NUSGRID - A Prototype for Grid Computing

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Grids and Grid Computing

Grids and grid computing are a recent, important development in distributed systems/computing research taking the academic world by storm. Grids have been popularized through the successful implementation of the Globus Toolkit by Ian Foster, a Computer Scientist at Argonne National Laboratory, USA, and his collaborators. In today's climate of shrinking budgets and increasing demands, the idea of resource sharing among individuals and organizations is a compelling force behind distributed systems research. The challenge is to provide an infrastructure for secure, flexible, yet coordinated resource sharing.

The difference between “grid technologies” and other distributed technologies/trends such as Internet and peer-to-peer computing, lies in the problem space addressed. To Foster, the resources being shared are not limited to files, but encompass computers, software, data, instruments and others. It is up to resource providers and consumers to define what is shared, who is allowed to share and the conditions for sharing. Thus, grids are infrastructures that enable the integrated, collaborative use of high-end computers, networks, databases, and scientific instruments owned and managed by multiple organizations. Grid applications may involve large amounts of data and/or computing and secure resource sharing across organizational boundaries, which are not easily handled by current internet and web infrastructures.

Interested readers may gleam further insights about grids from Ian Foster's seminal paper, “The Anatomy of the Grid: Enabling Scalable Virtual Organizations”. This and other grid articles may be found on the Globus research archives located at http://www.globus.org/research/papers.html.

The Globus Toolkit

Over the last 5 years, the Grid research community have developed an infrastructure of protocols, services, application programming interfaces and toolkits to meet the requirements for grids and grid computing. Foremost of these is the Globus Project (web site http://www.globus.org), initiated by Ian Foster (Argonne National Laboratory) and Carl Kesselman (University of Southern California), to conduct research and development into fundamental grid technologies. The project's open source Globus Toolkit includes software services and libraries for resource monitoring, discovery, and management, plus security and file management. It's popularity and widespread adoption among academic and research institutions implementing grids has made the Globus Toolkit the de facto grid middleware in use today.
Grids around the World

We look at several large grid projects that have been initiated around the world. One of the largest, the TeraGrid project, funded by the National Science Foundation (NSF) USA, was launched in August 2001 with four participating sites: the National Center for Supercomputing Applications (NCSA), the San Diego Supercomputer Center (SDSC), Argonne National Laboratory, and Center for Advanced Computing Research (CACR) at Caltech. In October 2002, the Pittsburgh Supercomputer Center (PSC) was added to the TeraGrid partnership. TeraGrid is a multi-year effort to build and deploy the world’s largest, fastest, distributed infrastructure for open scientific research. When completed, it will command 20 teraflops of computing power distributed at five sites, facilities capable of managing and storing nearly 1 petabyte of data, high-resolution visualization environments, and toolkits for grid computing. These components will be tightly integrated and connected through a network that will operate at 40 gigabits per second—the fastest research network on the planet.

The e-Science Grid project in the United Kingdom was launched in July 2001 by the Engineering and Physical Sciences Research Council to support the research activities of UK scientists. It will set up a national network that will link a National e-Science Centre to eight regional grid centres around the UK. These centres will be based at the universities of Newcastle, Belfast, Manchester, Cardiff, Cambridge, Oxford, Southampton and Imperial College London. The National e-Science Centre will supervise the setting up of the national grid, initiate and manage various grid research programmes, and develop communication, awareness and training activities. The regional centres will provide physical resources and information for grid application developers concentrating on those working with industry to develop grid-based applications. Together, the centres will provide a national grid resource of compute cycles, data storage and other key data and computational resources.

The EUROGRID is a European Union funded project started in November 2000. This project aims to federate the resources of leading European High Performance Computing (HPC) centres in a European grid network. It will demonstrate the use of grids in selected scientific and industrial communities, address and facilitate the specific requirements of these communities. The project consists of four application-specific grid work packages: Bio-GRID, Meteo-GRID, CAE-GRID, and HPC Research GRID. As their names suggest, these application specific packages aim to facilitate use of grid in the domains of biology/chemistry, meteorology/weather-prediction, Computer-aided Engineering and HPC, respectively. For the later, HPC centres in EUROGRID will make their computing resources available to other partners for general HPC use, and adaptations to a number of important HPC applications will be developed. Additional work packages will focus on development of technology that is relevant across application domains, integration and support for EUROGRID operation, information dissemination/liaison, and project management.
The NUS campus grid project, codenamed NUSGRID, aims to develop and implement a campus-wide prototype for grid computing. With the prototype in place, NUS researchers will have a platform to explore and exploit the benefits of grid technologies.

