid” while describing their product and service offerings. So, it has now become such a common industry buzzword, that the actual meaning needs to be inferred from the context, taking into consideration where it is coming from.

Let us then, provide yet another definition, one which encompasses a lot of existing definitions and describes some basic attributes of a “grid”:

“Grid is a type of parallel and distributed system that enables the sharing, selection, and aggregation of geographically distributed "autonomous" resources dynamically at runtime depending on their availability, capability, performance, cost, and users' quality-of-service requirements.” [1]

When compared with the definition above, we see that various distributed systems found today have a varying degree of grid-like characteristics. There are many systems developed and deployed for various purposes, and myriad arrays of names have come up to describe these: compute grid, data/storage grid, campus grid, enterprise grid, global grid, knowledge grid, sensor grid, cluster grid, pc grid, commodity/utility grid and so on. Ian Foster has written an interesting article in this connection that describes some characteristics of a grid system. [2]

In this article, we attempt to highlight the synergy arising out of applying grid technologies to enterprise systems. We identify how the enterprise can benefit from grid computing, and describe an open-source project, called Alchemi, which aims to serve as an service-oriented framework based on open standards for creating and using enterprise grids effectively.

What the grid brings to the enterprise: benefits and challenges

Various kinds of distributed systems operate today in the enterprise, each aimed at solving different kinds of problems. In a typical SME, there are many resources which are generally under-utilised for long periods of time. A “resource” in this context means any entity that could be used to fulfil any user requirement; this includes compute power (CPU), data storage, applications, and services. An enterprise grid can be loosely defined as a distributed system that aims to dynamically aggregate and co-ordinate various resources across the enterprise and improve their utilisation such that there is an overall increase in productivity.

Grid computing technology provides enterprises with an effective solution to the need for aggregating resources distributed within their organization and prioritizing allocation of resources to different users, projects, and applications based on their QoS (Quality of Service) requirements. These benefits ultimately result in huge cost savings for the business.

	Enterprise Grid Systems	**Non-commercial Grids**
Criticality of efficient and optimal resource usage	* * * * *	* * * * *
Sharing of inter-organisational resources	* * *	* * * * *
Authentication and authorization	* * * * *	* * *
Security of stored data and programs	* * * * *	* * *
Secure communication	* * * * *	* * *
Centralised / semi-centralised control	* * *	
License Management issues	* * * * *	* * *
Auditing	* * * * *	* * *
Quality of Service (QoS) and Service level agreements (SLA)	* * * * *	* * *
Economy-based & service oriented architecture (to support QoS)	* * * * *	* * *
Interoperability of different grids (and hence: the basis on open-standards)	* * * * *	* * * * *
Support for transactions	* * * * *	*

Table 1. Comparison of features / characteristics of a commercial and non-commercial distributed systems

[Note: A maximum of 5 stars means that the particular feature/attribute is of utmost importance. Absence of a star means the attribute is not required / not desirable]

There are various applications of grid computing in business. Many commercial compute-intensive applications such as drug-discovery, clinical modeling, simulation, investment and credit-risk analysis, large-scale document processing, and data-intensive applications that involve aggregation and management of distributed data storage centers, can vastly benefit from the performance enhancements and resource aggregation capabilities that are achieved through use of grid technologies.

However, grids as of today do not address all the issues that are important to the enterprise. This is because they were born in academic communities where such issues are not of the highest priority. It is useful to note that there are some important distinctions between the types of grids used in research communities and those that can be used in an enterprise or commercial environment. Table 1 outlines the characteristics that differentiate an enterprise grid from a research-oriented grid. The stars reflect the importance / desirability of the attribute to each type of grid.
Grid technology needs to evolve and expand to provide solutions to address these problems effectively before they become commonplace in the business world.

The current state of the enterprise grid

Grid computing is rapidly moving from academia and scientific research and applications towards mainstream enterprise applications with a special emphasis on service oriented architectures (SOA) and utility computing. The enterprise grid, as of today, includes a range of applications which make use of data centres and application clusters to distributing workloads of applications like accounts receivable, investment portfolio risk analysis, and pricing securities in the finance and insurance sector, finding solutions to bottlenecks in product design and development cycles in the manufacturing sector, drug discovery in the pharmaceutical sector, and digital media creation, rendering and distribution management. While most of these early-adopters are still running batch-oriented applications, the concepts of SOA and virtual organisations are already being used to explore the possibilities of running transactional and interactive applications on enterprise grids where the quality of services (QoS) is expected to be more or less reliable especially when bound by service level agreements (SLA).

