

# E-Infrastructure RENAM: Approaches and Solutions for Development of Modern Services and Resources

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**Abstract** — in the paper presented analysis of approaches and solutions developed within RENAM e-Infrastructure for improvement access to various services that deployed to support research and educational activities. These approaches focus on main aspects of national, regional and international connectivity and services developing that is ensuring wide use of electronic resources and services of the modern joint e-Infrastructure connected to the Pan-European Academic Network GEANT.

**Key words** — Digital environment, computer networks, IT and e-Infrastructure services.

## I. INTRODUCTION

With the progress in the field of telecommunications, the conditions have been created for the emergence of computer networking infrastructure, originally conceived as a network for the academic community (researchers and academics), which has generated a vertiginous expansion of the digital space with penetration into all areas of human activity. Global networking infrastructure moved priorities to issues of cooperation at national, regional and international levels in the field of information and communication technologies (ICT) development in order to improve research, education and other society activities.

Research and Education (R&E) have traditionally been based on two approaches (theoretical and experimental approach), but creation of the electronic computer in 1946 and the Internet in 1973 have contributed to the uprising of a third approach, as much important as the two traditional ones - the computational expedients and modeling. Transforming traditional education and science into e-Education and e-Science requires the existence and use of a unified e-Infrastructure, infrastructure that is integrated into the wide R&E community. What has contributed in recent years to massive investment in creation of specialized eInfrastructures for R&E, including in National Research and Education Networks, called NREN.

## II. WORLDWIDE ACADEMIC NETWORK FOR R&E COMMUNITY

Electronic communications and services have become a national and global priority in 21st century as a result of the fact that the knowledge-based society has a significant impact on all sectors of the economy and the competitiveness of society. The European authorities perfectly understand the need for a common vision of modernizing society and of developing the competitiveness of the European economy. This vision, formulated at the Council of Europe in Lisbon in 2000, sought to set out guidelines for strategies and policies that respond appropriately to these challenges.

In the European and other developed countries (USA, Canada, Australia, etc.), have been created and nationally subsidized National Research and Education Networks (NRENs), especially dedicated to the organizational, technological and informational support of the R&E domain. There are many examples of successfully operating NRENs: DFN - Germany, RENATER - France, GRNET - Greece, RoEduNet - Romania, RENAM - Moldova, etc. (now existing more than 40 NRENs in Europe and more than 160 NRENs in the world). With common goals aimed at increasing excellence in education and research, European NRENs are integrated into a pan-European academic network GEANT (Gigabit European Advanced Network Technologies, [www.geant.net](http://www.geant.net)), founded in 1993 with support of the European Union (EU) [1]. NRENs' development priority is promote specific services for R&E in order to improve level of research and education in Europe.

GEANT Network is one of the world's most advanced networks that is offering a wide range of specific IT resources and services for R&E. In interaction with GEANT RENAM is developing its own networking infrastructure that is covering now main universities and research institutes of Moldova. Mainly institutions and universities' campuses connected to RENAM National Fiber Optic Infrastructure with capacity of 1 Gbps. Since 2017, the backbone is gradually transferring to 10 Gbps transmission capacity.

Started extension of networking infrastructure for the territory covering – now connected universities in Cahul and Taraclia, there are plans to create nodes in Beltsi and Comrat [2].

All services and resources delivered over RENAM e-Infrastructure united in three main groups:

- National;
- International;
- NREN’s support of cooperation within projects.

### III. NATIONAL LEVEL SERVICES IN ACADEMIC NETWORK

RENAM at present developing and distribute the following services and technologies, available for research and educational community of Moldova [3]:

