Cloud Infrastructure for Research and Education at University of Sofia

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Abstract. The effective and efficient usage of available computational resources in universities can be achieved by their virtualization in clouds. In this paper, the experimental cloud of Faculty of Mathematics and Informatics at University of Sofia is described. Its development is funded from several research projects. The main purpose of the cloud is to serve the computational needs of the donating projects. This includes integration with similar structures at national and international level. The secondary purpose of the cloud is to support education at the university. Considerations for that are that the time slots of the educational and research activities of the main players – academic staff and students, do not intersect.

Keywords: cloud, education, research, university.

1 Introduction

Nowadays, cloud services are widespread. They are applicable not only for commercial purposes, but also for educational and scientific purposes. Until recently, grid infrastructures were used in scientific and academic fields to solve scientific problems, to provide storage for storing sensitive data and to provide computing resources. With the spread of cloud computing, a natural transition from grid to cloud technology has taken place. An example of this is the European Grid Infrastructure (EGI) – scientific grid infrastructure, which serves the needs for computational resources of the wide range of scientific projects and experiments. Since May 2014, the EGI infrastructure migrates its services to EGI, federated cloud and EGI data centers [1].

While grid is based on the resource sharing across boundaries, cloud is based on resource virtualization. In the last few years, cloud computing has also entered as a preferred approach for organizing the IT services of many universities. Furthermore, cloud computing provides opportunities of utilization of computing resources for teaching and learning purposes, for increased collaboration and for resource sharing [2].

Another direction in cloud computing, which is emphasized in [3] is related to the integration of various cloud infrastructures. The relevance of such direction in the academic fields is the need of controlled data sharing, access to additional computing resources and software.

In the context of these two directions: cloud integration and education, the experimental cloud of Faculty of Mathematics and Informatics at University of Sofia (BG-SU-FMI) is presented.

2 Cloud Infrastructure

The cloud of Faculty of Mathematics and Informatics at University of Sofia (BG-SU-FMI) is based on the open source platform OpenNebula. The choice for this cloud platform follows the requirements for integration with similar structures at national and international level. The architecture of the platform contains of two main components:

- Front-end node (FN), which consists of OpenNebula Core and web-based graphical user interface – OpenNebula Sunstone for access to the cloud services;
- Cluster nodes (CNs) – physical servers, which are containers for virtual machines (VM) created by the user.

The OpenNebula cloud platform provides two types of virtualization KVM (Kernel-based Virtual Machine), which is a full virtualization solution for Linux and vCenter, which is a VMware utility used for VM management. For the purposes of the funding research projects the experimental cloud BG-SU-FMI was established, based on the KVM virtualization. On Fig. 1 is shown BG-FMI-SU architecture.

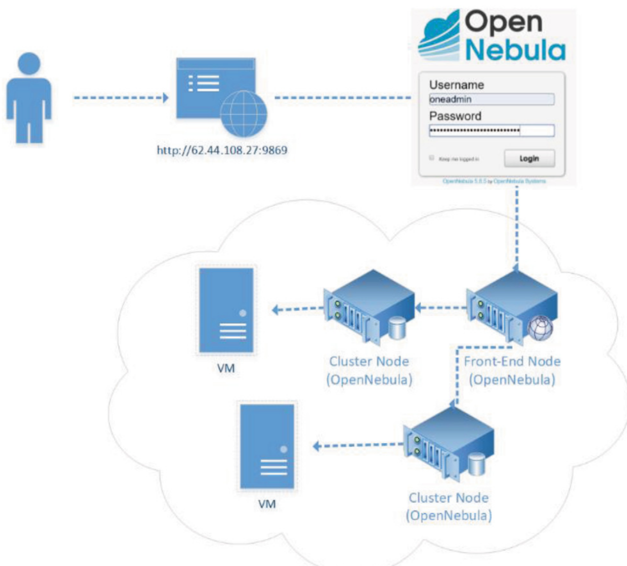

Fig 1. BG-SU-FMI Architecture.

We have 3 servers with 16 cores per server with 2 threads per core – 96 CPUs in total. On every server, we reserve 2 CPUs for the host that cannot be used for creation of VM. The total number of VM, which is allowable, is 90. All technical information for BG-SU-FMI cloud creation is generalized in Table 1.

Table 1. BG-SU-FMI Cloud Technical Specification.

