RUNNET: INFRASTRUCTURAL AND SERVICE BASIS OF THE NATIONAL RESEARCH AND EDUCATION NETWORK OF THE RUSSIAN FEDERATION

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The paper overviews the issues of the current state and prospects for the development of the Federal University Network RUNNet as the infrastructural and service core of the national research and education network of the Russian Federation. The characteristics of the telecommunication infrastructure, including the backbone infrastructure and the infrastructure of the access, the features of the connectivity of the RUNNet network with world's research and education networks are discussed. The information on implementation of some in-demand IT and network services in RUNNet is provided, including eduroam and eduGAIN projects which are based on the principles of federated authorization and authentication (AAI).

Keywords: RUNNet, NREN, national research and education network, telecommunication infrastructure, network connectivity, network services, scientific data, AAI

1. Introduction

Efficient use of ICT in education and science solving a complex task of creating a single digital platform of the Russian Federation is impossible without a balanced development of main components of the national information and technological environment. The most important components are the modern distributed infrastructure for storing and processing scientific data (supercomputers, data centers), a high-speed telecommunication infrastructure designed to provide transmission and transparent access to date, and an ecosystem of services for storing, transferring, processing, analyzing, searching and other operations with scientific data and educational resources [1-3].

The instructions to the Government for the development of national projects in the field of science and education, issued by the President of the Russian Federation and based on his "May" Decree #204 of 7 May 2018 include thesis that solution of such set of tasks is directly related to the implementation and ubiquitous use of digital technologies, the creation of an advanced research and development infrastructure in the country that exploits the global competitive infrastructure of high-speed transmission, processing and storage of large amounts of data.

It is expected that special attention will be paid to the implementation of the "mega-science" class projects, ensuring access of Russian researchers to international advanced research results and the international R&D infrastructure, the development of cooperative communications of Russian and foreign research organizations, expanding cooperation with the leading scientific centers of European countries as formulated in the National Project "Science" for 2018-2024 being developed currently.

The world professional community of scientists and researchers generally recognizes that the presence of own reliable and high-performance telecommunication infrastructure that corresponds to the advanced technological achievements of the industry and is used exclusively in the interests of science and education of the country is one of the significant characteristics of the level of economic and technological development of the state and that is strategically necessary condition for stable progress and condition for accordance the world level of attainments in the most diverse fields of science and technology [4, 5].

It is customary to call such a sectoral telecommunication infrastructure the National Research and Education Network (NREN) [4]. The main tasks to be solved by NRENs include the realization of network connectivity for science and educational organizations of the country, providing target users with the access to the global ICT space, the connectivity with international research and education networks and network consortia, the development and implementation of in-demand services, centralization, control and optimization of costs for network infrastructure and services.

To date, more than 140 countries around the world purposefully support and gradually improve NRENs as an integral part of their own telecommunication infrastructure. NRENs are usually affiliated with the state educational and scientific authorities and are representing their countries in the international projects, in the implementation of which the up-to-date telecommunication facilities and advanced network services and technologies are intensively used.

The effective solution of the above-mentioned and a number of related tasks, as well as the full-fledged and effective participation of leading Russian scientific and educational centers in international and domestic research projects carried out on the basis of the mega-science class facilities (primarily in nuclear physics, astrophysics and satellite observations, geophysics and climatology, etc.), requires the creation, formalization and provision of targeted support of the state of the functioning of the national research and education network of Russia as one of the key elements of the developing the single digital platform of the country.

The Federal University Network of Russia, RUNNet (Russian UNiversity Network, www.runnet.ru) had been operated and developed by SIIT&T "Informika" with the support of the state for almost 25 years [1-3]. Telecommunication and information services of the RUNNet network are used by more than 300 higher education institutions and scientific and research organizations, connected directly through the infrastructure of this sectoral telecommunication network, which has points of presence in more than 50 subjects of Russia and has unique connectivity with the world's

leading NRENs and network consortia (among which are GÉANT, NORDUnet, Internet2, ESnet, DFN, Jisc, RENATER, GARR, RedIRIS, SWITCH, SURFnet, etc.).

