
18



08 THE CESNET ASSOCIATION

16 CESNET E-INFRASTRUCTURE

30 INTERNATIONAL INFRASTRUCTURE PROJECTS

34 THE ASSOCIATION'S RESEARCH ACTIVITIES

40 PUBLIC RELATIONS

46 ECONOMIC RESULTS

A WORD FROM THE DIRECTOR

THE PROJECTS WE UNDERTAKE PROVIDE CZECH EXPERT FACILITIES IN VARIOUS FIELDS WITH ACCESS TO A CUTTING-EDGE OPTICAL INFRASTRUCTURE THAT OFFERS NOT ONLY AN EXCEPTIONAL CONNECTION QUALITY BUT ALSO A BROAD RANGE OF ADVANCED SERVICES.



The Annual Report you have just opened recapitulates CESNET's activities in 2018. It was a year in which we made considerable progress in the implementation of our strategic **CESNET e-infrastructure** project and the related **CESNET e-infrastructure – Modernization** project, among other things. These projects provide Czech expert facilities in various fields with access to a cutting-edge optical infrastructure that offers not only an exceptional connection quality but also a broad range of advanced services we provide in it. You can learn about our progress in further e-infrastructure development in 2018 as well as about our specific services on the following pages. You can also learn about major domestic and international research projects that we were involved in. The key purpose of all our efforts is to help turn the Czech Republic into advanced information society. It is not just about providing our

scientists, researchers and other specialists with state-of-the-art communications and information technologies that allow them to be part of the mainstream of development in their fields. It is also essential to make the results of our work bring specific benefits to the general public.

A typical example that we mention often is our unique solutions that we use for streaming videos of surgical operations. However, our activities have a much broader impact. To demonstrate this, I would like to mention several activities from 2018 in this text.

In February, we set up, in collaboration with partners, an audiovisual connection for two sports grounds holding an **Olympic Festival** during the Winter Olympic Games in South Korea. The sports grounds were the Brno Exhibition Centre and ČEZ Arena in Ostrava.

The connection allowed transmitting 4K picture at 60 frames per second. Signal latency was just about 2 ms, so the connection was usable for interactive communication. The transmission between the sports grounds was part of an experimental verification of technology we are developing under the 8KSVIP (8K Studio over IP) project. The event aroused much interest. In the course of 2018, we also increased the number of railway stations in the Czech Republic that offer eduroam, an international service that provides students, teachers and scientists with free Internet connection over Wi-Fi. It makes travelling highly comfortable for a large group of users. Today, the Czech Republic has 26 public colleges and universities with over 260,000 students, who account for more than 90% of tertiary education students in the country. And all of them have access to high-quality connection over the **eduroam** network, whose development in

the Czech Republic we support strenuously. We achieved exceptional social reach with our engagement in the **Tribute to the Brave** project, which was organized as an expression of respect to all who faced or are forced to face any form of injustice. During a gala concert held on the occasion of the presentation of the **Václav Havel Human Rights Prize** on 10 October, we remotely connected Czech and Slovak musicians by means of the Internet and our technologies. The artists and spectators in the Prague Crossroads spiritual centre where the event was held and in a hall of the Academy of Performing Arts in Bratislava thus experienced an unusual cultural performance. Our technology put the musicians at a virtual distance of about two metres, which corresponds to an acoustic delay comparable to sound spreading acoustically. As you can see, and, most importantly, as you will see in the next sections of our Annual Report, the range of our activities is really wide. The scope and results of our activities also evoke a positive response from institutions that have a cardinal influence on the further direction of our Association. In this context, I would like to thank the Ministry of Education, Youth and Sports (MEYS) for its long-term institutional support without which we would be unable to even think about tackling these difficult tasks.

It was the MEYS who included CESNET in the three research e-infrastructures that are part of the **Czech Republic Roadmap for Large Research, Experimental Development and Innovation Infrastructures**. It also decided to support these three infrastructures (in addition to us, they are **CERIT-SC** operated by Masaryk University and **IT4Innovations** operated by VŠB – Technical University of Ostrava) in the

period of 2020 to 2022 as a single national e-infrastructure, **e-INFRA CZ**, by means of two consortium projects. We are already working hard on the preparation of both. That is why I have no doubt that we will continue to be able to fulfil our important mission in the years to come.

In conclusion, please allow me to thank all CESNET employees and collaborators for their great erudition and commitment in the undertaking of specific projects, all Association members for their support and the users of our services for their patronage, loyalty and competent feedback, which is an invaluable source of inspirational stimuli to us.



Ing. Jan Gruntorád, CSc.

Director and Member of the Board of Directors, CESNET

THE CESNET ASSOCIATION

CESNET IS ENGAGED IN THE
DEVELOPMENT AND OPERATION
OF A NATIONAL SCIENCE,
RESEARCH AND EDUCATION
NETWORK (CZECH NREN)
AND RELATED ACTIVITIES.





THE ASSOCIATION'S HISTORY, CURRENT TASKS AND SCOPE OF ACTIVITIES

THE CESNET ASSOCIATION WAS FOUNDED BY PUBLIC UNIVERSITIES AND COLLEGES AND THE CZECH ACADEMY OF SCIENCES (CAS) IN 1996.

ITS OBJECTIVES ARE TO:

1. Independently conduct fundamental, industrial research and experimental development in information and communications technologies and their applications and disseminate the results of such activities by all available means, including technology transfer
2. Build, develop and operate the CESNET research infrastructure on a long-term basis and promote the development, adoption and utilization of state-of-the-art communications and information technologies
3. Support, in return for the reimbursement of related expenses, the dissemination of erudition, culture and knowledge, its members' cooperation with industry, expansion of applications of the latest information technologies, and improvement of the CESNET research infrastructure by adding more subscribers, information sources and services

When founded, the Association also operated as a commercial Internet service provider in order to earn additional money from these activities for its principal activity. It managed to gain a leading position in the Internet connection market in the Czech Republic. The Association discontinued that activity in 2000, chiefly for economic and legislative reasons. Since then, it has been engaged in the development and operation of a National science, research and education network (Czech NREN – National Research and Education Network) and related activities. The NREN is called CESNET2.

