Integrated Scientific Computing infrastructure in Moldova

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***Abstract* — Various fields of science require solving complex computational problems using resources of high-performance computing (HPC), high-throughput computing (HTC) or Distributed Computing Infrastructures (DCIs). Service oriented infrastructures based on Cloud paradigm simplify utilization of scalable on-demand unified sets of commonly used services. Virtualization and Cloud technologies based on Open Source solutions help to provide to researchers various variants of access to on-demand scalable resources from Private, Hybrid, Scientific, Scientific Federated or commercial Clouds. In the paper described the milestones and perspectives of deployment at the small joint IMI-RENAM cluster Open Source based Centre of Excellence with flexible internal reconfiguration and cost-effective access to unified sets of services.**

***Keywords* — Integrated Grid and Cloud infrastructures, HPC, Federated Cloud on-demand Services, Centers of Excellence, GEANT Testbed Service (GTS)**

I. INTRODUCTION

In recent years distributed information processing and high-performance computing (HPC, distributed Cloud and Grid computing infrastructures) technologies for solving complex tasks with high demands of computing resources are actively developing. In Moldova the works on creation of high-performance and distributed computing infrastructures were started with participation in implementation of a number of international projects. Research teams from Moldova participated in the regional and pan-European projects, including initiatives focused on integration in pan-European e-Infrastructures. That allowed them beginning forming of national heterogeneous computing infrastructure, get access to regional and European computing resources and expand the range and areas of solving tasks.

The important problem is to provide users possibility to debug and test their HPC applications at various types of local resources and prepare applications for porting on regional scientific or pay-for-use computing resources [1].

Various users' communities in Moldova are using scientific computing resources for solving scientific problems in the following research areas: weather forecast, climate monitoring, climate change modeling; medical image acquisition, storing, processing and visualization; computational physics; crystal lattice structures investigation; nanotechnology, nano-materials and nanoelectronic discrete devices modeling and computer aided designing of semiconductor devices; economical processes modeling based on game theory algorithms. The mentioned here directions represent the main, but of course not all research fields that are using computing infrastructures.

II. CURRENT MD-GRID STATE

The scientific computing resources in Moldova had begun developing from the initial deployment in 2006 of the first Grid cluster that was integrated in the regional South-East Europe Grid infrastructure. These specific and new for Moldova activities were supported by a serious of the regional SEE-GRID projects [2]. The initially accumulated experience was successful from the point of view of forming professional team of specialists in the area of distributed computing and examination of potential users' communities needs in computational resources that pave the way for creation of the prepared national users' community.

RENAM Association, representing national scientific-educational network of Moldova (NREN), started to build MD-Grid National Grid Initiative (NGI) in 2007. National Grid Initiative of Moldova represented by the Joint Research Consortium that was created within the framework of the SEE-GRID-2 project supported by the European Commission [3]. MD-Grid NGI - National Grid Initiative of Moldova was inaugurated on May 14, 2007 after receiving approval letters from Ministry of Information Development of Moldova and the Academy of Sciences of Moldova. The MD-Grid NGI Consortium is governed by RENAM as its Coordinating body and joins nine research, education institutions and industry that

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expressed their intent to participate in the processes of building National Grid Infrastructure and using its resources

The development of national Grid infrastructures since 2010 [4] is coordinating by European Grid Initiative within EGI-InSPIRE pan-European project that focused on supporting transition process to a sustainable pan-European e-Infrastructure [5]. EGI-InSPIRE activities cover grids of high-performance computing (HPC) and high-throughput computing (HTC) resources. The project integrates new Distributed Computing Infrastructures (DCIs) such as clouds, supercomputing networks and desktop grids, to benefit the user communities within the whole European Research Area.

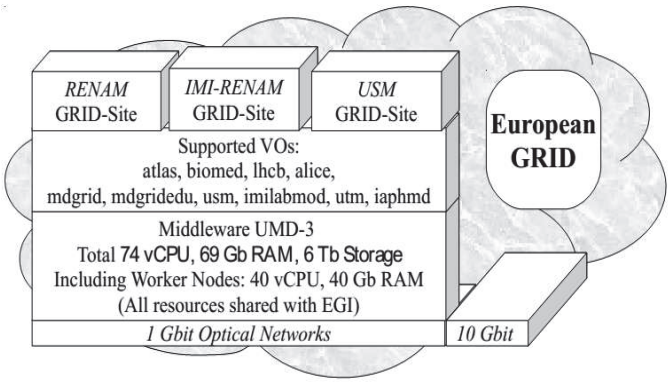

Fig. 1. MD-Grid current infrastructure

At present Grid infrastructure in Moldova (MD-Grid) unites three sites in Research and Educational Network Association of Moldova (RENAM), Institute of Mathematics and Computer Science of Academy of Science of Moldova (IMI ASM) and State University of Moldova (USM) [6]. MD-Grid has well determined perspectives for its further enlargement.

At all sites is used "Unified Middleware Distribution" (UMD) - the integrated set of software components contributed by Technology Providers and packaged for deployment as production quality services in EGI. Actively deploying of virtualization technology allows maximum flexible and efficient use of the available computational resources.