RUNNet de facto performs the basic functions of NREN, being the largest in the country and the only research and education network of national level and having the most extensive telecommunication infrastructure.

The main goal of RUNNet as an infrastructural and service basis for the national research and education network of the Russian Federation is to provide scientific and educational organizations of the country with the opportunities to carry out advanced R&D, to participate in the major international research projects based on the use of a sustainable ICT infrastructure, integrated into the global infrastructure of world's NRENs.

RUNNet provides its target users (scientific and educational organizations) with high-speed direct access to the world's NRENs and its resources and services, forms and ensures the functioning of a unified R&E information space for the sphere of education and science of the country for the implementation of information interaction between organizations in carrying out their core activities, providing educational services, joint implementation of scientific and technical projects.

RUNNet is actively cooperating with the leading scientific centers of the country (including the Joint Institute for Nuclear Research and the NRC "Kurchatov Institute") in part of the implementation of a set of activities aimed at developing the ICT infrastructure of the centers, optimizing the interworking of the organizations participating in experiments at CERN (Tier1/Tier2 grid sites), as well as improving the network access of individual Russian scientific centers and higher education institutions to unique research facilities and supercomputers located on the territory of these and a number of other organizations, with an emphasis on using the infrastructure capabilities of the RUNNet network.

The total amount of scientific data processed in RUNNet (the exchange of target traffic among users of the network, as well as with the world's R&E community) is considered to exceed 65 Petabytes per year. This data volume characterizes the stable demand for infrastructure and network services, and also confirms the existence of sustainable scientific and educational collaborations. The total quantity of network users by independent estimates exceeds 3 million.

2. Features of telecommunication infrastructure and network connectivity of the RUNNet network

The backbone network infrastructure and the infrastructure of the access are the parts of the telecommunication infrastructure of the RUNNet network. The High-Level Design Network Architecture of the RUNNet network is shown in Figure 1.

The transport basis of the main infrastructure of RUNNet is the backbone network, which provides intra-Russian backbone connectivity between all federal districts and the regions located in them, as well as with the international research and education telecommunications space.

The backbone network extends from Amsterdam to Khabarovsk at a distance exceeding 5000 km; its work is ensured by international, national-level and regional telecommunication nodes. The backbone infrastructure combines supporting nodes and telecommunication channels between them which form together the backbone network.

The national-level nodes of the RUNNet network are located in Moscow and St. Petersburg, and they are key elements of the backbone network. The nodes are connected within the cities through high-speed communication lines that have a ramified infrastructure and provide full redundancy. Between the cities the nodes are interconnected by 4 high-speed fiber-optic channels with full redundancy and a total capacity of 40 Gbps.

The national-level nodes are connected by backbone channels with regional nodes, access nodes, telecommunication research and sectoral networks of other departments, networks of other telecommunication operators, as well as with the global Internet.