Specification	Value
Number of servers	3
CPU model name	Genuine Intel(R) CPU @ 1.80GHz
CPU cores per server	16
RAM per server	132 GB
Total number of CPU(s)	96
Max number of VMs	90
Total storage	10TB
Operating system	CentOS Linux release 7.7
Cloud environment	OpenNebula 5.8.5
Virtualization system	KVM
Web interfaces	http://62.44.108.27:9869/

3 BG-SU-FMI Cloud Integration

Join Institute for Nuclear Research (JINR, Dubna) established a cloud based on OpenNebula [4]. This cloud is open for integration with the clouds of member's states. Currently, the BG-SU-FMI cloud is in progress of technical integration with JINR cloud. There are two supported approaches for integration with the JINR cloud.

The first approach – cloud bursting (Fig. 2) uses application-programming interface developed on Ruby (Ruby OCCI - rOCCI) and driver for integration based on peer-to-peer model. This approach was recently used for cloud integration between JINR member states and the JINR cloud [5]. However, the increased interest in member states for cloud integration with the JINR cloud reveals a major drawback of the approach - its low scalability and hard maintains. This obstacle has led of looking for new approaches for integration.

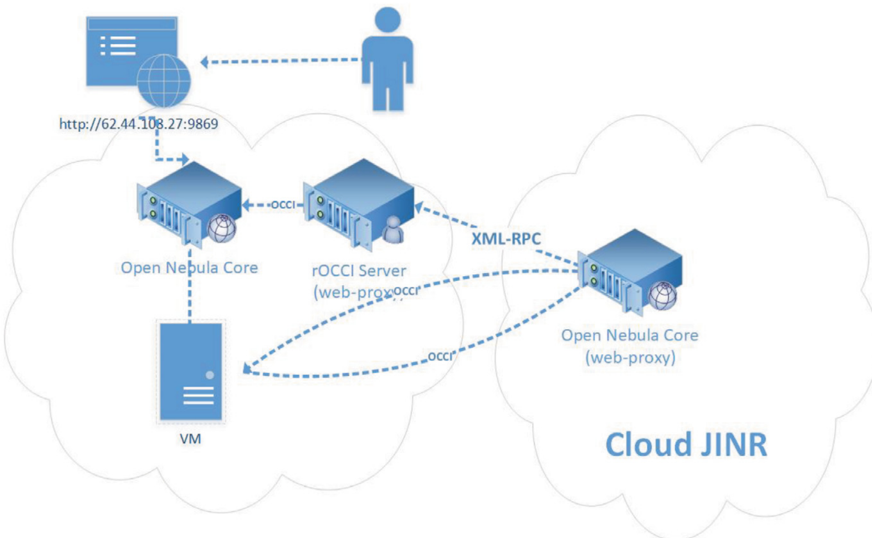

Fig 2. Cloud integration with cloud bursting.

The second approach with DIRAC - Distributed Infrastructure with Remote Agent Control is currently used approach for cloud integration with the JINR cloud. It is based on usage of DIRAC framework - a grid middleware (interware) for distributed computing. The advantage of this approach is usage of different computational resources through pilot jobs, good scalability and easier maintains. The source code of DIRAC is extended (VMDIRAC module is added to the framework) in order to provide the needed functionality for members' state clouds integration.

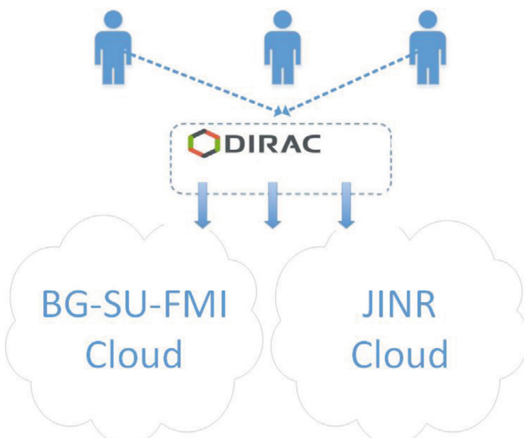

Fig. 3. Cloud integration with DIRAC.

In order to integrate BG-SU-FMI cloud with JINR distributed cloud environment (DICE) the following requirements need to be fulfilled:

1. Working OpenNebula cloud;
2. Special user for cloud integration with password for password-based authentication;
3. OpenNebula XML-RPC endpoint secured with SSL;
4. Specific firewall settings for incoming and outgoing connections for the BG-SU-FMI cloud;
5. Deployed perfSONAR monitoring service (optional) - monitors the network connectivity;

BG-SU-FMI cloud fulfills 1), 2) and 4) points form the above requirements and currently is in progress of technical integration with the JINR cloud.

