Introduction to Grid Infrastructures

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Abstract

Our purpose here is to briefly review the concept of Grid and present EGEE Grid infrastructures set-up and the associated middleware (gLite). We then review all these concepts from the point of view of a generic user. Our aim is to provide basic information on the concepts that will be thoroughly cited and discussed in the rest of the contributions.
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1 What is Grid computing?

The term Grid was coined in the mid-1990s to indicate the coordinated resource sharing and problem solving in dynamic, multi-institutional virtual organisations [1]. The name originates from the analogy with the Power Grid: the vision was that, within the framework of the Grid paradigm, computational resources should be ubiquitous, easily and seamlessly accessible as electricity. The Grid paradigm is in some sense a consequence of three aspects: the widespread use of the Internet, the availability of powerful computers and broadband networks. These three factors have dramatically changed the approach a scientist has towards research. By using the internet, scientists realized that the knowledge they had acquired in their laboratories could reach almost immediately the scientific community worldwide, thus creating a reservoir of resources accessible to all the researchers who would have benefited from the job done in other research institutes using it to advance with their own activities. The exponential growth of computing power, enabled by massive parallel computers and clusters of computers, enabled scientists to perform extremely complex calculations, solve major scientific and technical problems and process huge amounts of data. Finally, the presence of broadband connection makes it possible to easily exchange large amounts of data and to couple distributed resources worldwide to perform the same task. Grid Computing is thus the paradigm that enables the interaction amongst distributed resources, services, applications and data worldwide.

The key concept in Grid computing is the ability to negotiate resource-sharing arrangements among a set of participating parties (providers and consumers) and then to use the resulting resource pool to reach a specific goal. The sharing here involves not only exchange but rather direct access to hardware, software, data, and other resources, as is required by a range of collaborative problem-solving and resource-brokering strategies emerging in science and engineering. This sharing is, necessarily, highly controlled, by resource providers and consumers defined clearly and carefully just what is shared, who is allowed to share, and the conditions under which sharing occurs. A set of individuals and/or institutions defined by such sharing rules from what we call a Virtual Organization (VO). Grid computing is therefore an approach that leverages existing IT infrastructure to optimize computer resources and manage data and computing workloads.

There are many different kinds of Grid types and forms: we shall list
here the three most commonly recognized forms of Grid:

• Computing Grid - multiple computers to solve one application problem
• Data Grid - multiple storage systems to host very large data sets
• Collaboration Grid - multiple collaboration systems for collaborating on a common issue.

Grid Computing is now well established and its original aim to “provide a service-oriented infrastructure that leverages standardized protocols and services to enable pervasive access to, and coordinated sharing of geographically distributed hardware, software, and information resources” [2] has been pursued over the years. Nowadays, it has been adopted in many different ways, and is widespread with more and more research institutes, governmental organisations and universities setting up Grid infrastructures and performing many activities on top of them.

There are a few main reasons behind the Grid success:

1. The cost-effective use of a given amount of computer resources
2. The on-demand availability of an enormous amount of computer power
3. The possibility to collaborate with virtual organizations from different sectors in order to allow a multidisciplinary approach to the solutions of complex problems
4. The size of the computing problems that exceed the possibility to manage them in a unique local infrastructure.

Grid infrastructures are nowadays routinely used in several scientific communities. The resulting high capacity, world-wide infrastructure provided by a Grid infrastructure greatly surpasses the capabilities of local clusters and individual centres, providing a unique tool for collaborative computing in science. This actually lead to the concept of “e-Science”.

There are indeed many different Grid infrastructures established by many different scientific projects and organizations which really enable a new scientific approach. It is also worth to notice that nowadays, one of the main efforts is to make large Grid infrastructures interoperable. So now the standardization of Grid protocols is becoming of utmost importance in order to facilitate and fasten the access to storage systems, data resources, supercomputers, instruments and devices belonging to different Grid infrastructures.
2 EGEE infrastructure

The European scenario in Grid is mainly represented by the EGEE project, by far the largest and most important EU funded Grid infrastructure project. EGEE (Enabling Grids for E-Science) is a collaboration that comprises almost 150 institutions in 32 countries, organized in 13 Federations. The associated Grid production infrastructure is comprised of more than 250 sites across 50 countries offering around 100000 CPUs, and a few dozen Petabytes of storage. The infrastructure is available to users 24 hours a day, 7 days a week, achieving a sustained workload of approximately 150,000 jobs/day. A trusted federation of Certification Authorities (EUGridPMA) grants the issuing of credentials to EGEE users, and this federation belongs to a worldwide network of trust called International Grid Trust Federation (IGTF). IGTF provides the basis for a worldwide interoperable Grid infrastructure. EGEE is actively involved in the Open Grid Forum (OGF) promoting the adoption of common standards in the Grid domain, and above all is involved in the GIN working group (Grid Interoperability Now).