III. RENAM Cloud - Current Experimental State

A. Deploying OpenNebula

The first practical results on deploying of open source Cloud computing infrastructures for research and educational area were obtained during RENAM Association participation in the regional project "Experimental Deployment of an Integrated Grid and Cloud Enabled Environment in BSEC Countries on the Base of g-Eclipse (BSEC gEclipseGrid)". The main purpose of the project was to deploy a regional integrated Grid and Cloud enabled environment based on g-Eclipse for the South-East Europe region including Armenia, Georgia, Moldova and Romania [7].

Users will access Grid and Cloud resources with g-Eclipse in an easy and uniform way, instead of having to use application specific portals or specific Grid consoles. As an example, if the user requires parallel computational resources, he will submit a job on the Grid, but if the user needs any specific software or environment to solve some special problem, create new distributed service, he can use a dedicated Cloud service or virtual images for that purpose.

In the "BSEC gEclipseGrid" project distributed Cloud computing platform was deployed using resources provided by each partner country. As a result in Moldova had been deployed the Cloud testing infrastructure based on OpenNebula 4.4.1 middleware. The national Cloud resources have been joined together using the OpenNebula Zones (oZones), which allows centralized management of multiple instances of OpenNebula and especially designed to create federated Cloud infrastructure. Some disk images with preinstalled operation system and main open source applications for solving computational problems in different scientific domains such as environment, meteorology, seismology and astrophysics [8] were integrated in this computing Cloud infrastructure.

B. Deploying OpenStack

OpenStack cloud middleware is highly configurable to meet different needs with various computing, networking, and storage options. OpenStack in general has more built-in features and is considered as a leading open source Cloud realization. These middleware main components provide at least the same functionality in common sense that any other open source cloud solutions. OpenStack middleware can be used for building any types of Clouds: private, public, mixed and those Clouds can be of any complexity and scale [9].

OpenStack cloud as infrastructure for Virtual Machines creation and management stands in a basement of GN3plus project service activity SA2: Testbed as a Service – GEANT Testbed Service (GTS) (http://services.geant.net/gts) [10].

GTS gives researchers the opportunity to set up their own customized experimental platforms (Testbeds) in order to be able to test new concepts in networking and telecommunications without affecting production traffic. To create this customized environment the user has access to a pool of virtualized resources that can be programmed and reserved using a Domain Specific Language (DSL) description or selected via a Graphical User Interface (GUI). With the DSL it is possible not only to define requests, but it also offers Groovy programming language syntax that allows the specification of scalable and complex topologies. DSL code can be saved to ensure that testbeds or testbed segments can be iteratively reused and built into much larger constructs.

Working of the team from Moldova in the above-mentioned initiatives pushed us to deploy additional Cloud computing infrastructure on the base of OpenStack middleware.

We have used the latest at the moment of deployment Ubuntu Server 14.04 LTS as a base operation system for all nodes and deployed latest version of OpenStack release "Juno" [11]. This infrastructure interconnected via two Gbit dedicated switches - one for management and one for data network. Internet connectivity for virtual machines provided with Generic Routing Encapsulation (GRE) tunneling protocol via the Network Node, which uses Software Defined Network (SDN) technology software – Open Virtual Switching (OVS).

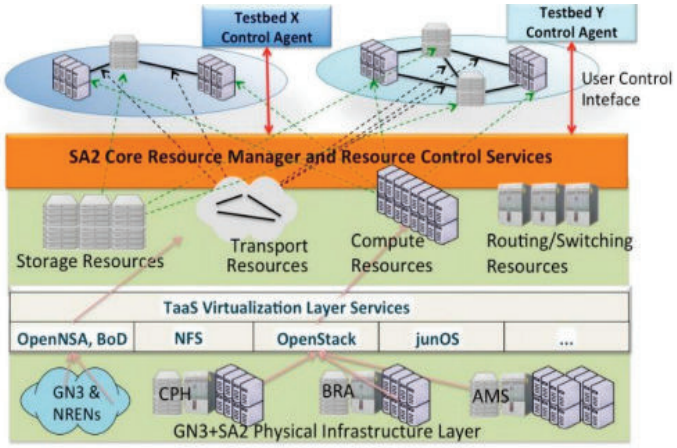

Fig. 2. GTS Infrastructure virtualization concept

This network model provides connectivity between all VMs in a tenant network, regardless of which compute node the VMs reside in and segregates VMs, which are in different tenant networks in this sense, GRE tunnels are an alternative to VLANs. Open Virtual Switch based network infrastructure in our second Cloud testing infrastructure is a big step forward compared to the first one built using Open, which is built using standard Linux bridge module. Network layout for OpenStack Cloud testing infrastructure presented in Fig.3. It supports main networking protocols including OpenFlow and is a very flexible and powerful instrument.