4 BG-SU-FMI Cloud Usage in Education

The experimental cloud of Faculty of Mathematics and Informatics at University of Sofia (BG-SU-FMI) is used in two university courses: Database systems – practice and Grid and cloud computing – exercises. The Database systems – practice course is proposed for second grade in bachelor program of Information systems. The course covers database administration, tuning and maintains for the different DBMS – DB2, Oracle, MySQL etc. This require every student enrolled to the course to have administrative rights at the OS in order to install, configure and maintain the database server. Usage of VM for that case is not only preferable but also equitable. The Grid and cloud computing - exercises course is proposed for master program of Information systems. The course covers Grid usage, running jobs to batch system: PBS or Condor, OpenMP parallelization and cloud usage. Again, usage of VM is equitable. Usually, number of students, which enroll to these courses, are not more than 50.

On Fig. 4 is shown university's resources used in education and their integration with the university's LDAP. For every course led in Faculty of Mathematics and Informatics there is corresponding course in Moodle – learning management system. The process is automated. Communication with the students is through Moodle or through Zimbra – email web client. Students used the same credentials for Moodle and authorization through LDAP Server authentication. In order to allow students to create and to use VM through OpenNebula Sunstone interface, two steps has to be done.

The first step is to integrate OpenNebula with the university LDAP server. This will allow every student with access to Moodle and Zimbra to have access and to the Sunstone web interface with the same credentials.

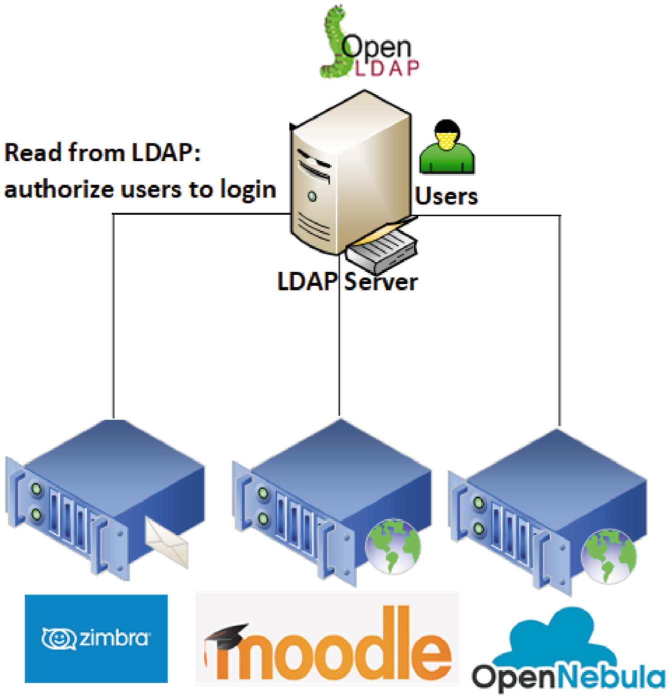

Fig. 4. User authentication and authorization in OpenNebula through LDAP

In order to enable the LDAP Authentication in OpenNebula (BG-SU-FMI cloud) two files have to be modified /etc/one/auth/ldap_auth.conf and /etc/one/oned.conf and configured. This will permit users to have the same credentials as in LDAP and will centralize authentication.

The second step is to create VM templates for the two courses. The minimal requirements for the VM depends from the course. For example, for the Database course VM with one CPU will be sufficient. For Grid and cloud computing course VM with at least 4 CPUs are equitable. BG-SU-FMI cloud allows every student to start his own VM and to exercise installation of database server or Grid, OpenMP and cloud usage.

5 Conclusions and future work

Development of our cloud is founded on some ideas presented in [6], but since then more detailed and sophisticated improvements and developments happened in the Grid and clouds worlds. Current developments are given in this paper.

BG-SU-FMI is the cloud of Faculty of Mathematics and Informatics at University of Sofia. It was applied in education for two university courses. We plan to extend its application and for other university courses. This will require additional resources to be added to the cloud in order to upgrade its abilities. Currently the cloud is in progress of technical integration with the JINR cloud. We are working also in direction of integration and on national level. As participants, we will benefit from cloud integration with access to the projects' specific data, software and computational resources.

6 Acknowledgements

Presented in the paper results are part of the NSF project "GloBIG: A Model of Integration of Cloud Framework for Hybrid Massive Parallelism and its Application for Analysis and Automated Semantic Enhancement of Big Heterogeneous Data Collections", Contract DN 02/9 of 17.12.2016.

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