The EGEE infrastructure is mainly used by the WLCG project, the World Wide LCG Computing Grid project. EGEE provides a distributed computing infrastructure for the data analysis of the huge amount of data produced by the Large Hadron Collider at CERN, the European Centre for Nuclear Research. Other scientific communities are represented within EGEE as well: around 200 registered virtual organizations allow the usage of the Grid infrastructure by scientists from a variety of different disciplines like Bioinformatics, Chemistry, Fusion Physics, Health Science and Medicine, etc.

The main user community in the field of computational chemistry and material science is represented by the COMPCHEM Virtual Organization managed by University of Perugia whose horserace is the set of programs being part of the a priori molecular simulator GEMS. Several applications belonging to such a large user community have already been ported to the Grid and have been run in production to calculate observables for chemical reactions, to simulate the molecular dynamics of complex systems, and calculate the structure of molecules, molecular aggregates, liquids and solids.

EGEE also collaborates with a number of similar projects to provide a worldwide expansion of the infrastructure. We consider here, as a significant example, the EU-IndiaGrid project that aims at connecting the Europe and Indian Grid infrastructures.
At the moment, in essentially all European countries, parallel to the national contribution to EGEE and other international Grid projects, the National Grid Initiatives (NGI) are relevant actors to coordinate, at national level, the development and deployment of Grid middleware and infrastructures. NGIs will be coordinated for the establishment of a long-living permanent European Grid Initiative, whose scope is much longer than the short-living projects on Grids. The EGI Design Study project is an effort to study the establishment of a permanent sustainable Grid infrastructure, commonly referred to as European Grid Infrastructure EGI, in Europe. It is planned that EGI will take over at the end of phase three of EGEE, which is starting in spring 2008 and lasting until spring 2010. EGI is expected to allow interoperability among the NGIs and the existing deployed middleware distributions, coordinating national efforts on Grid computing.

3 gLite: EGEE’s next generation Grid middleware

The software which glues together all the services and the resources of a Grid infrastructure is called middleware. In the case of EGEE the software stack providing all the Grid services is named gLite.

The gLite stack combines low level core middleware with a range of higher level services. It integrates components from the best of current middleware projects, such as Condor and the Globus Toolkit, as well as components developed for the LCG project. The product is a low level middleware solution, compatible with schedulers such as PBS, Condor and LSF, built with interoperability in mind and providing a basic set of services that should facilitate the building of Grid applications.

At present several academic and industrial research centres are collaborating in the development of the software, organized in a number of different activities: Security, Resource Access (Computing and Storage Elements), Accounting, Data Management, Workload Management, Logging and Bookkeeping, Information and Monitoring, and Network Monitoring and Provisioning.

The gLite Grid services follow a Service Oriented Architecture, meaning that it will be easy to connect the software to other Grid services, and also that it will facilitate compliance with upcoming Grid standards. The gLite stack is envisaged as a modular system, allowing users to deploy different services according to their needs, rather than being forced to use the whole system. This is intended to allow each user to tailor the system to their in-
individual situation. Building on experience from EDG and LCG middleware development, gLite adds new features in all areas of the software stack. In particular, it features better security, better interfaces for data management and job submission, a refactored information system, and many other improvements that make gLite easy to use as well as effective. gLite is now at release 3.1 and is complemented by a set of extra services developed by different user communities to fulfill their own requests.

4 Using EGEE infrastructure: a users perspective

After a very short presentation of the main concept we now mention briefly the few steps to be undertaken by a generic user interested in using the EGEE Grid infrastructure and what is possible to do on the top of it. This is a very general overview: more details and specific commands can be found in the official user guide [3].

• Enrolling and installing Grid software

A user should first have to enroll in the Grid and use some Grid software in order to interact with the generic Grid infrastructure.