In 2011, the Association received two crucial decisions of the Ministry of Education, Youth and Sports of the Czech Republic on funding for two large projects. One of them was **CESNET Large Infrastructure**, a project implemented in 2011–2015.

The purpose of the project was to rebuild the CESNET2 national research network as a large infrastructure, which would include all the information and communications e-infrastructures necessary for the Czech Republic's involvement in the European Research Area and enabling, for example, connection to the other E-infrastructures described in the ESFRI Roadmap.

The other project crucial for the Association's activities was the **Extension of the National R&D Information Infrastructure in Regions** (abbreviated as **elGeR**), the main objective of which was to build regional foundations for a comprehensive national research and development e-infrastructure in the Czech Republic. The project was implemented between May 2011 and October 2013. According to the grant decision, the Association was obligated to make the project sustainable at least until the end of 2018. In line with its goals and as part of its main activities (see below), the Association began implementing the **CESNET E-infrastructure** project (identification code LM2015042) in 2016. The project's objective is to develop the national e-infrastructure, which was built under the previous **CESNET Large Infrastructure** project, during 2016–2019.

The CESNET E-infrastructure is used to provide non-public services to support and serve Czech science, research, development and education. CESNET E-infrastructure services are described in the next sections of the Annual Report. The Association provides these services to not only its members but also other entities that meet the current **CESNET E-infrastructure Access Policy**. The other project crucial for the Association's activities was the **Extension of the National R&D Information Infrastructure in Regions** (abbreviated as **elGeR**), the main objective of which was to build regional foundations



**VELKÉ VÝZKUMNÉ
INFRASTRUKTURY**

for a comprehensive national research and development e-infrastructure in the Czech Republic. The project was implemented between May 2011 and October 2013. According to the grant decision, the Association was obligated to make the project sustainable at least until the end of 2018. The CESNET E-infrastructure was included in an assessment of research infrastructures made by the Ministry of Education, Youth and Sports of the Czech Republic in 2014. It received the highest score possible, becoming one of the infrastructures that would receive priority support in the next period. CESNET is also part of the new **Czech Republic Roadmap for Large Infrastructures**, formally acknowledged by the Government of the Czech Republic on 30 September 2015. The first interim assessment of large research infrastructures was carried out in early 2017 in order to obtain independent expert data for the government's informed political decision on the provision of specific MEYS aid to large research infrastructures in 2020–2022. Based on the assessment, the CESNET E-infrastructure is included in the top category of research infrastructures with excellent quality comparable to that of similar infrastructures worldwide, highly relevant to the future development of the Czech Republic's research and innovation environment and necessary for the enhancement of the Czech Republic's competitiveness.

THE SCOPE OF THE ASSOCIATION'S MAIN ACTIVITIES IS AS FOLLOWS:

1. Conducting independent research and development activities in information and communications technologies and providing research services in this field
2. Supporting education in information and communications technologies

3. Putting the results of in-house research and development into practice through technology transfer of internal nature
4. Undertaking the following activities for the benefit of its members, their subsidiary organizations as well as other entities:
 - Developing and operating the national communications and information infrastructure to enable the interconnection of their infrastructures, provide access to the CESNET infrastructure and connect to similar third-party infrastructures (including Internet access)
 - Building shared hardware, communications and software and information services
 - Verifying new applications, collaboration and complementarity of member activities at a level comparable to that of leading academic and research infrastructures abroad

The Association performs and provides its activities within the scope of received subsidies and partial compensation for expenses associated with these activities. It is not the Association's objective to generate any profit on these activities. The Association pursues supplementary activities in addition to its main activities, but solely for the purpose of making more efficient use of its property and without any negative impact on research activities. The services are not provided on a publicly available basis. Any loss incurred in connection with the Association's supplementary activities will always be settled by the end of the fiscal period in question or the supplementary activity in question will be discontinued before the beginning of the following fiscal period.

The Association uses all of its profits to promote research and development.

MEMBERSHIP OF INTERNATIONAL AND NATIONAL ORGANIZATIONS

CESNET WAS A MEMBER OF THE FOLLOWING RENOWNED
INTERNATIONAL AND NATIONAL ORGANIZATIONS IN 2018:

INTERNATIONAL ORGANIZATIONS

GÉANT Association – an association of European national research networks that is engaged in the operation and advancement of the GÉANT European communications infrastructure and coordination of related activities

GLIF (Global Lambda Integrated Facility) – global experimental network activities, focusing on support for the development of the most demanding scientific and research applications; their main objective is to create a network to serve applications with extreme bandwidth requirements

Internet2 – a consortium led by US research and educational institutions endeavouring to develop and deploy new types of networking technologies, services and applications; CESNET has been an associate consortium member since 1999

PlanetLab – a consortium of academic, commercial and governmental organizations from all around the world, collectively operating a global computer network designed for developing and testing new telecommunications applications; the network currently encompasses 780 nodes in 31 countries

EGI.eu – an organization focusing on coordinating European computing grids used for scientific computations and supporting their sustainable development

Shibboleth – an international consortium for the coordination of the development of a service providing a single sign-on solution, meaning that a user can use multiple secured network resources using a single login; Shibboleth is the foundation for academic identity federations

NATIONAL ORGANIZATIONS

NIX.CZ – CESNET is one of the founders of NIX.CZ, z. s. p. o. (Neutral Internet Exchange), an association of Internet service providers in the Czech Republic that provides interconnectivity for its members' networks; the association had 66 members as of 31 December 2018

CZ.NIC – the Association is also one of the founding members of CZ.NIC, z. s. p. o., which administers the .cz domain and supports publicly beneficial projects and activities relating to the Internet; it had 111 members as of 31 December 2018

