DEVELOPMENT OF EFFECTIVE ACCESS TO THE DISTRIBUTED SCIENTIFIC AND EDUCATIONAL E-INFRASTRUCTURE

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The article presents the analysis of approaches and solutions for upgrading of the distributed e-infrastructure of NREN RENAM as a key factor for support of research and educational (R&E) activities in Moldova. Special attention is paid to the development of cross-border optical connections for interaction of the national networking infrastructure with the pan-European academic network GEANT and neighborhood NRENs, the introduction of modern services for support R&E, improvement of national and regional cooperation. The infrastructure upgrade is focused on supporting a high-bandwidth distributed environment for deploying and operating a wide range of services offered to end users by the RENAM-GEANT platform.

Keywords: Distributed e-infrastructure and services, Cross border fiber connections, NREN optical backbone

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1. Introduction

The e-infrastructure for science and education in the Republic of Moldova is based on the networking infrastructure of RENAM Association, which provides the necessary specific services and ensures interaction with the pan-European academic network GEANT. Organizational structure of RENAM Association uses the European model attributed to a National Research and Education Network (NREN) aimed to support collaborative research of regional and pan-European scale that is realizing in a form of various international projects. Current trends in the modernization of e-infrastructures indicate the need to expand the capabilities of the optical networking infrastructure of NREN RENAM in order to improve regional connectivity and offer possibility to deploy modern services for support research and education.

Expanding the capabilities of national optical infrastructure and Cross Border Fiber (CBF) connections are the main directions of RENAM network development that is supported by international projects. In this direction it is important participation of RENAM in the European Commission (EC) initiatives focused on analyzing current state and activities of NRENs in the Eastern Partnership countries (Azerbaijan, Armenia, Belarus, Georgia, Moldova and Ukraine), developing appropriate proposals for the regional NRENs operation enhancement, implementation of modern services and effective connections to GEANT network.

2. Previous preparation activities

RENAM together with other NRENs of the Eastern Partnership countries in 2006-2007 participated in the EU project "Distributed optical gateway from Eastern Europe to GÉANT (Porta Optica Study - POS)" [1]. Within the framework of the project, a feasibility study of possible solutions for creation of a regional fiber-optic infrastructure for the integration of NREN of Eastern European countries into GÉANT was carried out. Specific recommendations have been developed for the construction of a number of cross-border CBF connections that will integrate neighboring NRENs and potential points of presence (PoP) of GEANT backbone were specified for connecting the regional infrastructure to GÉANT network.

Within the framework of the following projects (2011–2015), the study of possible solutions for development of e-infrastructures for support R&E in the Eastern Partnership countries and creation of cost-effective, reliable and scalable optical connections was continued [2]. These studies included argumentation of the need to use of long-term optical connections based on Independent Rights of Use (IRU) approach with operational support for 10-15 years, as well as CBF-based solutions for interconnecting regional NRENs and connecting them to GEANT backbone via selected PoPs of GEANT. The elaborated recommendations, proposed technical solutions and support of EC projects allowed establishing in the region direct optical links between NRENs from Romania and Moldova, Poland and Ukraine, Poland and Belarus. Thus, Moldova, Ukraine and Belarus gained effective cross-border connectivity to satisfy the current users communities' needs. However, to comply with GEANT resilience backbone construction requirements, it was necessary to create new back-up connections to GÉANT network for NRENs of Moldova and Ukraine.

The first RENAM external optical connection for access to GEANT network was Chisinau - Iasi - Bucharest channel (initially with a scalable bandwidth of 1-10 Gbps). The optical channel was created and put in operation in 2010 as part of the successful implementation of two international projects: SEE-GRID-SCI (funded by the European Commission) and NIG 982702 (funded by NATO). The first RENAM-RoEduNet-GÉANT optical connection was implemented by using Nortel – Ciena optical equipment [3].

In 2012, after successful implementation of the initial optical connection of RENAM to GEANT, a dialogue between experts from GEANT, EU NREN, RENAM and other EaP NRENs was resumed. New stage of research was initiated in order to identify priority areas and possible solutions for the integration of all Eastern Partnership countries into GEANT. Based on the data obtained, the needs of the national R&E communities for connectivity, computing resources and specific electronic services were analyzed. The collected information and accumulated experience formed the basis for the development of conceptual directions of the new EaPConnect project, taking into account the specific needs of each Eastern Partnership country.

3. Development of regional optical CBF infrastructure

The development of the regional optical networking infrastructure for efficient access to the GEANT network and associated services required the identification of sustainable and cost-effective technical solutions. For this, a number of technical workshops were organized, in which specialists from GEANT, EU and EaP NRENs took part. The results of these studies and discussions within the technical team allowed to form a common vision regarding the development of the regional network infrastructure in the Eastern Partnership region and recommendations for the use of long-term allocated DF or spectrum on fiber connections [4]. The proposed regional network topology is considering consisting of two sub-regions that will have their own primary and back-up connections to GEANT:

- Eastern Europe networking segment, which covers NREN Belarus, Moldova and Ukraine;
- Caucasus Networking segment, which includes NRENs from three Caucasus countries.

The developed topology for Eastern Europe networking segment became the subject of implementation within the framework of the first stage of the EaPConnect project, which was launched in 2015. At this stage a detail technical solution was developed to create a CBF connection between Moldova (NREN RENAM) and Ukraine (NREN URAN), to establish effective connections to GÉANT network PoPs in Poznan (Poland) and Bucharest (Romania) as development of regional communication arch implemented by support of the EaPConnect project [5].

The general scheme of regional connectivity proposed for implementation, that is taking into account the requirements of RENAM and URAN, is shown in [fig. 1]. The proposed solution based on results of previous studies and analysis of new RENAM and URAN connectivity requirements, overview of the currently available options to use DF, lambda or spectrum resources.