Enrolling in the EGEE Grid requires authentication for security purposes. Authentication and Authorization policies in EGEE are managed through digital certificates. The user positively establishes his identity with a Certification Authority (CA). Once the Certification Authority is sure that the user is in fact who he claims to be, issues a special digital certificate to the user. This certificate will act as an electronic identity card (ID) which will be used by Grid services to check the true identity of a Grid user and his Grid requests. The user has the responsibility of keeping his Grid credentials secure.

The so-called User Interface (UI) is the gLite software layer that allows users to interact with the Grid. Generally, the User Interface is installed on a dedicated Linux server made available by an organization and/or institution belonging to the EGEE project. There are however several Plug and Play UI packages that can easily be installed on many different Linux flavours. This allows Linux users to install their own personal UI on top of their personal machines. Milu (Miranare Lightweight User Interface) [4], developed in a joint collaboration among Miranare scientific institutions, is an example software project of such products.
• Logging onto the Grid

A Grid login is usually required for Grid users. This login eliminates the ID matching problems among different machines and scales well on large infrastructure composed by thousands of different systems. To the user, it makes the Grid look more like one large virtual computer rather than a collection of individual machines.

The EGEE Grid environment uses a proxy login model that keeps the user logged in for a specified amount of time, even if he logs off and logs on again the operating system, and even if the machine is rebooted. A proxy, created by a specific command on the UI, is nothing but a temporary copy of the digital certificate issued by the CA. Using the proxy the user can interact with all the services on behalf of his original certificate that should be kept in a safe place.

• Interacting with Grid services

Once logged on, the user can interact with Grid services to perform his/her computational task on the Grid. Grid services available are of three kinds in this context:

– information services to query the Grid and getting information about computational resources available,
– resources management services that allow to use the resources by submitting jobs and then retrieve the results,
– data management services that allow the user to deal with data on the Grid infrastructure.

• Queries to the information system

The user will usually perform some queries to check how busy the Grid is, how submitted jobs are progressing, and to look for resources on the Grid. EGEE provides command-line tools for queries of this kind. These are especially useful when the user wants to write a script that automates a sequence of actions. For example, the user might write a script to look for an available resource, submit a job to it, watch the progress of the job, and get the results when the job is completed. EGEE implementation permits some query functions also if the user is not logged into the Grid. Once information about the availability and status of resources has been obtained the user can move on and submit some tasks on the identified resources.
• **Submitting jobs**

Job submission usually consists of three parts, even if there is only one command required.

First, some input data and possibly the executable program or execution script file are sent to the Grid infrastructure that will decide where to execute the job. Sending the input is called staging the input data. Alternatively, the data and program files may be pre-loaded on some Grid storage resources (Storage Elements in the EGEE infrastructure) and the script submitted from the UI just indicates where to find them.

Second, the job is dispatched to some Grid resource to be executed. This task on EGEE is performed by the WMS (Workload Management Systems) that will match the request specified in the job submitted with resources actually available in the infrastructure. Finally, the job reaches a Grid node that will execute it: this execution node is called Computing Element (CE) in EGEE language. The Grid software running on the CE executes the program in a process on the users behalf. It uses a common user ID (pool account) on the CE to do this. We note that a CE is the front-end of a local cluster, equipped with some computational nodes (named Worker Nodes (WN) in EGEE). It is therefore a WN to actually execute the job.

Third, the results of the job are sent back to the WMS where the user can take it with a specific command. This is done intentionally to allow the user to submit from one UI and retrieve final data from another UI. gLite provides a set of commands to monitor all the submission steps.

• **Data management**

The data accessed by the Grid jobs may simply be staged in and out by the Grid system. However, depending on its size and the number of jobs, this can potentially add up to a large amount of data traffic. For this reason, EGEE provides a set of commands to load data on the Storage Element (SE) and a service to move them from one SE to others. A Logical Filename Catalog (LFC) service was also developed to allow to replicate data on several different Storage Element to keep them safe and to minimize data movement. For example, if there will be a very large number of jobs running for an application that will
be repeatedly run, the data used may be copied to many different SE machines than can be close to the CE where jobs are actually executed. This is much more efficient than moving them from a central location every time the application is run. There are many other advanced services in EGEE/gLite with respect to data management: a detailed presentation of them is however not within the scope of this short overview: interested readers can find all the information and links in the already cited gLite User Guide.

5 Conclusion

We introduced in this short paper a few key concepts needed to better understand the following contributions. Our review is necessarily concise: the idea here is to give only an overview and leave details and in-depth analysis to the other contributions in this volume.


References