The regional nodes of the RUNNet network are located in the largest cities of Russia (Nizhny Novgorod, Perm, Yekaterinburg, Chelyabinsk, Ufa, Samara, Saratov, Novosibirsk, Tomsk, Barnaul, and Khabarovsk); they are backbone telecommunication nodes used to connect scientific and educational organizations located mainly in the center of the corresponding subject.
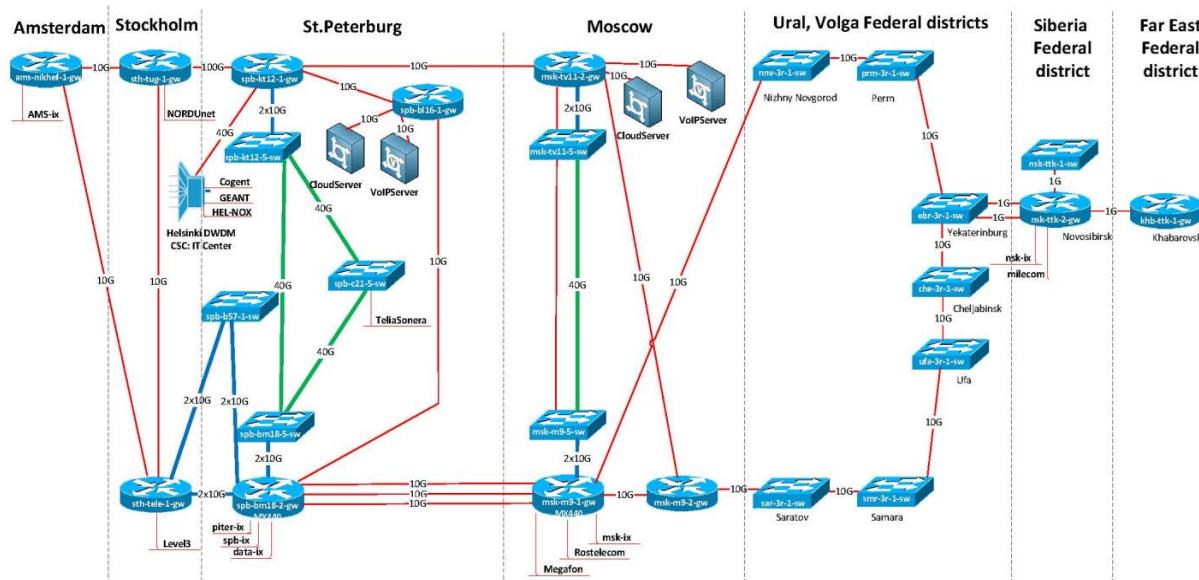
Figure 1. High-Level Design network architecture of the RUNNet network

The telecommunication nodes located in the cities of the European part of the country (namely in Moscow, Nizhny Novgorod, Perm, Yekaterinburg, Chelyabinsk, Ufa, Samara, Saratov) are interconnected using a network with ring topology and 10 Gbps bandwidth (project 3R – RUNNet Russian Ring). In these cities productive data transmission equipment is mounted, which serves for connectivity across the ring and organizes connectivity with local networks of scientific and educational organizations of the city. Access to the RUNNet network and transit to the global Internet is carried out through the nodes of RUNNet in Moscow; there is also a direct connection of the ring with the regional node in Novosibirsk which is the key node for the Siberian and Far Eastern regions.

Connectivity of RUNNet with the world's NRENs and with the global Internet is provided through the national-level network nodes in St. Petersburg through redundant high-speed backbone channels.

The international backbone infrastructure of the RUNNet network is based on a long-term stable and successful cooperation with the research and education network of Nordic countries, NORDUnet (used to access resources and services of NRENs) and an established network interaction with a number of leading world's Tier1 operators (for access to the global Internet; total capacity of 30 Gbps). The international telecommunication nodes of RUNNet are located in Helsinki, Stockholm, and Amsterdam.

RUNNet has two independent connections to one of the largest research and education networks – in Helsinki (to GÉANT, via NORDUnet) and in Stockholm (to NORDUnet) with a capacity of 10 Gbps each and the possibility of expansion.

RUNNet operates and develops its own high-performance DWDM network on international routes from St. Petersburg to Helsinki (utilized bandwidth of 40 Gbps) and from St. Petersburg to Stockholm (100 Gbps) [1].

RUNNet participates in traffic exchange on 6 IX nodes (including AMS-IX, MSK-IX, DATA-IX, PITER-IX; 41 Gbps in total), and has more than 25 direct peering connections (e.g. Google, MegaFon, Rostelecom, Mail.ru, Selectel, Nauka Telecom, MnogoByte, FIORD, Filanco, ER-Telecom; 175 Gbps in total). More than 220 Petabytes of data are processed annually on the RUNNet network infrastructure. In terms of the overall level of network connectivity, RUNNet is ranked as the Top10 in Russia (on the background of the largest network operators, such as Rostelecom, Transtelecom, Vimpelcom, MegaFon, RASCOM, MTS, et al.) and occupies at the moment the 68th place in the world (see http://as-rank.caida.org).

