# New developments of Distributed Computing Technologies in Moldova

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In the paper described directions of distributed, high performance computing (HPC) and other computer technologies development in Moldova. Considered research includes analysis of trends in the development of computer technologies, which focused on creating conditions for solving complex applied problems with high demands of performance computing resources. The result of these studies is the following conclusion: the main development directions focused on integration of distributed Grid and parallel HPC facilities on the base of virtualization paradigm within integrated cloud infrastructure in order to expand the range of opportunities for end-users by providing heterogeneous computing resources. Perspectives of utilization of cloud computing technologies for integration of distributed Grid infrastructures and HPC clusters in heterogeneous computer infrastructures that are offering effective computational resources and end-user interfaces are considering.

Keywords: distributed computing technology, cloud computing, high performance computing, computational clusters, grid computing infrastructure.

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## 1. Introduction

In the past years, development of distributed and high-performance computing (HPC) technologies for solving complex tasks with specific demands of computing resources are actively developing, including in Moldova. New areas of works in this direction focused on integration of Grid, HPC and Cloud infrastructures and gain benefit to end users from uniting computational resources of Grid and HPC clusters with effective users' interfaces and computer infrastructure management tools offering by cloud.

## 2. Approaches of Heterogeneous Federated Infrastructure realization

These developments are using results of previous projects like the regional project "Experimental Deployment of an Integrated Grid and Cloud Enabled Environment in BSEC Countries on the Base of g-Eclipse (BSEC gEclipseGrid)" supported by Black Sea Economic Cooperation Programme (http://www.blacksea-cloud.net). For this project we selected middleware implementing computing architecture that provide a collaborative, network-based model that enables the sharing of computing resources: data, applications, storage and computing cycles. The project allowed introducing the general idea of federated Cloud infrastructure, which can offer different solutions for universities, scientific and research communities [Astsatryan, Hayrapetyan, …, 2013; Bogatencov, Secrieru, …, 2016]. The project was focused on implementation approaches to combine the Grid and Cloud resources together as a single enhanced computational power and offer the possibility to use Grid or Cloud resources on demand. 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, he can use a dedicated Cloud service or virtual image for that purpose. Fig. 1 shows the skeleton of the suggested platform.

The proposed platform made possible to solve the following problems:

- increasing the effective usage of computational resources;
- providing additional services on demand for scientific and research communities;
- close collaboration between different resources providers.

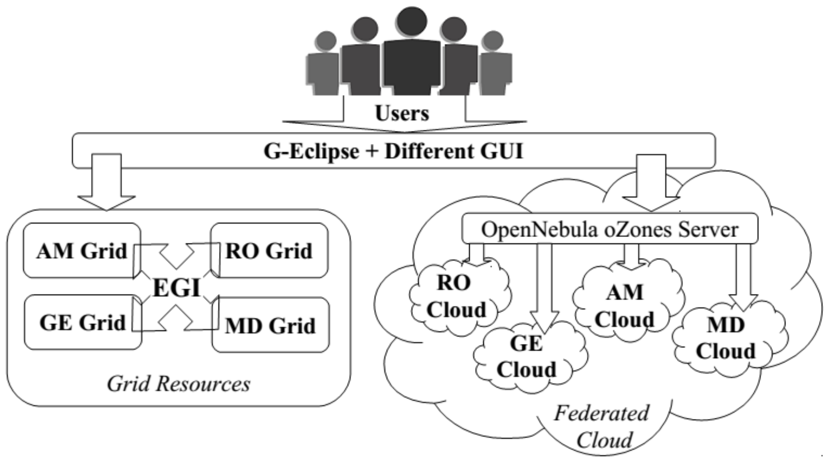


Fig. 1. General structure of the proposed heterogeneous regional platform

The objective was to create an infrastructure, which uses resources provided by geographically distributed heterogeneous computing clusters. Different sites are operating by independent organizations, which have total control on managing their own resources, including the setup and enforcement of special administrative policies regarding authorization and access, security, resource usage quota, monitoring and auditing of the local infrastructure. The resource providers delegate the control for a part of their infrastructure in a safe and efficient way, so a federated infrastructure can be build based on the resources available on these distinct administrative domains. This is a major challenge regarding the implementation of a federated Cloud infrastructure as it is sought to be achieved by the currently implementing initiatives.