ASSOCIATION MEMBERS

THE FOLLOWING INSTITUTIONS WERE MEMBERS OF THE ASSOCIATION IN 2018:

- Academy of Arts, Architecture and Design in Prague
- Academy of Fine Arts in Prague
- Academy of Performing Arts in Prague
- Brno University of Technology
- Charles University
- The Czech Academy of Sciences
- Czech Technical University in Prague
- Czech University of Life Sciences Prague
- University of Chemistry and Technology, Prague
- Janáček Academy of Music and Performing Arts in Brno
- Jan Evangelista Purkyně University in Ústí nad Labem
- Masaryk University
- Mendel University in Brno
- Palacký University Olomouc
- The Police Academy of the Czech Republic in Prague
- Silesian University in Opava
- Technical University of Liberec
- Tomas Bata University in Zlín
- University of Defence
- University of Economics, Prague
- University of Hradec Králové
- University of Ostrava
- University of Pardubice
- University of South Bohemia in České Budějovice
- University of Veterinary and Pharmaceutical Sciences Brno
- University of West Bohemia
- VŠB – Technical University of Ostrava

INTERNAL ORGANIZATIONAL STRUCTURE

CESNET HAS THE FOLLOWING BODIES:

- GENERAL ASSEMBLY
- BOARD OF DIRECTORS
- SUPERVISORY BOARD

GENERAL ASSEMBLY

The Board of Directors consisted of the following members until 12 July 2018:

- Mgr. Michal BULANT, Ph.D.
- RNDr. Igor ČERMÁK, CSc.
- RNDr. Alexander ČERNÝ
- Ing. Jan GRUNTORÁD, CSc.
- Mgr. František POTUŽNÍK
- Doc. RNDr. Pavel SATRAPA, Ph.D.
- Prof. Ing. Miroslav TŮMA, CSc.

The **Chairman** was Prof. Ing. Miroslav Tůma, CSc., and the **Vice Chairmen** were RNDr. Igor Čermák, CSc., and Mgr. František Potužník.

The 45th General Assembly held on 12 July 2018 elected the following Board of Directors members for the term of 2018–2020:

- Mgr. Michal BULANT, Ph.D.
- RNDr. Igor ČERMÁK, CSc.
- RNDr. Alexander ČERNÝ
- Ing. Jan GRUNTORÁD, CSc.
- Mgr. František POTUŽNÍK
- Doc. RNDr. Pavel SATRAPA, Ph.D.
- Prof. Ing. Miroslav TŮMA, CSc.

Prof. Ing. Miroslav Tůma, CSc., was elected as **Chairman**; RNDr. Igor Čermák, CSc., and Mgr. František Potužník were elected as **Vice Chairmen**.

BOARD OF DIRECTORS

The Supervisory Board consisted of the following members in 2018:

- Doc. Ing. Vojtěch BARTOŠ, Ph.D.
- Mgr. Jan GAZDA, Ph.D.
- Ing. Jakub PAPÍRNÍK
- RNDr. David SKOUPIL
- Ing. Michal SLÁMA

Ing. Michal Sláma was elected **Chairman** of the Supervisory Board. Ing. Jan Gruntorád, CSc., was the **Director** of the Association in 2018.

DEVELOPMENT FUND BOARD

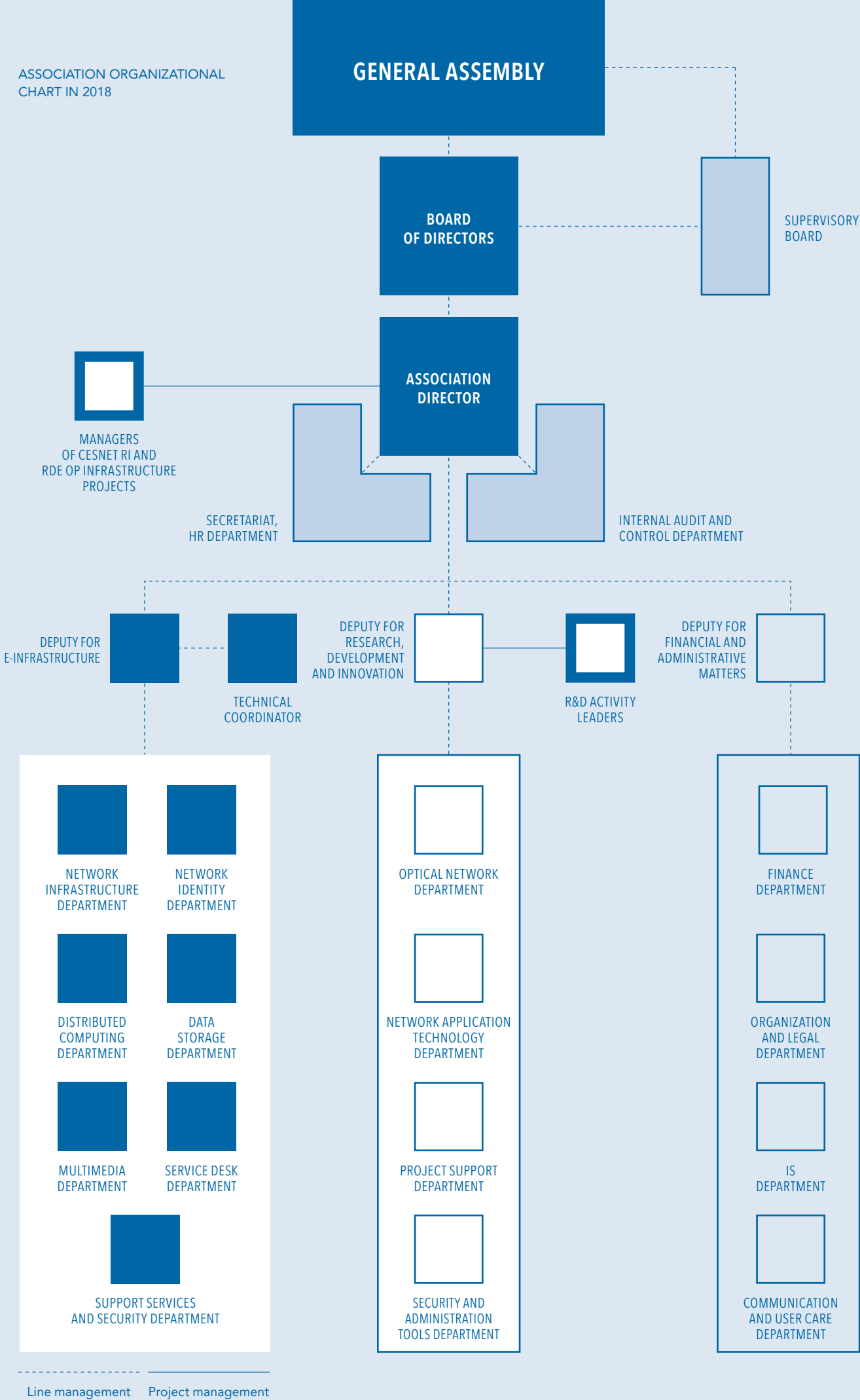
The Development Fund Board consisted of the following members in 2018:

- Doc. RNDr. Eva HLADKÁ, Ph.D.
- Ing. Miroslav INDRA, CSc.
- Ing. Olga KLÁPŠŤOVÁ
- Doc. RNDr. Antonín KUČERA, CSc.
- Prof. Dr. Ing. Zdeněk KŮS
- Ing. Jaromír MARUŠINEC, Ph.D., MBA
- Prof. Ing. Zbyněk ŠKVOR, CSc.

The **Chairwoman** of the Development Fund Board was Ing. Olga Klápšťová.

ORGANIZATIONAL CHART

Following discussion with the Board of Directors, the organizational chart was approved by the Association's Director on 18 May 2018 and entered into force on 1 June 2018. The Association had a total of 171.05 full-time equivalents in 2018. The Association's basic organizational structure comprises departments, which may be aggregated into sections. Management within this structure is performed by line managers.



CESNET E-INFRASTRUCTURE

IN THE PAST PERIOD,
THE ASSOCIATION FOCUSED
ON ASSURING RELIABLE
OPERATION, MAINTAINING
ADEQUATE PERFORMANCE
CAPACITY, AND SUPPORTING
OTHER SERVICES OF THE
CESNET E-INFRASTRUCTURE,
CONNECTED LARGE
INFRASTRUCTURES
AND OTHER NETWORK
SUBSCRIBERS.





CESNET E-INFRASTRUCTURE

**CESNET'S PRINCIPAL ACTIVITY IS DEVELOPING, BUILDING
AND OPERATING THE CESNET E-INFRASTRUCTURE.**

THE CESNET E-INFRASTRUCTURE IS A COMPLEX ENVIRONMENT COMPRISING A HIGH-THROUGHPUT NATIONAL COMMUNICATIONS INFRASTRUCTURE, A NATIONAL GRID INFRASTRUCTURE (NGI) AND A DATA STORAGE INFRASTRUCTURE, WHICH ARE COMPLEMENTED WITH TOOLS AND SERVICES FOR MANAGING ACCESS TO RESOURCES, COMMUNICATION SECURITY AND DATA PROTECTION TOOLS AND TOOLS FOR EFFICIENT COLLABORATION BETWEEN DISTRIBUTED USERS AND TEAMS.

THE CESNET E-INFRASTRUCTURE IS INCLUDED IN THE CZECH REPUBLIC ROADMAP FOR LARGE RESEARCH, EXPERIMENTAL DEVELOPMENT AND INNOVATION INFRASTRUCTURES FOR 2016–2022.

NATURALLY, THIS E INFRASTRUCTURE IS INTEGRATED WITH RELEVANT INTERNATIONAL INFRASTRUCTURES. THE CESNET E-INFRASTRUCTURE IS ALSO USED AS A TESTING AND DEVELOPMENT ENVIRONMENT FOR NEW TECHNOLOGIES AND APPLICATIONS IN INFORMATION AND COMMUNICATIONS TECHNOLOGY.

SPECIAL-PURPOSE SUPPORT FOR DEVELOPING AND OPERATING THE CESNET E-INFRASTRUCTURE

THE DEVELOPMENT AND OPERATION OF THE CESNET E-INFRASTRUCTURE ARE CONSIDERABLY SUPPORTED FROM PUBLIC FUNDS, WITH THE MEYS PROVIDING SPECIFIC SUBSIDIES FOR TWO PROJECTS.

CESNET E-INFRASTRUCTURE

The **CESNET E-infrastructure** project (2016–2019) funded under the Large Research, Development and Innovation Infrastructure Projects programme. The subsidy is earmarked for covering a portion of operating costs associated with the operation of the CESNET e-infrastructure. The year 2018 was the third year of project implementation.

CESNET E-INFRASTRUCTURE – MODERNIZATION

A project named **CESNET E-infrastructure – Modernization** (2017–2020), funded under the Research, Development and Education operational programme (RDE OP). Aid under this project is intended both for investments in infrastructure renovation and development and for operating cost associated with in-house research on security, flexible infrastructures and the development of new technologies for network applications. The year 2018 was the second year of the implementation of this four-year project.



