Towards virtual learning grid developments

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Abstract

Virtual learning has opened new vistas in meta-information handling. Large collections of portfolios and e-books, large communities of e-people and processes over widespread virtual campuses impose a new management strategy. The most appropriate solution for a global university is to use a grid architecture based on distributed warehouses in order to use its distributed processing power. This paper describes the state of the art in grid computing methodologies and reviews grid models to support the global university paradigm.

Keywords: virtual learning, interoperability, grid computing, global university

1 Introduction

Virtual learning becomes an important topic not only for business entities, but also for academic institutions and for researchers. Recently, a great interest in using advanced ICT methodologies like grid computing proved the validity of the globalisation theory related to business, research and education.

According to (Albeanu, 2007), virtual learning "is a subset of technology-based learning using Virtual Reality Technologies or/and Virtual Environments". Virtual reality applications for education ask for powerful computing resources, mainly for simulation and visualization. A solution for managing costs consists of using the grid paradigm.

Created by UNESCO, the United Nations University, and the Technical University of Catalonia, in 1999, the Global University Network for Innovation - GUNI is composed of the UNESCO Chairs in Higher Education, higher education institutions, research centres and networks related to innovation and the social commitment of higher education", according to GUNI. This is an idea to think about a global university. Another thought comes from distance learning based on ICT methodologies. Finally, an entrepreneurial characteristic of the global university should be considered due to the current nature of globalisation phenomena in business, research and education.

There are universities which already added the slogan "global university". Only one search using the global searching machine will identify them. However, in our opinion, a global university represents more when taking into account a global infrastructure, not only based on some internet services offered by one server or a cluster of servers.

The aim of this paper is to describe the state of the art in grid computing methodologies suitable for developing powerful virtual learning applications for global universities.

The presentation is organised as follows. The second section is a review on current grid computing methodologies used both for research and e-learning.

A grid computing based model of the infrastructure of the global university is described in the third section. A distributed infrastructure as considered by (Berman et al., 2003) is used to solve the problems of interoperability, scalability, reliability and availability, to mention only some quality attributes of such a solution.

Finally, a set of concluding remarks will be outlined in the fourth section.

2 Grid computing methodologies

The grid concept was defined by (Foster & Kesselman, 1998) as the "controlled and coordinated resource sharing and problem solving in dynamic, multi-institutional virtual organizations". Considering the references (Ferreira et al, 2003) and (Jacob et al, 2005), "a grid is a collection of machines, sometimes referred to as nodes, resources, members, donors, clients, hosts, engines, and many other such terms", being seen as a virtual computer, where "individual users (or client applications) gain access to computing resources (processors, storage, data, applications, and so on) as needed with little or no knowledge of where those resources are located or what the underlying technologies, hardware, operating system, and so on are". Other debates related to definitions, grid architecture requirements, and generations of grid systems can be found in (Berman et al, 2003).

When an organization will develop a large scale application, as virtual learning projects for global universities, the grid characteristics of infrastructure, methodologies and a best understanding of the computing power, type of systems' coupling and interoperability standards are very important.

According to (Jacob et al, 2005), the benefits of grid computing are: 1) reducing time processing by running the application on an idle machine from the network, or using a set of machines available in the grid for parallel/distributed processing by *scalability* – a measure of the efficiency of the multiple processors usage on a grid; 2) the unused storage capacity can be aggregated, using the *data grid* concept (a larger virtual data store), in order to improve the performance of the system; 3) the *virtualization of resources* (files, specialized devices, software, services, licences, etc.) improves the interoperability among heterogeneous grid users; 4) the *virtualization of organizations*, the building of virtual communities of users improves the *sharing* and *balancing* of resources and asks for special security rules; 5) the *automatic computing* approach is used by grid systems, that means the "grid management software can automatically resubmit jobs to other machines on the grid when a failure is detected", in order to increase the *service availability*, or "multiple copies of important jobs can be run on different machines throughout the grid", for assuring an increased level of *fault tolerance* and *reliability*; 6) the maintenance actions of the machines does not decrease the service availability, and a dynamic resource management of the shared resources will assure the needs of running applications; 7) grid computing makes use of "an evolving set of *open standards for Web services* and *interfaces*".