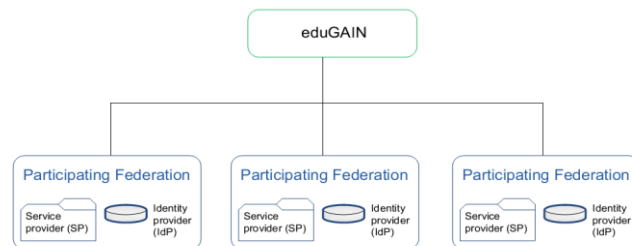
- World-wide secured access to academic networks and global internet through the GEANT network infrastructure;
- Providing high-speed connections between national and international institutions;
- Interconnection of national research and educational institutions: ASM, UTM, ASEM, USM, UPSC, USMF "N. Testimițianu", USEM, State University in Taraclia, State University in Cahul, AMTAP, USPEE and others;
- CISCO Academy - Authorized ICT Training Service within CISCO Academy Support Center (RENAM)
- e-LIBRARY - authorized access to electronic publications, database (EBSCO, etc.)
- Support by Computer Security Incident Response Team (CSIRT);
- GCS (Digital Certificate Service) - access service to DigiCert digital certificates via GCS (GEANT Certificates Service); the service includes issuing personal certificates (email signature, documents, access, etc.), server certificates (SSL, EV SSL, Grid etc.) and some other on users request;
- Access to RENAM Cloud services. The main aim of RENAM Cloud is to provide for R&E community resources for projects with preconfigured Virtual machines (VMs). Now RENAM offering cloud infrastructure for the following useful services:
  - mail (Zimbra);
  - Help Desk (GLPI);
  - Wiki (BlueSpice MediaWiki);
  - Video conference (Big Blue Button);
  - LDAP (OpenLdap);
  - OwnCloud;
  - Eduroam (Radius server);
  - Network Monitoring tools (Zabbix);
  - Clear OS: Ubuntu, CentOS, Debian etc.

### IV. INTERNATIONAL SERVICES PROVIDED BY NREN

RENAM network as a NREN of Moldova is a member of GEANT Consortium and all services developed and operated by GEANT community accessible for national R&E, cultural and medical institutions via RENAM networking infrastructure. Among these services the following can be

mentioned as important for users’ community of Moldova [4]:

- EDUGAIN – Federated Identity Management service that is using global inter-federation mechanism (as it shown in Fig. 1) that is uniting



National identity federations;

Fig. 1. The eduGAIN Inter-federation Model

- Access to high-performance computing resources (HPC) of European computing infrastructures for executing applications of connected institutions;
- Access to Cloud computing resources of the world-class cloud infrastructures (Amazon, Microsoft, CloudSigma, etc.) via GEANT Framework Contract for obtaining various cloud resources using federated access;
- EDUROAM (education WiFi roaming) - secured WiFi network access service over the world (see – [www.eduroam.org](http://www.eduroam.org));
- Unified distributed network monitoring and security system;
- GTS (GEANT testbed service) - access to virtualized resources for testing information systems and new communication protocols. GEANT Testbeds Service (GTS) provides dynamically created, fully isolated, production-grade, packet testbeds as a service for the research and education community worldwide. The main purpose of GTS is to provide infrastructure and tools for easy creation of user defined experimental networks for testing novel networking and telecommunications concepts at scale, and across a geographically realistic European footprint. Current GTS topology includes eight location-s in Europe (Amsterdam, Bratislava, Hamburg, London, Madrid, Milan, Paris and Prague). User can easily build high performance heterogeneous virtual environments using following resources (see Fig 2.): virtual machines (VMs), virtual links (Links), bare metal servers (BMSs), virtual switch instances (VSIs). The network testbed resources dynamically allocated from real e-infrastructure distributed throughout the GEANT network. Different topology Testbeds can be used not only for network experiments, but also for Computing Classes, computational facilities, applications testing and so on.

## V. PROJECTS RESOURCES AND SERVICES FOR R&amp;E

The European Union invests heavily in the development of electronic research infrastructures, based on interconnected supercomputers and HPC clusters, using open-source software and providing a rich set of user oriented services. The European Commission has supported substantial investment in building and integrating electronic research infrastructures comprising of High Performance Computing resources and data warehouses with large cloud storage capacities and advanced features. In order to maximize the use of such expensive equipment it is necessary to deploy an integrated set of services that provide flexible and transparent access to the computing and storage resources [5].

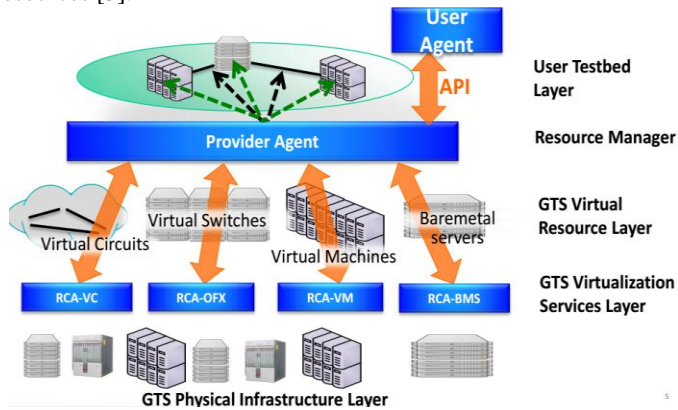


Fig. 2. GTS Virtualization, Management, and User Control Layers

As an example of this initiative is H2020 “VRE for regional Interdisciplinary communities in Southeast Europe and the Eastern Mediterranean (VI-SEEM)” regional project. VI-SEEM is a three-year project that aims at creating a unique Virtual Research Environment (VRE) in Southeast Europe and the Eastern Mediterranean (SEEM), in order to facilitate regional interdisciplinary collaboration, with special focus on three scientific communities - Life Sciences, Climatology and Digital Cultural Heritage [6].