Figure 1. Topology of proposed CBF connections

In the elaborated proposal specified the list of equipment that includes modern optical devices required to create a reliable network infrastructure in the region. To comply with general approach of GEANT network backbone extension, for connecting of Eastern Europe NRENs to GÉANT network

proposed to create GEANT PoPs in Kiev (Ukraine) and Chisinau (Moldova). This proposal takes into account the long-term perspective of possible updates of the NRENs interconnection topologies and also expansion of the GÉANT network in the Black Sea region.

4. Updating and utilization of distributed computing resources

Over the past few years, during RENAM's participation in the EaPConnect and other international projects, not only the network infrastructure has been seriously upgraded. The significant changes were achieved in development of many other e-Infrastructure components: server infrastructure had been extended with the new high-performance and highly reliable servers, the uninterruptible power supply and air conditioning systems of server's facilities were also modernized. RENAM computer resources were integrated at national level in common distributed infrastructure with multiprocessor clusters and servers' resources operated in the Moldova State University and in the Institute of Mathematics and Computer Science. Created robust, performant and secure infrastructure has become a platform for expansion and improvement of services provided for R&E institutions of Moldova.

These realizations allowed to intensify the use of the distributed computing resources. One of the representative examples is recently launched and actively used multi-node distributed video-conferencing system, that providing facilities for organization of online classes since the beginning of the lockdowns, caused by the COVID-19 pandemic back in 2020. Video-conferencing system is powered by the open-source project BigBlueButton [6]. The system is integrated with the Moodle, creating a self-sufficient distant e-learning platform and it is now actively used for distant learning by the main universities of Moldova: the Moldova State University, the Academy of Economic Studies of Moldova, as well as by some smaller institutions in Chisinau and in the regions (e.g., in Comrat city). It hosts roughly 1 – 1,2k of concurrent users daily with the peaks up to nearly 2k users in about 60 separate virtual rooms distributer among the servers' cluster. The statistics for the first half of September 2021 is presented below [fig. 2].

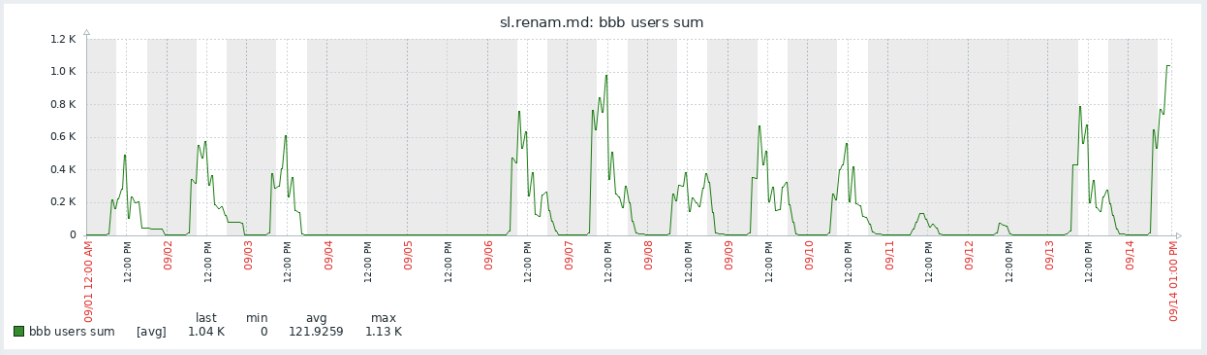

Figure 2. Number of online users of VC system

The effective use of the VC system has been achieved by uniting 9 distributed BBB nodes in a cluster using Scalelite project. Scalelite is an open-source load balancer that manages a pool of BigBlueButton servers. It makes the pool of servers appear as a single (very scalable) BigBlueButton server. A front-end, such as Moodle or Greenlight, sends standard BigBlueButton API requests to the Scalelite server which, in turn, distributes those requests to the least loaded BigBlueButton server in the pool [7]. We are also using Greenlight as a meeting managing plugin and a pool of three Traversal Using Relay NAT (TURN) servers for relaying the traffic between peers behind the NAT.

The modernization of the network and server infrastructure contributed to the development of RENAM's Cloud infrastructure to ensure the conditions for solving various R&E problems according users' requests. Active work is underway to increase the resources provided by our OpenStack Clusters, accessible at cloud.renam.md, by increasing the number of computing nodes, switching from 1Gbps to 10 Gbps connections, as well as migrating to a new version of OpenStack middleware.

For the development of eduroam Wi-Fi roaming infrastructure, ensuring safe and fast Wi-Fi coverage of campuses of educational and scientific organizations, in the first phase of the EaPConnect project Cisco Wi-Fi equipment was purchased and 140 new Wi-Fi access points were distributed to operate eduroam in R&E institutions in Moldova. To provide Identity Management service six new IdPs (Identity Providers) base on the universal software platform have been deployed and supported for universities, research institutes and medical institutions in Chisinau and Comrat.

5. Conclusions

Within the framework of the EaPConnect project, a CBF regional optical infrastructure was created with the possibility of increasing the connections throughput up to 300 Gbps by upgrading of the existing communication equipment. GEANT PoP was deployed in Chisinau, that has connections by separate lines with two GEANT access PoPs in Europe. The created infrastructure ensures reliable interaction of NREN RENAM and NRENs of neighboring countries with the GEANT network and is designed to provide an internal connectivity with a speed of 10 Gbps and more, that corresponds the current specific needs of R&E institutions in Moldova. Modernization of the network and server infrastructure allowed to intensify the use of the distributed computing resources and contributed to the qualitative development of IT services for R&E in Moldova.

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