The data grid capacity is increased dynamically by usage the storage of the multiple machines based on a unified file system like: NFS (Network File System), DFS

(Distributed File System), GPFS (General Parallel File System), AFS (Andrew File System), or the generic GFS (Grid File System) assuring distributed replication, and distributed data request/fulfilment.

Depending on the grid size, the implementation can use the *cluster* approach (the machines have the same architecture and operating system), the *intragrid* solution (heterogeneous machines but a networked file system; for single organizations, no partner integration support, a single cluster, with a static set of resources), and the *intergrid* approach (intragrids are extended with dedicated grid machines and dedicated communications’ connections; providing support for many organizations, multiple partners, and based on many multiple clusters). As already established by scientists, and stated in the IBM Red Book, written by Jacob et al (2005), “the primary characteristics of an intragrid are a single security provider, bandwidth on the private network is high and always available, and there is a single environment within a single network”.

An intermediate grid architecture model is called the *extragrid*. An extragrid brings together two or more intragrids, and involves more than one security provider. Following (Jacobs et al, 2005), “the primary characteristics of an extragrid are dispersed security, multiple organizations, and remote/Wide Area Network connectivity”.

Any application asking for peer-to-peer computing, serving a collaborative computing community, or based on end-to-end processes will be designed in the framework of an intergrid architecture. This is the case of global universities or networks of universities virtual learning solutions.

A particular machine can be enrolled in the grid by installing the grid software and declaring the machine role (passive or donor). As (Jacob et al, 2005) mentioned, the enrolling requires authentication for user/machine. Logging onto the grid depends on the grid solution adopted (ID, grid login, proxy login); once logged on, the user can sent different queries (grid status, the submitted jobs’ status, etc), and can submit jobs. A possible software solution is GSI-OpenSSH being also used to remotely create a shell on a remote system to run scripts or sent shell commands interactively. The grid application developer will use special functions provided by the grid system software application programming interfaces in order to automate the monitoring and recovery from fail of subjobs (processes, threads).

A special grid user is the administrator with special tasks in managing the grid: grid configuration, software customization, the members’ management, controlling the rights of the users/machines, removing the users/machines, communication with the administrator of the donor machine (about user ID, software, access rights, policy restrictions, etc.), setting permissions for grid users to access resources (usage tracking, billing reports generation), job priority assignment and data grid maintenance (creating backup copies and replicas).

The highest level of security it is assured using a Certificate authority having the following responsibilities: a) to identify the entities requesting certificates; b) certificates management (issuing, removing, archiving); c) names management (by a namespace of unique names for certificate owners); d) the Certificate Authority server protection; e) to manage the signed certificates, and f) to assure the login/logout activities. Currently, the public key encryption system is used.

Developing a grid application requests the usage of open solutions like OGSA (Open Grid Service Architecture), OGSI (Open Grid Service Interface), OGSA-DAI (Data Access and Integration), GridFTP, WSRF (Web Services Framework), XML, WSDL, SOAP, and standards related to Web Services Interoperability.

OGSA is the general model for grid computing environments defining all requirements related to resource models, interfaces, expected behaviours, and run-time bindings. The creation of new instances of resources, global naming and references management, lifetime management, registration and discovery operations, clients notification, authorization and concurrency control are some of the key capabilities of OGSA. OGSI can be used to implement OGSA-compliant services, and deals with mechanisms for creating, managing, and exchanging information for Grid services using an extension of the WSDL (Web Service Definition Language), called GWSDL. OGSA-DAI provides the basis for “access and integration of data from separate data sources via the grid”, according to the mentioned reference. Data transfer across the grid network is supported by GridFTP. Parallel transfers and partial file transfers can be realized secure and reliable. The developers can implement high level services on top of GridFTP. Before discussing WSRF it is important to mention that Grid services are implemented using Web-services technology. However a fundamental difference among them there exists: Web services deal with persistent services, while grid services are transient, being created/destroyed dynamically. Other considerations can be found in (Berman et al, 2003).

WSRF, also, can be used to implement OGSA-compliant grid services. The Web Service Resource definitions are described using WSDL (XML style) and presents the properties of the resource (called *stateful resources*). Any stateful resource “is known to and accessed by one or more Web services”, and can be implemented as a file, a record in a database, or a data structure stored in memory. Its life-cycle is well defined and the data about its state is described using XML.