The VI-SEEM project unites 16 partners (one of them is RENAM), each of which provided for the purposes of the project part of the own resources with project aims to deliver to R&E community integrated Virtual Research Environment, including supercomputers, HPC clusters and advanced storage facilities.

The common hardware infrastructure consists of a number of supercomputers, high-performance clusters with advanced interconnects as well as some more generic clusters, mainly providing resources for Grid jobs. The table below (see Table 1) shows the computing and storage resources provided for VI-SEEM project.

The idea of the Virtual Research Environment is to create an integrated environment that serves the needs of a wide set of researchers. The innovative potential of such virtual labs makes them interesting for industry, especially for medical research and research related to agriculture and the impact of climate change.

The researchers can obtain two types of access. Those that apply and obtain access through the Open Calls run by the project will get direct access to the resources and services and will be able to request modifications and extensive support. The other scientists will get access through web portals and other

similar interfaces, so that they would benefit from running the applications and workflows, but without direct control of the execution. In this way, the use of the infrastructure and the services developed is maximized and the technology barrier to using computing resources for scientific research is lowered, as the hard work is done in advance by a few dedicated developers and system administrators.

TABLE I. COMPUTING AND STORAGE RESOURCES IN VI-SEEM

Country	Grid			Storage			Cloud		HPC			
	Sites	Project Cores		Sites	Project TBs		Sites	Project VMs	Sites	Project Cores		
		CPU	GPU		Disk	Tape				CPU	GPU	Phi
Greece	6	43	0	1	100	250	1	200	1	425	0	0
Cyprus	0	0	0	2	145	0	2	16	1	209	2,419	0
Bulgaria	2	155	0	2	80	0	1	64	2	166	819	963
Serbia	3	42	0	1	10	0	0	0	1	85	2,714	0
Hungary	0	0	0	1	50	300	0	0	2	48	14,3	0
Romania	1	6	0	1	5	0	1	40	2	819	720	0
Albania	0	0	0	0	0	0	0	0	1	14	0	0
Bosnia	1	16	0	1	1	0	0	0	0	0	0	0
FYROM	2	2	0	1	4	0	1	20	1	50	0	0
Montenegro	1	32	0	0	0	0	0	0	0	0	0	0
Moldova	3	8	0	1	2	0	1	8	0	0	0	0
Armenia	2	12	0	2	16	0	1	32	1	26	0	0
Georgia	1	19	0	1	2	0	0	0	0	0	0	0
Egypt	0	0	0	1	100	0	0	0	1	208	0	0
Israel	1	3	0	2	5	0	1	28	0	0	0	0
Jordan	4	44	3,296	0	0	0	0	0	0	0	0	0
TOTAL	27	382	3,296	17	520	550	9	408	13	2050	1558,433	963

Within first two years of the project for R&E community was provided user-friendly integrated e-Infrastructure platform for Scientific Communities in Climatology, Life Sciences, and Digital Cultural Heritage for the whole SEEM region. The platform is linking compute, data, and visualization resources, as well as services, software and tools for the next Virtual Research Communities (as it presented in Fig. 3):

## A. Climatology

VI-SEEM have strong impact on the Climate Modelling and weather forecasting communities. First, there is significant potential to share best practice and data for local and regional Climate Modelling, Weather forecasting and air quality simulations. The community will benefit from the combination of HPC and Grid computing jointly with the storage facilities as it heavily relies on data from very scattered locations.