In phase 1 of the project (recently concluded), Globus Toolkit middleware was set up to connect three sites on campus. These sites are the Supercomputing and Visualisation Unit of Computer Centre (SVU), Engineering IT Unit (e-ITU) and Computational Science Department (CZ). Each has contributed a computing resource to NUSGRID:

<table>
<thead>
<tr>
<th>Site</th>
<th>Resource Description</th>
</tr>
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<tbody>
<tr>
<td>e-ITU</td>
<td>SUN BLADE 2000 workstation cluster</td>
</tr>
<tr>
<td>CZ</td>
<td>HP Itanium workstation cluster</td>
</tr>
<tr>
<td>SVU</td>
<td>Compaq ES40 (4 CPUs) server</td>
</tr>
</tbody>
</table>

SVU will also be contributing a Linux cluster in the next phase. Additionally, 2 INTEL based Linux servers were purchased for central/web services. Figure 1 shows the NUSGRID configuration:

Figure 1

**Phase 1 Deliverables**

With the successful installation of GlobusToolkit, three types of services are available:

- Resource management
  These services let users run commands/jobs on the grid hosts.
- Data management
These services let users copy files between the grid hosts.

- Information services
  These services let users find out static information about resources on the grid, such as host/machine names, configuration and file systems.

Security considerations underlie all the above services. The Globus Toolkit uses the Grid Security Infrastructure (GSI) for enabling secure authentication and communication over an open network. GSI is based on public key encryption, X.509 certificates, and the Secure Sockets Layer (SSL) communication protocol. Digital certificates are required at host and user levels. For convenience, the Toolkit allows grid users to set up their own certificate authority (CA). A CA for NUSGRID has been installed on one of the INTEL servers at SVU.

We have also set up a master information server and configured the hosts at each site to report to this master server. Static information about all resources on the Grid may be obtained by querying the master information server. The next figure shows the information reporting structure in NUSGRID:

![Information Reporting Structure](image)

**Figure 2**

Generally, in cluster or large resource environments, a local job manager is very useful for resource management and control. These local job managers may need to be integrated with Globus Toolkit. Some job managers, such as Load Sharing Facility (LSF) and Sun Grid Engine (SGE), were tested and integrated to work with Globus Toolkit.

**The Challenges Ahead**

With the core grid services in place, we can now move forward. Some of the main challenges lie in making NUSGRID usable and useful. We have seen that the Globus Toolkit services are invoked through a command line. Considerable exploration/time may be needed to understand how to use these commands effectively. The command interface needs to be made more accessible and user friendly. A graphical user interface offered in a well designed web portal could greatly simplify the presentation, convenience and ease of access/use of the Globus services.
Ideally, the web portal interface should hide the complexity that comes with the heterogeneous environment of the grid. System peculiarities and details like resource requirements and where a user job runs, should be made as transparent as possible. A user would just need to select or specify his application / input / output locations.

To increase the utility of the grid, more applications need to be identified, tested and integrated to work with Globus Toolkit. The ease of application integration varies and may be time consuming. For some applications, e.g., message passing interface (MPI), Globus-aware releases are available for use. Some applications may just need to be supplied with variables to work in the Globus environment. Others may need to interface directly with Globus supplied programming and scripting interfaces.

As we continue to grow NUSGRID, it is timely to remember that technical constraints may limit what platforms and resources could be added. Although Globus Toolkit is designed to work on all/heterogeneous platforms, in reality, there are certain platforms on which it may not install successfully. Application level integrations with the Toolkit are also platform dependent and come with varying levels of success. Fortunately, as grid computing becomes more widespread, computer and application vendors will devote more resources into integrating their platforms/applications with Globus.

The Globus Toolkit has been undergoing continuous change to improve code and functionality, fix bugs, etc. This is a good thing but is quite a challenge keeping up with the new Toolkit releases. Concurrent with the current release (version 2), the Globus Project team have been working on the next generation toolkit, version 3 (GT3), which is radically different. It uses a web services approach (wherein the future lies), based on the Open Grid Service Architecture (OGSA). A beta version of GT3 was recently released. More details on OGSA may be found in the paper “The Physiology of the Grid” by Ian Foster, et al., on the Globus research archives.

Aside from technical issues, governance of the grid is another important consideration. The essence of grids is about resource sharing across organizational boundaries. To achieve this, (access) policies on resources, such as who may use the resources, what and when they may be used, need to be decided and agreed on by all members of the grid.

Summary

Grids and grid computing present a technology for resource sharing within and across organizations. There has been tremendous interest in grid technologies in academia and research circles and, increasingly, in the commercial space. We hope that the NUSGRID prototype, when completed, will be a timely vehicle for NUS staff and students to discover the benefits and opportunities of grid computing.
NUS researchers who are interested in porting/testing their applications on NUSGRID are cordially invited to participate in this project. For queries and feedback, please contact the author at ccefoog@nus.edu.sg.