

Moving From Grid to Cloud Computing: The Challenges in an Existing Computational Grid Setup

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ABSTRACT

Today's scientific research is much based on large-scale numerical calculations, data analysis and collaboration at various levels. In an R&D organization there always exist requirements for more and more computational and huge data volume requirements, to solve challenging scientific and engineering problems. Grid computing addresses this challenge by employing powerful clusters locally and interconnecting them through wide area networks. As far as high performance and scientific computing concerned, Cloud computing provides an infrastructure paradigm which allows sharing the computational resources as a web based service. The attracting feature here is that it relieves the institution from burden of infrastructure development and maintenance of highly expensive supercomputing setup. This paper conducts a study about the issues; challenges involved and suggest possible solutions for an R&D organization, when it moves from an existing Grid computing setup to the Cloud computing model.

Keywords: Virtual Organisation, Virtualisation, gLite Middleware, Grid Security Infrastructure (GSI), High Performance Computing (HPC), Programming Models

1. INTRODUCTION

Grid computing and Cloud computing share many common features in their goals, architecture and technology, but at the same time they differ in many other aspects. These differences include architecture, security, virtualisation, applications and abstractions. There are basically two types of Grid computers based on their functionality namely Computational Grids and Data Grids. Computational Grids deals with sharing and utilizing computing resources from geographically distributed multiple administrative domains and Data Grids deals with controlled sharing and management of large amounts of distributed data. The present Cloud computing models also follows these two major categories. But most of today's scientific computing applications require both of these features together i.e. they need extensive computational power as well as operate on large size data sets.

The paper addresses the major challenges and possible solutions while moving from an existing Grid computing setup to Cloud computing model. One of the major challenges is security related issues. Here we have to consider the uncontrolled nature of World Wide Web (WWW) in contrast with the controlled nature of computational grids. Architecture wise Grid provide a set of standard protocols and middleware, toolkits and services built on the top of these protocols but Cloud is using many existing web based protocols and applications. Another issue that we consider is virtualisation of resources. Virtualisation is more

important to a Cloud than to a Grid. This provides the scientific computing user an illusion that his application is always getting the required computing resources even though many such applications are running simultaneously. We will be considering the most plausible solutions with respect to above issues for a smooth transition from Grid to Cloud.

For this study we are considering an existing computational grid setup implemented using the gLite middleware. The gLite is one of the most commonly used grid middleware which is developed by WLCG/EGEE (Worldwide LHC Computing Grid/ Enabling Grids for E-science).

2. MOVING FROM GRID TO CLOUD: THE REQUIREMENT

The Grid and Cloud share the common goals like reduction in cost of computing; improve quality of service and increase flexibility and reliability. Most of the computational grids are implemented by commodity clusters and are utilised for running highly parallel codes. Even though this setup satisfies the requirement of scientific and research community to a certain extent, the technology incurs certain drawbacks like limitations in growing a parallel job beyond a Grid site, specific nature of supported applications, high cost of operation and maintenance. When we move from grid to cloud, the approach is towards service oriented rather than application oriented. In Cloud computing paradigm, the computing infrastructure is treated as a service which

can be utilised by a larger community through the WWW. Hence Cloud computing can be considered as next generation of Grid computing where the widely accepted web based technologies are wisely incorporated to address the technological and commercial challenges.

3. ARCHITECTURE: VIRTUAL ORGANISATION VS VIRTUALISATION

The challenge what we have to address here is how to move from Virtual Organisations (VO) of Grid environment to virtualisation of Cloud environment. By principle, in Grids the resources are not subjected to centralised control hence the concept of VO has been introduced. VO refers to a group of individuals and/or institutions and resources that work in collaboration towards a common goal. The users of Grid can be organised in different VOs each having different set of policies. The authorisation in Grid is at the VO level, i.e. a user belonging to a particular VO can access those resources that supported by his VO. Hence VO in Grid unifies the resources belonging to different administrative domains. In a gLite based Grid environment, the Grid sites can choose which VOs to support at what level by the administrator. Hence the user at a Grid site can join one or more VOs supported by the site by passing through the required authentication and authorisation procedure.

In Cloud computing, the key concept is virtualisation. Even though the VO concept in Grids provides a sort of virtualisation, there is no virtualisation at resource level of Grid sites. This can be evident from the fact that in Grids, the resource control is decentralised at the site level. That means each site in a VO has full control over its resources, which is not the case with Clouds. In Clouds, virtualisation provides necessary abstraction between the hardware resources and the software services that run on it. This provides the cloud user an illusion that for his application, there always exist the necessary Cloud resources. This concept has great advantages like it reduces the hardware dependency of the Cloud applications and makes them insulated from hardware failure.

Now we will consider how to implement the virtualisation concept over the existing VOs. The virtualization layer that we consider should have two basic functions. First of all it should give an on-demand resource provisioning at the Grid site level. That means the virtualisation software module run at the Grid site will give the job management software an illusion that all the clusters (even if they are heterogeneous) at the site are unified to a single pool of resources. Second, in the similar way the virtualisation layer should give on-demand resource provisioning for remote sites in the same VO. This concept essentially relaxes the resource

provisioning and resource assignment activities from resource management software and it will be taken care by the virtualisation software. The virtualisation layer software will create virtual machines dynamically as pre-created software environments for job execution.