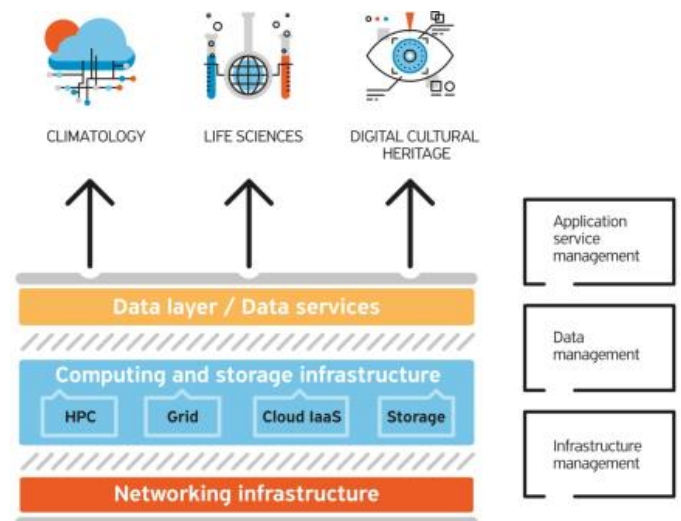


Fig. 3. VI-SEEM integrated e-Infrastructure platform

Next Climatology applications were awarded to use VI-SEEM resources on base of evaluation of results of the two announced "Calls for resources": ACIQLife, ClimStudyArmenia, DREAMCLIMATE, DRS-ACS, EMAC, ENB-RCM, HIRECLIMS, OPENFOAM, RCM MENA-CORDEX, TVRegCM, VINE, WRF-ARW, WRF-Chem (NOA) (source - <https://vi-seem.eu/climate/>)

Additionally, VI-SEEM creating many opportunities for users that have not collaborated before to engage in joint activities: with code repositories and training material for climate models, the VRE providing a highly productive working environment for Climate scientists from the 12 different research groups distributed over 10 countries. Finally, the regional research activity also links into global efforts towards understanding the climatic changes and challenges. The services provided by this community enable contingency planning and help understand climatic conditions within which our future societies will live.

### B. Life Sciences

Life Sciences largely benefit from VI-SEEM. The associated data analysis challenges include capture, curation, analysis, search, sharing, storage, transfer, and visualization. The VI-SEEM Life Sciences community consists of 12 research institutes from nine different countries of the region. Next Life Sciences applications use VI-SEEM resources on base of evaluation results of the two "Calls for resources": BioMoFS, CCC, CNCADD, DICOM, MD-Sim, MDSMS, MS4DD, NGS1, NGS2, PSOMI, SEMaCD, SQP-IRS, THERMOGENOME, D3R (source - <https://vi-seem.eu/life-sciences/>).

The project is improving the innovation capacity as well as the efficient collaboration of researchers in the SEEM region by providing access to needed codes, data repositories, training material for data generation, processing and simulation setup. The Life Sciences community will lay the foundations for a larger infrastructure aiming to integrate all the laboratories that generate big data in the SEEM region in the future.

### C. Digital Cultural Heritage

The Cultural Heritage researchers pursue activities on a number of common themes and topics that impacted by the shared e-Infrastructure. Common data repositories and software, such as content management system MEDICI, algorithms for remote sensing image classification, idPromo for automatic object recognition etc., advancing the research capacity of the various groups by optimally utilize provided tools.

Next Digital Cultural Heritage applications use VI-SEEM resources on base of evaluation results of the two "Calls for resources": 3DINV, AutoGR, BVL, CH-CBIR,CHERE, CSAD, Dioptra, ELKA, Manuscript, PETRA, VirMuf, IMC4CH (see - <https://vi-seem.eu/cultura-heritage/>).

Beyond the data needs, VI-SEEM also facilitate the slow transition of the Cultural Heritage community towards computational more intensive activities, such as high detail

rendering of 3D modelling, and simulations of environmental influence on historical buildings. Shared datasets, easy remote access and visualization enabled by the VI-SEEM platform offer a novel approach to Cultural Heritage research that can foster innovation in methodologies and applications used. The Cultural Heritage Scientific Community of VI-SEEM consists of 11 research institutes from seven countries.

Some of the applications within the project foresee industrial use. For example, the drug research-related applications aim to develop new workflows for drug development and testing using compute power. The research in the domain of climate change and its impact on the environment can be important for making business plans in the medium to long term, in domains like agriculture or energy production.

## VI. CONCLUSIONS

Digital space development marks a new generation of integrated resources and services that form a new environment for research and education, providing users with affordable online resources and services, regardless of time and geographical location, and a unique tool for nationwide and international collaboration in applications development.

The overall aim of RENAM as a NREN is to make resources and services of the national and European e-infrastructures widely accessible that will significantly reduce the digital divide and brain drain by increasing participation of research communities of Moldova in European research and innovation programmes and enhanced international cooperation in education.

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