These achievements we used for development of the national distributed computing infrastructure. The general scheme, showing the plan of the integrated computational infrastructure evolution in Moldova presented in fig. 2.

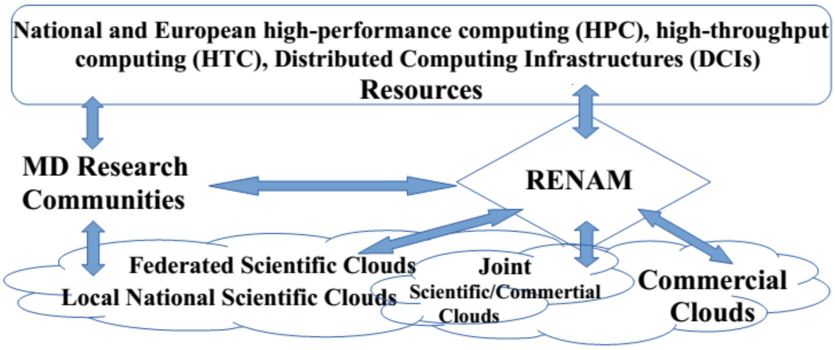


Fig. 2. The prospects of evolution of the distributed computing infrastructure in Moldova

## 3. OpenStack Based Solutions for Integrated Infrastructure Deployment

Future developments of integrated heterogeneous distributed computing infrastructure since 2016 continued within new regional project VI-SEEM (VRE for regional Interdisciplinary communities in Southeast Europe and the Eastern Mediterranean) [European Commission H2020 project]. During preparations for this new project the works were effectuated to unite in one regional infrastructure various distributed computing resources like Grid, HPC, storage and computing cloud. To achieve the initial idea and ensure heterogeneous resources management for HPC, Grid and storage access on the cloud we in Moldova continued works on development of relevant and flexible basic cloud infrastructure.

The first experimental infrastructure based on OpenStack middleware was deployed using the latest at the moment Ubuntu Server 14.04 LTS as a basic operation system for all nodes and the latest version of OpenStack release “Juno”. This infrastructure was interconnected via two dedicated Gbit switches - one for management and one for data transfer network. External networking connectivity and internal networking for virtual machines provided via the Network Node. The Network Node runs SDN (Software Defined Network) technology software – Open Virtual Switch (OVS). OVS created virtual network infrastructure for virtual machines and segregates different network slices using GRE (Generic Routing Encapsulation) tunneling protocol. It also supports many networking protocols including OpenFlow and it allowed us to implement very flexible and powerful management instrument.

To develop OpenStack management capabilities and flexibility at the next step of cloud infrastructure extension we used Fuel open source deployment and management tool for OpenStack. Developed as an OpenStack community effort and approved as an OpenStack project under the Big Tent governance model, it provides an intuitive, GUI-driven experience for deployment and management of a variety of OpenStack distributions and plug-ins.

Fuel brings consumer-grade simplicity to streamline and accelerate the otherwise time-consuming, often complex, and error-prone process of deploying various configuration flavors of OpenStack at scale. Unlike other platform-specific deployment or management utilities, Fuel is an upstream OpenStack project that focuses on automating the deployment of OpenStack and a range of third-party options, so it is not compromised by hard bundling or vendor lock-in [Mirantis OpenStack].

Later we deployed our OpenStack cluster using Mirantis 7 Fuel project solutions (see fig. 3). The deployed cluster contained two computing nodes, one controller and had in total 16 CPU cores, 32GB of RAM and 1 TB HDD storage. Fuel gives us the speed, ease and reliability of Open Stack cluster deployment, as well as the flexibility to configure the cluster on the fly. New cluster's components, such as computing nodes, controllers and storage nodes can be easily connected to an existing infrastructure or be removed from it when needed. The entire installation and configuration takes place automatically, followed by a set of special scripts that check system availability after cluster deployment (health check). Thanks to this, we are able to use efficient of the existing computing resources, reconfigure access to other virtualized facilities and save huge amount of time that was previously required to deploy and manage the distributed resources manually.