Investment in enterprise grids is expected to grow manifold in the next five years as more and more companies come up with value-added services. Various major companies are already offering a range of services such as IBM’s “Grid and Grow” [7] includes IBM’s grid hardware, operating systems, schedulers, services and client training to enable businesses get the competitive edge by using the available resources better and saving time. Oracle’s grid computing solution [5] allow businesses to standardize on modular servers and storage; consolidate servers and storage with Oracle Database (10*g*) and Real Application Clusters; and automate day-to-day management tasks. Sun Microsystems’ “Grid Utility Computing” [6] is a pay-per-use service that lets users dynamically provision compute power, depending on application requirements. They provide access to a standardized grid computing infrastructure that allows you to offload your compute-intensive workloads, with minimal risk and no capital investment. Not to be left behind, HP is delivering grid-based storage products today that are built according to their “StorageWorks” architecture. These products either use early versions of smart cell technology or exemplify other design attributes of the architecture, such as single system image management.

The Enterprise Grid Alliance (EGA) is an open, non-profit, vendor-neutral consortium formed to develop enterprise grid solutions and accelerate the deployment of grid computing in enterprises. It consists of more than 30 members including grid users, vendors and solution providers including IBM, Oracle, Sun, Intel, HP, DataSynapse, Univa and Dell. The EGA aims to encourage and accelerate movement to an open grid environment through interoperability solutions. It will work on grid computing standards by endorsing and supporting existing specifications, assembling and profiling component specifications, and defining new specifications where needed.

Open-source software is involved in a big way in the development of enterprise grids. A lot of the grid solutions (in the enterprise including the IBM's grid service offerings) are currently based on the open-source Globus toolkit [9] developed by the Globus Alliance, Argonne National Laboratory and the University of Chicago, USA. It is a set of software services and libraries for resource monitoring, discovery, and management plus security and file management that facilitate construction of computational Grids and Grid-based applications, across corporate, institutional and geographic boundaries. Globus offers grid middleware that mainly runs on the Unix-like platforms. A number of open-source grid projects have developed user-level middleware that work with the Globus toolkit. One such effort is the Gridbus project (at the University of Melbourne) which developed the Grid Service Broker [11] that supports creation, scheduling, and deployment of computational or data grid applications (including work flows) on enterprise and global Grids. Another open-source grid initiative, from the Gridbus project is the Alchemi [10] enterprise grid-computing framework that harnesses the power of a network of computers, running Windows OS. The following section describes Alchemi in more detail.

Alchemi: an open-source Enterprise Grid-computing framework

Alchemi is an open-source .Net based Enterprise Grid computing framework developed by researchers at the GRIDS lab, in the Computer Science and Software Engineering Department at the University of Melbourne, Australia. It allows you to painlessly aggregate the computing power of networked machines into a virtual supercomputer and to develop applications to run on the grid with no additional investment and no discernible impact to users. It has been designed with the primary goal of being easy to use without sacrificing power and flexibility. It has been designed for the Microsoft Windows operating system, which is seen as key factor in industry adoption of grid computing technology since more than 90% of machines worldwide run variants of Windows.

The main features offered by the Alchemi framework are:

- Virtualization of compute resources across the LAN / Internet
- Ease of deployment and management
- Object-oriented "grid thread" programming model for grid application development
- File-based "grid job" model for grid-enabling legacy applications
- Web services interface for interoperability with other grid middleware

The architecture of Alchemi is shown in Figure 1. An Alchemi grid has three types of components:

- The Manager
- The Executor
- The User Application

The Manager node is a computer with the Alchemi Manager component installed. Its main function is to service the user requests for application distribution. The Manager receives a user request, authenticates it, and distributes the workload across the various Executors that are connected to it. The Executor node is the one which actually performs the computation. Alchemi uses role-based security to authenticate users and authorize execution.

A simple grid is created by installing Executors on each machine that is to be part of the grid and linking them to a central Manager component. The Windows installer setup that comes with the Alchemi distribution and minimal configuration makes it very easy to set up a grid.

An Executor can be configured to be dedicated (meaning the Manager initiates application execution directly) or non-dedicated (meaning that the execution is initiated by the Executor.) Non-dedicated Executors can work through firewalls and NAT servers since there is only one-way communication between the Executor and Manager. Dedicated Executors are more suited to an intranet environment and non-dedicated Executors are more suited to the Internet environment.