3. In-demand services for R&E community in the RUNNet network

The specialists of the RUNNet network deploys, operates and constantly supplements the pool of promising and widely-demanded services and information resources for the R&E community of our country, being guided by the best world practices and taking into account the experience of leading NRENs and network consortia, firstly, GÉANT, Internet2, ESnet, SURFnet, SWITCH, UNINETT, and some others [1, 5].

The permanently expandable portfolio of services covers next main directions: data transfer services, infrastructure services, real-time communications services, cloud services, trust & identity services.

Separate attention deserves very promising services intensively developed in RUNNet from recent times, which are based on the principles of federated authorization and authentication (AAI) – eduroam and eduGAIN [6].

Eduroam (EDUcation ROAMing, www.eduroam.org) is a service of a safe and free international roaming in Wi-Fi networks for the R&E community, developed by the consortium GÉANT [6]. Students, teachers and scientists receive free access to the Internet and the resources of NRENs at universities and research institutes in Russia and abroad at the campuses of organizations participating in the project. Transparent access is provided by the credentials (login and password) given to the user by his "home" organization. From a technical point of view, the service is based on a distributed hierarchy of RADIUS servers interacting with each other (specialized software that implements the authentication, authorization and collection of information about the resources used by the RADIUS protocol).

The eduroam service operates in more than 85 countries, supporting the processes of scientific cooperation, educational mobility and the exchange of more than 15,000 scientific and educational organizations only in Europe.

The main results of the eduroam project activities in RUNNet for now are realization and support the functioning of the integrated AAI on the basis of RUNNet and RASNet (sectoral network of the RAS) networks with the organization of reservation of key infrastructure elements (within the framework of the Cooperation Agreement with the Joint Supercomputer Center of the RAS), carrying out of works on connecting higher education institutions of Russia to the project, deployment of pilot roaming zones in scientific and educational organizations of the country.

The eduGAIN project (EDUcation Global Authentication Infrastructure, www.edugain.org) of the consortium GÉANT connects Identity federations operated in different countries around the world and providing access to content, services and resources of the global R&E community [6]. The project comprises today over 50 participant federations, within which there about 2,150 service provider nodes (SP) and more than 2,800 nodes of identity provider (IdP).

The infrastructure of authentication and authorization allows users to access information resources and services of NRENs and the Internet using the technology of Single Sign On (SSO). The existence of identity federations greatly simplifies the organization of interaction between the supplier of scientific and educational resources and services and the end user, while the storage and processing of user's personal data is carried out in full compliance with the requirements of the current legislation.

Specialists of RUNNet during 2017-2018 carried out a wide range of works in the part of the deployment of a basic AAI platform in the network, among which:
• creation of a federation management infrastructure on the base of the RUNNet network;
• deployment of a demonstration polygon of federated access to corporate cloud services including ownCloud, FileSender, Redmine, et al.;
• development and approval of organizational-legal and technical regulations of the identity federation of Russia;
• preparation of necessary documents and filing an application for the entry of the identity federation of Russia into the global project eduGAIN.

Based on the results of the organizational and technical work performed, the identity federation of Russia (named RUNNetAAI) became the 56th participant of the eduGAIN project in April 2018. In the immediate plans – involvement of scientific and educational organizations of our

country to participate in the projects of federated authorization and authentication, as well as the promotion of Russian resources and services in the world's R&E space.

4. Acknowledgement

5. Conclusion

The Federal University Network RUNNet has for many years successfully and effectively solved its tasks, providing reliable and high-speed network connectivity of higher education and science organizations of the country, giving target users the access to the world's R&E ICT space for participation in joint research and educational projects, in the implementation of which up-to-date means of telecommunications, network technologies and services are used intensively.

The assignment of the official status of the national research and education network of RUNNet will make it possible to contribute to the creation of the single digital platform of the country as a full-fledged sectoral network, to strengthen the positions of Russian science and education in the world arena, to expand opportunities for interaction with leading foreign NRENs, and increase the performance of scientific data exchange in the implementation of joint projects through the use of the dedicated access network that is free from restrictions on the public network operated by commercial operators.

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