4. SECURITY RELATED ISSUES

The security model implemented by gLite middleware based computational Grids are more robust than the presently available Cloud implementations. Hence we have to essentially consider how to move from the Grid setup to Cloud model without compromising the essence of security. In almost all successful Cloud models presently available, the hardware and software configurations and the supporting platforms are homogeneous and controlled by the same organisation. But Grid is built on the assumption that resources are heterogeneous and dynamic and each Grid site has full autonomy over its resources. Now we will consider in brief how the security model is built in the gLite based Grid setup.

Globally the Grid user community is grouped in to VOs. Before the Grid resources can be used, a user must read and agree with the rules and regulations of the VO he wishes to join, and register some personal data with a Registration Service. Once the user registration is complete, he can access the Grid Services. The gLite based Grid implementation follows the Grid Security Infrastructure (GSI) which provides framework for authentication (public key cryptography and X.509 certificates) and for secure communication (using Secure Sockets Layer i.e. SSL communication protocol). In order to authenticate a user to Grid resources, the user needs to have a digital X.509 certificate issued by a Certification Authority (CA). Grid resources are generally also issued with certificates to allow them to authenticate themselves to users and other services. The user certificate, whose private key is protected by a password, is used to generate and sign a temporary certificate, called a proxy certificate (or simply a proxy), which is used for the actual authentication to Grid services and does not need a password. As possession of a proxy certificate is a proof of identity, the file containing it must be readable only by the user and a proxy has, by default, a short lifetime (typically 12 hours) to reduce security risks if it should be stolen. The above mentioned Grid resource authentication is implemented by Virtual Organization Membership Services (VOMS) mechanism in gLite based environment.

Following are the security features obtained by implementing the gLite based security model that discussed above.

Single Sign-on: As Grid users frequently want to initiate computations that access multiple remote

resources, a user should be able to “sign on” (authenticate) just once, rather than once per resource or administrative domain accessed.

Delegation: A user must be able to provide a program with the ability to run on the user’s behalf, so that the program is able to access the resources on which the user is authorised.

User-based Trust Relationships: If a user has the right to use multiple sites, then the user should be able to use all sites together without requiring that each site’s security administrators interact.

Presently the security model for clouds seems to be relatively simpler and less secured than the corresponding Grid model that we considered. Cloud infrastructure typically relies on Web forms over SSL to create and manage account information for end users. Even if this approach is simpler and less time consuming compared to that of Grid setup, when we consider cross-administrative domain interaction, the more stringent security model as that of Grid is essential. Hence it is recommended to rely on the Grid security model when we move from existing computational Grid to Cloud. That requires additional effort from the developer side to give proper interfaces for the Cloud services to communicate with the Grid based security model.

5. APPLICATIONS AND PROGRAMMING

Traditionally the Grid Computing applications are of High Performance Computing (HPC) nature with tightly coupled parallel jobs which can be executed within a homogeneous cluster environment with low-latency interconnects. Hence the existing Grid setup with gLite based implementation has the limitation that the parallel jobs can not grow across a wide area network. We suggest solving this limitation by implementing an on-demand resource provisioning virtualisation layer for remote sites as discussed in section III. Essentially this implementation has to be supported by a sufficient bandwidth wide area network connecting different Grid sites.

Next we have to address another issue i.e. how to support the typical Cloud applications on the existing Grid system. The typical applications run on present Clouds are loosely coupled i.e. jobs which are composed of many tasks that can be individually scheduled on many different computing resources across multiple administrative boundaries to achieve some larger application goal. Apart from this, typical Cloud applications are transaction oriented and interactive in nature. Hence when we migrate to a Cloud model on the top of implemented Grid setup we have to implement the virtualisation layer that supports the above mentioned typical Cloud applications also. Hence the

virtualisation layer should provide an interface through web technologies to get these added features.

As far as programming models concerned for Grids, the gLite based implementation follows MPI (Message Passing Interface) model in parallel computing, in which a set of tasks use their own local memory during computation and communicate by sending and receiving messages. The same model can be followed in transformed new Cloud model also for compute intensive tightly coupled jobs. The implemented virtualisation layer will give the interface for selecting and managing the required resources dynamically from the virtualised resource pool. Similar way the loosely coupled transaction oriented jobs also can be handled properly by the virtualisation layer.

6. DIRECTIONS FOR IMPLEMENTATION

Based on the study that explained in this paper we suggest the following directions for the implementation of a Cloud computing model on top of the existing gLite middleware based Grid implementation. This is given in Table 1.

Table 1
Directions for Implementation

Sl. No.	Feature	Supported by gLite middleware based Grid model	Suggested for the new Cloud model
1	Architecture	Virtual Organisation (VO) based	Virtualisation over VO
2	Resource management	Done by resource management software of the middleware	Considered as functionality of virtualisation layer
3	Security	Grid Security Infrastructure (GSI) which is more robust and more secure	Rely on the same GSI model for Cloud environment.
4	Applications scalability	Parallel jobs are restricted to run within a Grid site.	On-demand resource provisioning for including remote sites is envisaged with the help of high bandwidth wide area network.
5	Application type	Suitable for tightly coupled compute intensive parallel jobs.	Suitable for tightly coupled as well as loosely coupled interactive jobs
6	Programming model	MPI(Message Passing Interface) support for parallel jobs	MPI support retained with additional support for web based user interactive and transaction-oriented jobs.

7. CONCLUSION

In this study we considered how to move from the existing gLite based Grid computing setup to a Cloud computing model where the promising essence of Computing Grid is retained. We have discussed about the Cloud computing model with parallel distributed systems consisting of collection of inter-connected and virtualised resources that are dynamically provisioned over the existing Grid Virtual Organisations. This move will provide a better single system image for the Grid setup with improved support for high performance computing as well as emerging web enabled applications.

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