COMMUNICATIONS INFRASTRUCTURE

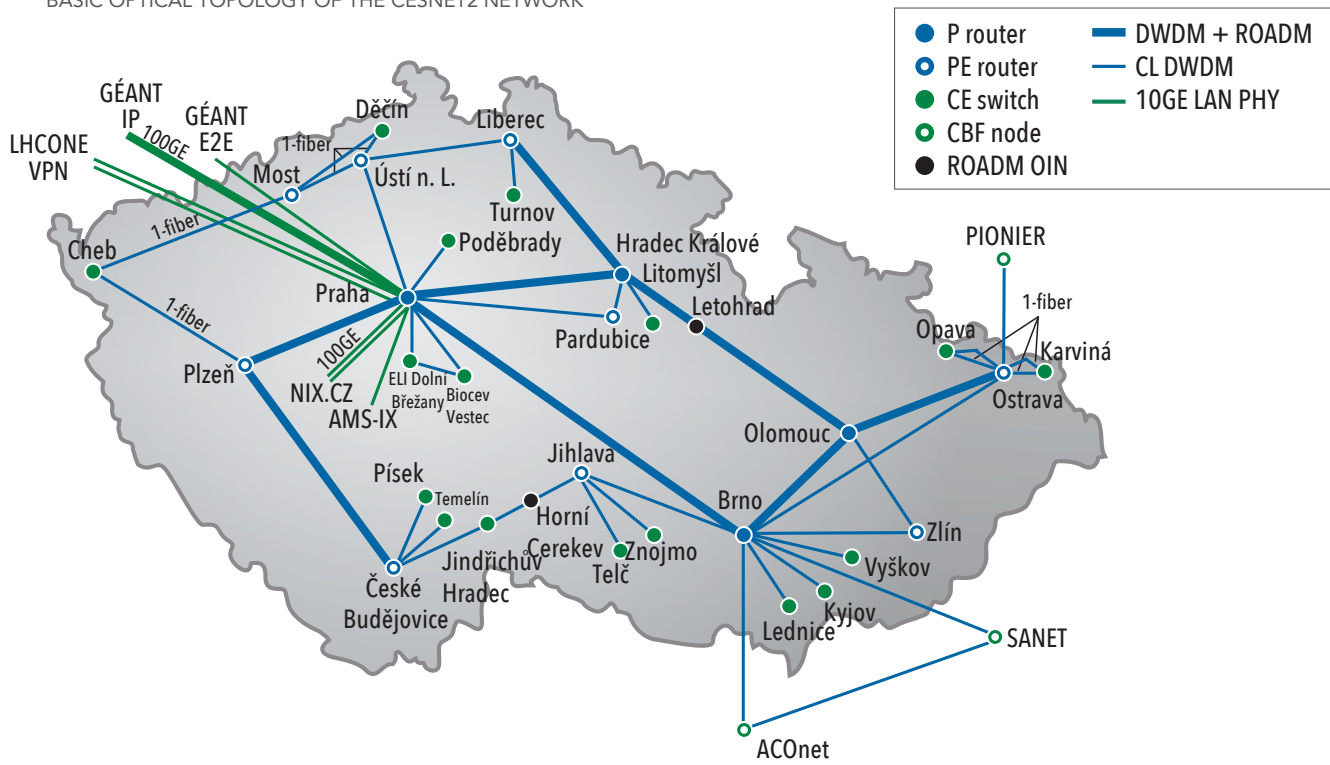
IN THE PAST PERIOD, CESNET FOCUSED PRIMARILY ON ASSURING RELIABLE OPERATION, MAINTAINING ADEQUATE PERFORMANCE CAPACITY, AND SUPPORTING OTHER SERVICES OF THE CESNET E-INFRASTRUCTURE, CONNECTED LARGE INFRASTRUCTURES AND OTHER NETWORK SUBSCRIBERS.

CESNET continually monitors traffic in order to identify and remove bottlenecks, such as insufficient capacities of some backbone transmission circuits, external connectivity or lack of connecting ports with sufficient capacity for the purposes of large infrastructures to which the CESNET e-infrastructure provides network services. Its activities inherently involve continual communication with other large infrastructures for which CESNET prepares and provides network-level services. Such services include, in particular, high-speed IPv4/IPv6 connectivity, L0 and L1 circuits or L2/L3 VPNs.

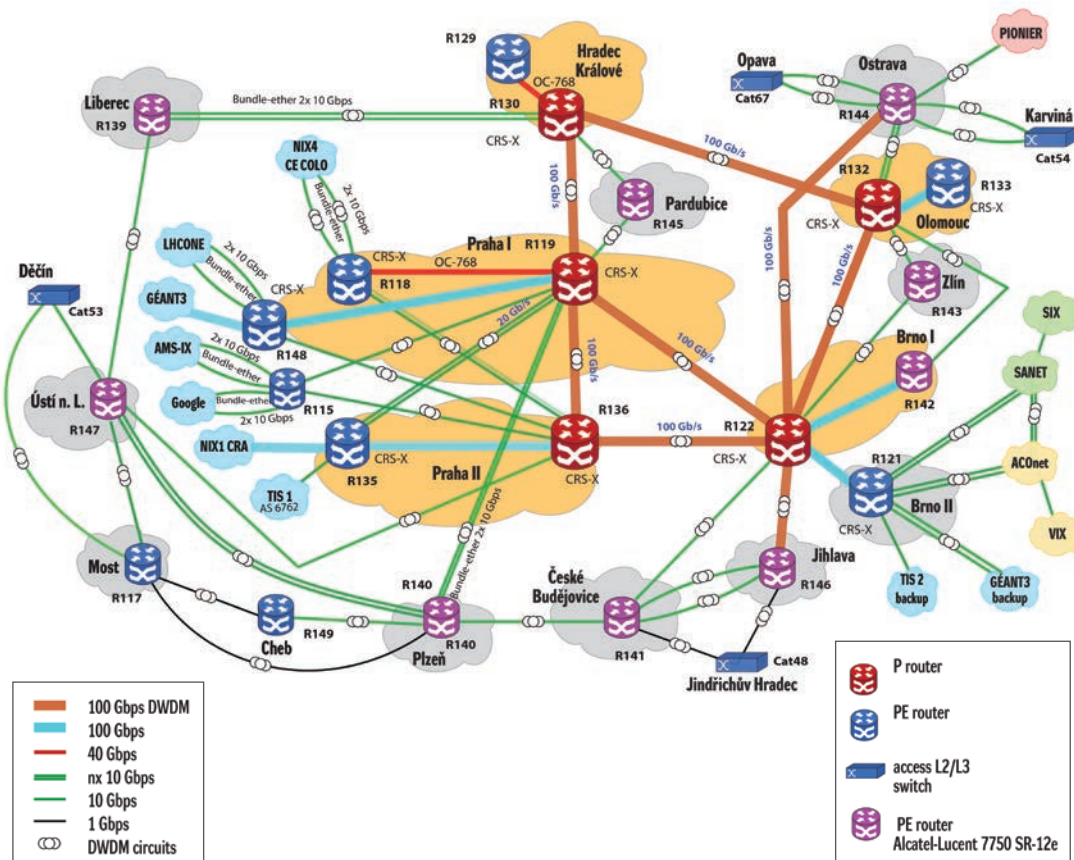
THE FOLLOWING FUNDAMENTAL CHANGES AND ACTIVITIES TOOK PLACE IN 2018:

- 1. Adding 100GE and 40GE interfaces to a Nokia router at the Plzeň node.** These interfaces will allow upgrading connection capacities from 10GE to 40GE (data storage facilities and other subscribers in the region). The 100GE interface will be used to upgrade the connection of the Plzeň node to the CESNET2 backbone network to 100GE (Prague–Plzeň DWDM line). The upgrade was scheduled to be carried out in the second quarter of 2019.
- 2. Upgrading the Jihlava node connection to 100GE.** This upgrade required, most importantly, new data storage as the existing capacity of $2 \times 10\text{GE}$ was insufficient to ensure proper operation and high-quality access for CESNET2 subscribers. The upgrade involved adding 100GE and 40GE interfaces to a Nokia router (40GE connection for data storage and additional subscribers) and upgrading the Jihlava–Brno DWDM line to 100GE.
- 3. Upgrading the main DWDM system to new SW version 10.7.** The main reason for the upgrade was extending the functionality of the DWDM system as well as fixing some bugs in the SW (without effect on proper system operation). The system upgrade also involved upgrading the Prime Optical central management system of the DWDM network to the same version 10.7.
- 4. Upgrading the GÉANT network backup connection to 20GE.** The existing backup capacity of 10GE was absolutely insufficient (the main connection is 100GE). At the same time, the backup connection was moved from the Praha_1 node to the Brno_1 node and is terminated at the Bratislava GÉANT node. A dedicated Brno–Bratislava CL DWDM line is used for transport. Moving the backup connection has eliminated total dependence on the condition of the Praha_1 node.
- 5. Renewing and extending service agreements for Nokia technology.** Service agreements for deliveries of Nokia (formerly Alcatel-Lucent) technology were made for approximately five years when the eIGeR project was under way. These agreements began to expire in 2018. CESNET carried out a tendering procedure for servicing and manufacturer's support for all Nokia technology with an option to renew as needed and required by the Association. Unfortunately, no considerable savings were achieved, but the availability of CESNET2 services to users cannot be guaranteed without servicing and support by the manufacturer Nokia.
- 6. Commencing an upgrade of the single-fibre CL DWDM Praha_1–UMG Krč–Biocev Vestec–ELI & HiLASE Dolní Břežany–Praha_1 system to a double-fibre system with higher capacity.**

BASIC OPTICAL TOPOLOGY OF THE CESNET2 NETWORK



BASIC IP/MPLS TOPOLOGY OF THE CESNET2 NETWORK



Demand by the Czech Academy of Science's research infrastructures and institutes exceeded existing capabilities of the access DWDM system. Most lines were upgraded to new technology with support for ROADM and VMUX/DMUX and support for 40 DWDM channels with 50 GHz spacing. The last portion between UMG Krč and Praha_2 will be completed in the second quarter of 2019.

7. Designing and preparing the main DWDM system for research into QKD (Quantum Key Distribution) encryption techniques.

This concerns the Brno–Olomouc segment for the purposes of research at ISI Brno and Palacký University in Olomouc, where a portion of the spectrum needs to be rerouted away from the existing DWDM system. Implementation is expected in the second quarter of 2019.

8. Upgrading connection to NIX.CZ to 100GE. The existing capacity of $2 \times 10\text{GE}$ was no longer sufficient, requiring an upgrade because no adequate backup would be available in case of a failure of the second connection to NIX.CZ (also $2 \times 10\text{GE}$). The second $2 \times 10\text{GE}$ connection to the NIX4 node (SITE1) will be upgraded in the second quarter of 2019. A fully featured dual connection to NIX.CZ is also required under the FÉNIX security project, which CESNET takes an active part in.

9. Upgrading connection to the AMS-IX peering centre to 20GE. The existing 10GE capacity was becoming insufficient due to increased traffic. CESNET used another 10GE L2 channel over the GÉANT network for the upgrade.

10. Preparing a CESNET2 NG network (modernization expected in 2020–2022).

The existing infrastructure was built under the eIGeR project (2011–2013); it will be becoming obsolete after 2020 as it will no longer be able to meet new demand by research infrastructures and research projects. CESNET3 will be based on the latest technologies and will allow providing new services (such as QKD or transmission of accurate time and frequency on a larger scale). Naturally, an important aspect is meeting demand for higher transmission capacities (400GE and higher) and, in particular, interconnection with the new generation of the GÉANT network and its user services. Task group outputs will be used to design a feasibility study.

DDOS ATTACKS

Due to an increasing frequency and intensity of DDoS attacks, CESNET worked intensely on the protection of network communications infrastructures and connected subscribers.

We made RTBH services available in the CESNET2 network environment for their needs. The Association also continued with tests of the promising BGP FlowSpec technology on Cisco and Alcatel-Lucent/Nokia routers, which provide more advanced functionalities for blocking attacks over the network than RTBH.