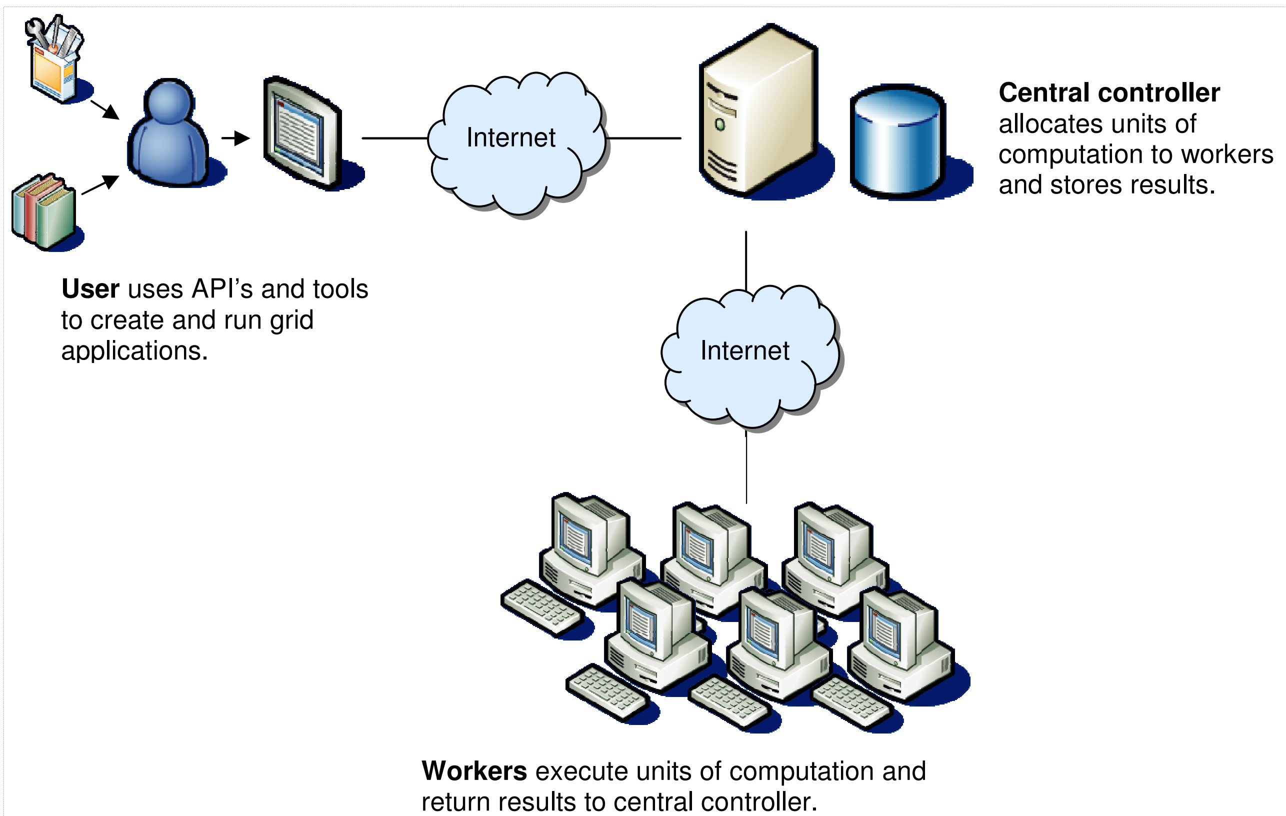

Figure 1. A simple Alchemi grid.

Users can develop, execute and monitor grid applications using the .NET API and tools which are part of the Alchemi SDK. Alchemi offers a powerful grid thread programming model which makes it very easy to develop grid applications and a grid job model for grid-enabling legacy or non-.NET applications.

An optional component is the Cross Platform Manager web service which offers interoperability with custom non-.NET grid middleware. Alchemi also comes with a Java API which can be used to develop Java-based clients that need to harness the computing power of an Alchemi grid.

Alchemi Applications:

Alchemi is widely used in both the academic community and industry, for a variety of applications. It has been used for teaching and setting up test–grids and also some serious applications in the commercial world. Some of the industrial applications / projects using/based on Alchemi are listed below:

- Large scale document processing (Tier Technologies, USA)
- Natural resource modelling (CSIRO, Australia)
- Asynchronous Excel tasks using Managed XLL (stochastix GmbH, Germany)
- Detection of Patterns of transcription factors in mammalian genes (The Friedrich Miescher Institute (FMI) for Biomedical Research, Switzerland)
- Finding the location of a HF radio transmitter using SSL technology (Correlation Systems Ltd. , Israel)
- And many more…

More information about Alchemi can be found at http://www.alchemi.net/

A peek into the future

As we have noted thus far, the enterprise grid is still in its nascent stages in terms of development and industry-wide adoption, and is poised for huge growth in the coming years. However, there are various issues that stand in the way of a big revolution that the Grid promises to bring to IT. Some of the problems to solve include security, development and wide adoption of standards for representing and executing applications and workflows, resource description, monitoring and management, dynamic service composition and aggregation. There are also issues relating to managing data, IP, developing new software licensing models and their enforcement, representing QoS and formulating and enforcing SLAs which are especially important in a commercial environment. A lot of research work is going on, in these areas and the standards are constantly evolving. In addition to the above, for the Grid to be as successful as the WWW a sustainable business model has to be developed, so that all involved parties obtain value from adopting Grid technologies.

One thing that seems to be commonly accepted and believed to be a workable solution is that the Grid in the future is going to be based on SOA and software and hardware would just be available as a utility with demand and supply being regulated by the concept of an economic market, just like it works for any other utility such as electricity, telephone and water.

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