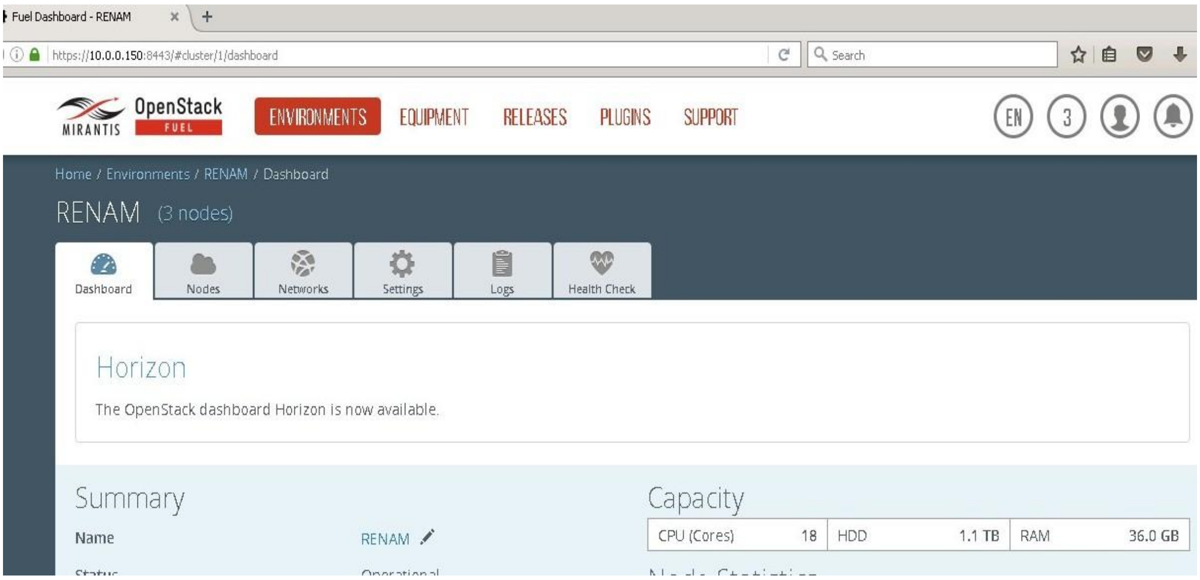


Fig. 3. Configuration of the OpenStack cluster based on open source Mirantis Fuel project

However, in the course of our acquaintance with Mirantis we periodically had different kinds of problems that hindered the raising of a stable fault-tolerant infrastructure. There were problems with containers running on Fuel Master Node, affected various inconsistencies with the existing hardware at our disposal. Deploying of the same infrastructure models completed with varying success depending on the selection of a particular configuration of server type or hardware. One of the goals of Fuel was to rid the system administrators and people, who decided to start learning the OpenStack, from solving of a huge range of technical issues by choosing a particular model installation and implementation of it in the automatic mode. By automating of infrastructure deployment, the needed time reduced several times, and the probability of mistakes made by the administrator in configuration of services has decreased to zero. Nevertheless, even though it saves us from the "headache", it also imposes greater restrictions on the possibility of a flexible infrastructure configuring. In addition, hiding from our eyes the huge number of settings in order to automate the installation imposes additional complexity in the subsequent operation in the case of the equipment failure or the need to change the configuration of the already running infrastructure. Having a very valuable experience while exploring Fuel, and after weighing the strengths and weaknesses of Mirantis we have created the optimal for us model of OpenStack Cloud infrastructure deployment.