The target solution is to allow rerouting suspicious traffic to a 'traffic scrubber', a system developed under the Association's research activities that will allow blocking unwanted traffic (especially during DDoS attacks). This technology is now in pilot operation.

In the area of specific network services, the Association continues building the national optical infrastructure for time and frequency transmission – the TF infrastructure.



NATIONAL GRID INFRASTRUCTURE

THE ASSOCIATION'S LONG-TERM OBJECTIVES IN THE AREA OF DISTRIBUTED COMPUTING ARE THE OPERATION AND GROWTH OF THE METACENTRUM NATIONAL GRID INFRASTRUCTURE (NGI) AND INTEGRATION OF THESE ACTIVITIES WITH CORRESPONDING INTERNATIONAL INFRASTRUCTURES (ESPECIALLY EGI, EOSC AND ELIXIR) AND PROJECTS.

The NGI includes computing clusters of various types: conventional computing clusters with smaller numbers of more powerful processors, high-performance SMP servers with larger numbers of processors in a large shared memory, specialized machines with up to 6 TB of memory, clusters with specialized GP-GPU cards as well as clusters prepared for MapReduce computations (Hadoop or Spark) with larger storage space in each cluster node. Along with these computing servers (about 18,000 CPU cores in late 2018), the MetaCentrum also operates extensive data

storage capacities (6 PB at the end of 2018) that are used for temporary storage of processed data.

In the international EGI environment, the NGI provides an additional approximately 3,200 CPU cores and 3.8 PB of disk space for international projects, especially for the LHC. In 2018, a computing cluster at the University of West Bohemia in Plzeň and a cluster accessible under the EGI project (located in Prague) were renovated and disk capacity was expanded in Brno. Clusters of the Technical University of Liberec and the ELIXIR-CZ consortium were

METACENTRUM INFRASTRUCTURE





INSTITUTIONS' SHARES IN THE UTILIZATION OF METACENTRUM COMPUTATIONAL RESOURCES

Masaryk University [26 %]

Charles University [20 %]

Czech Technical University [14 %]

Institute of Organic Chemistry and Biochemistry, CAS [7 %]

University of Chemistry and Technology, Prague [6 %]

Institute of Physics, CAS [4 %]

Brno University of Technology [3 %]

University of West Bohemia [3 %]

Jan Evangelista Purkyně University [2 %]

Institute of Biotechnology, CAS [2 %]

University of Pardubice [2 %]

University of South Bohemia [2 %]

Palacký University, Olomouc [1 %]

Other [8 %]

integrated into the MetaCentrum environment. CESNET functions as the national coordinator for the NGI, interconnecting individual clusters built by other organizations or projects into a single national grid and providing its resources also for balancing peak demand by individual groups and for a faster start-up of application projects that are only planning to acquire their own computational resources. Its integration activities include the development and management of grid and cloud middleware, coordination of application software purchases and user support.

The NGI provides access to cloud-based services and environments for MapReduce computations. A test version of OpenStack was put into operation in 2018; all cloud-based traffic will be moved to the system in 2019. CESNET joined the pan-European GÉANT IaaS Framework tender to be able to resell the services of commercial cloud providers (Microsoft Azure, Amazon AWS and other OIPs – Original Infrastructure Providers).

In respect of our international activities, we continue to support international LHC projects, the Pierre Auger Observatory experiment and the **Belle**, **ELIXIR**, **ELI** and **CLARIN** projects. At national level, we focus on direct support of user groups in the Czech Republic interested in using the pan-European EGI infrastructure. Specific examples are our involvement in the European **ELIXIR** project, in its **EXCELERATE** development project and in the construction of an ELIXIR research infrastructure in the Czech Republic. CESNET joined the **EOSC-hub** and **EOSC-Pilot** projects where it is participating in the construction and operation of the EOSC (European Open Science Cloud) infrastructure.

The **EOSC-Synergy** project was prepared in 2018 and the national EOSC centre will further develop under it starting from 2019.

During 2018, the Association continued working on international H2020 projects that the NGI participates in. These included, in particular, the **EOSC-hub** and **DEEP** projects, which dealt with the operation and development of the European EGI and EOSC e-infrastructure and the development of grid and cloud middleware. The Association has been developing its collaboration with ESFRI activities under the **ELIXIR** project; in particular, we are responsible for the preparation of cloud services and a federated service for the ELIXIR AAI under the **EXCELERATE** project. At national level, we participated in the operation of the VI ELIXIR infrastructure and administered the first cluster dedicated to this group under the RDE OP **ELIXIR** project. We also managed to extend our support for the European Space Agency (ESA), where we participate in making Sentinel satellite data available to the Czech Republic. Disk capacity for this service was increased considerably under an ESA project at the end of the year.

DATA STORAGE

ANOTHER FUNDAMENTAL COMPONENT OF OUR E-INFRASTRUCTURE IS DISTRIBUTED DATA STORAGE. IN 2018, IT CONSISTED OF INTERCONNECTED HIGH-CAPACITY DATA CENTRES FITTED WITH HIERARCHICAL STORAGE SYSTEMS, LOCATED IN PLZEŇ, JIHLAVA, BRNO AND OSTRAVA.

The first three storage systems were acquired in 2011–2013; the Ostrava storage system was acquired at the end of 2017. The system in Plzeň was beyond the limits of its useful and technical life, so a transfer of its users to Ostrava, including necessary migration of data, was under way for most of the year. Migration of users from the Jihlava storage system to Ostrava was started at the beginning of the third quarter so that the system can be shut down in mid-2019.

From a technical point of view, the above-mentioned storage systems are implemented as hierarchical systems (HSM – Hierarchical Storage Management). On the basis of extensive tests of object storage technologies started in 2017 and with regard to the fact that purchasing additional hierarchical storage systems was no longer economically and technically reasonable within the financial scope planned under the RDE OP investment project, tendering procedures took place in 2018 for two new infrastructure components: a standard disk array with a file system and a smaller cluster for object storage for the pilot operation of Ceph, the technology chosen as a tool for building an infrastructure that would also allow users to directly connect their own data sources. Both devices are located in Jihlava and were delivered on the threshold of 2019. Tender specification for the object storage cluster was prepared in order to allow investments to be made in 2019.