An OGSA-compliant middleware is Globus Toolkit (Foster, 2005), an open source software useful for building computational grids and grid applications. Binary packages of GT4 are available for Linux environments and Solaris. However, by compiling the source packages or making use of Java-based components, the GT4 can be used on other operating systems. The major components of the version 4 (GT4) address: runtime processing, security, data management, information services and execution management. There available Web service based components (as Java WS Core, C WS Core, Python WS Core, Reliable File Transfer, OGSA-DAI, RLS , WS GRAM, WebMDS, etc.), and non Web service based components (like GridFTP, C-common libraries, etc.). Java WS Core, C WS Core, or Python WS Core, consists of APIs implementing WSRF, and other grid services with Java, C, or Python. The RFT provides a Web service interface useful for transferring, and deletion of files, and is built in top of GridFTP. The RLS (Replica Location Service) provides information about the physical location s of replicated data. MDS (Monitoring and Discovering Services) is responsible with the collection, indexing, archival, distribution of information about the state of resources, services, and configurations. WebMDS is a Web-based interface to WSRF information. WS GRAM provides the remote execution and status management of the jobs.

For computing intensive jobs the Condor software which incorporates many of the emerging Grid-based computing methodologies and protocols is an important solution. Condor-G is fully interoperable with resources managed by GT4. Previous information about Condor was published by Berman et al (2003). Recent information about the last version of Condor is available on the Condor website. A powerful system for automated installation, configuration and management of clusters and farms is Quattor. A positive experience using Quator for Grid-Ireland and Irish e-Research is reported in (Gerdelan, 2008).

In the following, we describe the most valuable characteristics of the grid methodologies to be use in virtual learning solutions.

3 On supporting global university by grid computing

Our study considers the usage of grid computing concepts for supporting e-learning and research in the framework of global society. The concept of global university arises in the recent time, mainly based on e-learning. However, a lot of advantages were established, but there are some disadvantages related to communication (communication between students, and between students and teachers/supervisors can not be as close as face-to-face communication), and laboratory-based activity.

Recently, more advance in creating virtual laboratories and virtual e-lessons removed such disadvantages, and the new ICT methodologies with the aid of grid computing advancement create the environment for building a global university having mission related to research and education, all levels. Collaborative learning is possible using CSCW/L-oriented grid architecture (Li et al, 2006), communication with artificial agents (Cerri, 2008; Cerri et al, 2008), by sharing artefacts based on OSCAR – the Open Source Component Artefact Repository (Boldyreff et al, 2002), using the Shared Event Model (Wang et al, 2005), developing semantic grids, as described by (Bachler et al, 2004) and (Page et al, 2005), using portals like Chiron (Bardeen et al, 2006), and other models and tools for grid or non-grid infrastructures.

The Access Grid Toolkit (AGTk) was used to implement a multi-campus live lecture environment, as described by (Arns et al, 2006). Group-to-group collaborations are supported through the integration of various resources: large-format displays, multiple camera views and audio systems, multicast functionality. AGTk is an open source project, flexible software available for various platforms/hardware setups and operating systems, including Linux and Windows.

Other learning grids were developed for science, libraries, or distance learning. The five layer architecture described by (Tsai, 2006) supports multiple learning management systems (ILIAS, Claroline, and Dokeos, installed on different locations) and GridPortlets in order to use the Grid Portal. A similar architecture was reported by (Yang and Ho, 2005) being based on Globus and AGTk.

Supporting reusability, interoperability and shareability for virtual learning is possible by using standards for resource addressing, learning object description, and object sharing (ADL/SCORM). The EU project InteliGrid (Dolenc et al, 2007) is based on OGSA, and is complied with WSRF, WS+I (Web Service Interoperability), RBAC

(Role Based Access Control model) and uses the Web Ontology Language for describing web services. Also, semantic grids were used for the SELF project (Abbas et al, 2005), and for Mobile Learning (Woukeu, 2005). Positive experience concerning the remote access and programming of robots was reviewed by (Albeanu et al, 2008) proving that a collaboration between engineering laboratories is possible.

4 Conclusions

Taking into account the interconnection of specialized laboratories to the grid infrastructure, it is only a small step to create large scale virtual learning applications supported by the grid infrastructure. The global university will use not only e-learning platforms, but also virtual learning platforms integrating virtual reality laboratories.

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