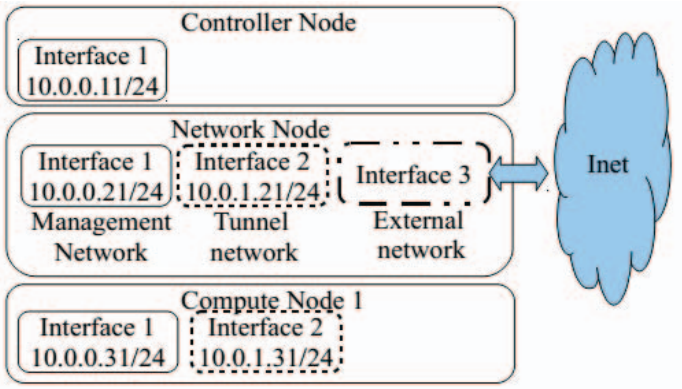

Fig. 3. Network layout for OpenStack Cloud testing infrastructure

IV. MD GRID AND CLOUD ROADMAP

RENAM and the Institute of Mathematics and Computer Science have enough resources in the joint cluster to develop, debug and prepare for porting scalable applications that will use different HPC resources. Our strategy is to train researchers, PhD students and university students getting started with parallel clusters' systems, educate them how to create and run applications using different programming technologies and parallel computing facilities. Our 64-core cluster has appropriate resources for development and debugging of initial versions of parallel applications for different projects and for further scaling them for porting to resources that are more powerful. By using of virtualization and private cloud, we can deploy required infrastructures for wide range of scientific experiments.

Using resources of IMI-RENAM joint cluster in the Institute of Mathematics and Computer Science of ASM started creation of the Centre of Excellence (ICELEN). ICELEN planned as a complex of technologies for learn-test-use-with-support approach to assist:

- investigation and deployment of actual and innovative IT technologies;
- providing to researchers access to various local, national and regional computing infrastructures;
- organizing workshops and trainings with online participation by utilization of Big Blue Button (BBB) web-conference tool;
- deploying Learning Management Systems (LMS) Moodle (Modular Object-Oriented Dynamic Learning Environment) for distance learning;
- creating Testbeds or provide on-demand computational resources for researchers;
- offering support for researchers over Service Desk OTRS (Open-source Ticket Request System) with add-ons OTRS ITSM (IT Service Management).

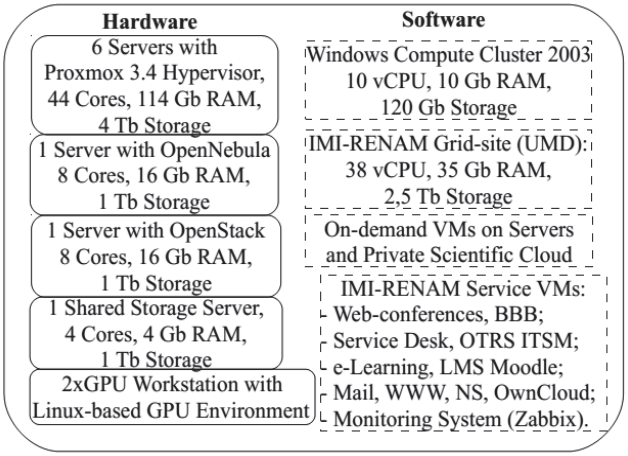

Fig. 4. IMI-RENAM joint cluster infrastructure.

V. CONCLUSION

Virtualization and Cloud technologies gives resource providers flexible tools for effective resource manipulation in small-medium computing infrastructures.

The created regional cloud testing infrastructure is the successful example of adaptation of new technologies and open source software platforms for providing computational resources to scientific community.

There are perspectives to continue development of the scientific Cloud infrastructure and technologies at national and regional levels. We intend together with other BSEC gEclipseGrid project partners to continue works focused on adaptation and implementation new open source tools for extension of the created federated cloud infrastructures. Other perspective direction that can get new experience for national scientific computing infrastructure and services development is

cooperation with partners within new cloud activities initiating by GEANT project community and with new projects realizing by European Grid Initiative that comprises activities related to integration of the national and European Grid and Cloud computing infrastructures.

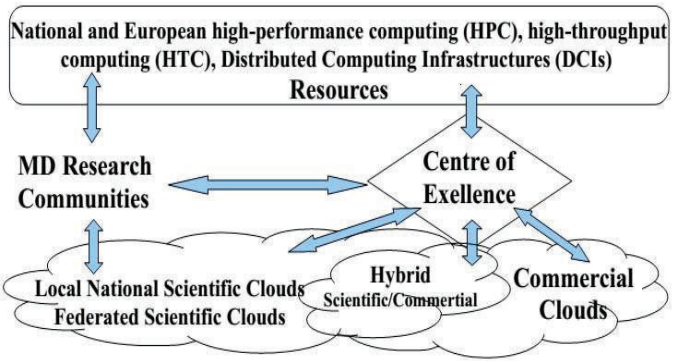

Fig. 5. Computing resources for MD Research Communities.

We expect positive outcome from realization of the described above concept of creation of the new Centre of Excellence focused on a perspective approach of implementation of the proposed jointly by RENAM and IMI ASM the idea of deployment of national federated network of cloud computing resources. This network would provide wide range of unified services for research and educational institutions that significantly contribute to the development of the national scientific computing infrastructure.

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