Starting with version 8.0, Mirantis Fuel requires mandatory use of the Neutron network controller that leads to waste of resources and creation of additional difficulties in cases where the problem can be solved much easier (for example, for our small infrastructure). Moreover, by abandoning new version of Fuel we saving resources because there is no need to provide them for a separate virtual machine “Fuel Master Node”. As a result, we decided to refuse from using new Mirantis 8 additional features and proceed further with manual installation of OpenStack. RENAM Scientific Cloud (RSC) now is re-deployed by using OpenStack 13.1.1 Mitaka middleware (see fig. 4). In RSC installed digital certificate TERENA SSL CA 3. Access to RSC resources provided via https://cloud.renam.md.

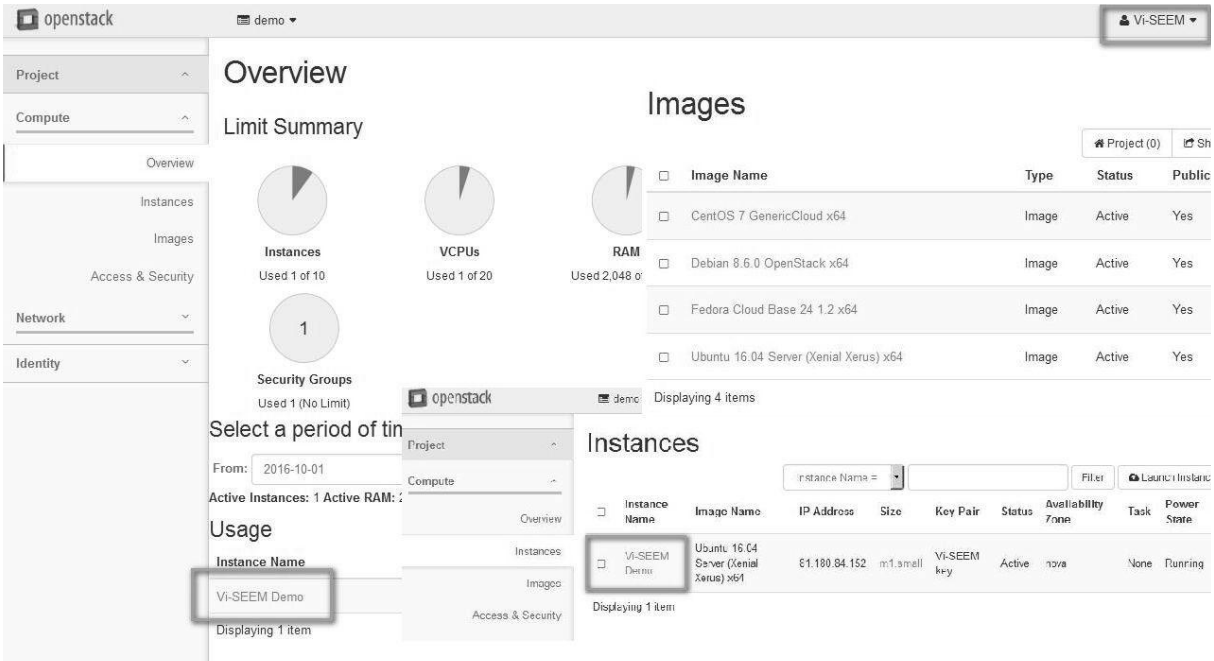


Fig. 4. Configuration of the OpenStack cluster based on OpenStack 13.1.1 – Mitaka

## 4. Federated IdM to access integrated computing infrastructures

To ensure operation of federated mechanism to access distributed computing resources were finalized works to realize solutions that allow providing unified access to cloud infrastructures and be integrated in the creating Research & Educational identity management federations operated within eduGAIN inter-federation authorization & authentication mechanism (AAI). The practical results in the area of implementation of federated access to cloud are based on realization of EGI-Inspire AAI Cloud Pilot project “Federated Authentication and Authorization Infrastructure (AAI) for NREN services” and other new results obtained during deployment and administration of OpenStack cloud infrastructure [Bogatencov, Degteariov, …, 2014].

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