The data storage infrastructure stored over 7,500 TB of user data at the end of 2018. The storage was used via standard file-oriented interfaces by about 220 user groups (virtual organizations), which translates to more than 5,000 individual user accounts (people and service identities). Over 14,100 TB of available

media was occupied in total (according to internal system redundancy settings).

In infrastructure development, we were developing a system for reliable long-term data storage. FileSender (a popular service for exchanging large files among users) and ownCloud (cloud storage with about 12,800 registered users and 135 TB of data in 112 million files) were linked to proxyIdP and thus strongly integrated into a single user identity management system. They were also migrated to a cluster platform, which greatly improved the stability and scalability of their operation. A user data accounting application, including a user interface, is headed for the implementation of a system for controlling the amount of data in storage, which is applied to the Ostrava storage system.

Its basic principles are:

- Maintaining a reserve for institutions that do not use storage services yet
- Enforcing rotation of data having the nature of backup by administratively deleting files older than a defined limit (typically, a year)

COLLABORATION INFRASTRUCTURE AND USER SUPPORT

E-INFRASTRUCTURE SECURITY / NETWORK IDENTITY /
IP TELEPHONY, VIDEO AND WEB CONFERENCING AND MULTIMEDIA
STREAMING / COLLABORATION WITH NATIONAL RESEARCH
AND DEVELOPMENT INFRASTRUCTURES

E-INFRASTRUCTURE SECURITY

An internationally accredited CESNET-CERTS security team is the basic element ensuring e-infrastructure security. Its core activity is incident handling – receiving reports of security incidents concerning the CESNET e infrastructure and responding and coordinating response to such incidents in cooperation with network and service administrators at CESNET and connected organizations.

The team works closely with other security teams and relevant organizations at national and international level, is a member of the CSIRT.CZ Working Group, organized by the Czech Republic's National CSIRT Team, and is also involved in the TF-CSIRT platform coordinated by GÉANT. Members of the CESNET-CERTS security team have handled a large number of security incidents throughout its existence – about 78,000.

The first stage of the implementation of an ISMS (information security management system) was completed in 2018. CESNET obtained internationally recognized certification of its information security management system (ISMS) to the ČSN EN ISO/IEC 27001:2014 standard, which specifies requirements for an information security management system within an organization's activities and provided services with the aim of eliminating the risks of data loss or corruption. As concerns legislation, the year 2018 was also significant in that the GDPR came into effect, that is, Regulation (EU) 2016/679 of the European Parliament and of the Council on the protection of natural persons with regard to the processing of personal data and on the free movement of such data.

As part of its activities related to network security, the Association runs a number of its own detection systems to obtain information about attacks in progress. An important role in security is played by network monitoring and security event and anomaly detection, which are provided in the CESNET e-infrastructure by HW-accelerated network probes, FTAS and G3 systems and services and the Warden and Mentat systems. These are operated to very high standards, enabling both CESNET administrators and administrators at connected institutions to improve the level of network, service and user security and eliminate identified problems quickly and efficiently. All the systems are results of the Association's own work and have been developed continually in accordance with trends and the Association's needs.

Since 2013, the Association has operated FLAB, a forensic laboratory providing state-of-the-art security services – security incident analysis, penetration and stress tests and, since mid-2017, also penetration tests using social engineering methods, which test users' caution and ability to identify cyber threats. The laboratory's services are available to CESNET e-infrastructure subscribers as well as other clients.

The forensic laboratory was asked for two analyses in relation to security incident handling, undertook seven commissions for penetration and stress tests and four commissions for separate phishing tests and provided several expert consultations in 2018.

The Association is committed to the edification of users and network administrators. We hold expert workshops and training courses, give presentations at numerous events and publish papers focusing



on security. We organized another annual security workshop and a traditional IPv6 workshop in 2018. There were also three practical courses of Forensic Training. As part of the Cyber Security Month, that is, in October, CESNET organized the third annual Security Fest, a public edification workshop, and prepared another run of The Catch, an annual 'hacker' contest in which participants could test their analytical skills. CESNET also participated in several international exercises in 2018, especially the prestigious and highly valued Locked Shield 2018 exercise in which three members of the CESNET Forensic Laboratory took part for the Czech team. While the Czech Republic's team consisting of the best specialists did not defend its victory from 2017, it came in third.

NETWORK IDENTITY

An integral component of the comprehensive e-infrastructure is a system for user management and control of access to services. User management is based on the **eduid.cz** distributed identity federation, where initial user registration and authentication services are provided by the home organizations while authorization information is managed at the level of services or their administrative domains. At the end of 2018, the federation included 127 identity providers (IdPs) and more than 200 service providers (SPs). It also allows interconnection with the **eduGAIN** international federation of services. One highly used federated service is **eduroam.cz**, which provides users with wireless connectivity at their home institution or any other cooperating institution. Secure user authentication is always provided by the home institution. This academic roaming

system was created as a European initiative under the TERENA Association (now GÉANT Association) and has since spread all over the world. The Czech federation had a total of 269 member organizations in 2018, providing connectivity in more than 800 locations. More than 40,000 users take advantage of connectivity at an organization other than their home institution on a daily basis. To ensure secure and trustworthy communication, the Association operates a **public key infrastructure** (PKI) based on the **CESNET CA** certification authority, which issues various types of certificates for specifically defined application areas to selected groups. This also includes providing the **GÉANT TCS** (Trusted Certificate Service). The service is used by 112 organizations. Our portfolio of PKI services also includes a Time Stamp Authority, which is used by fifteen organizations.

For identity and access management, we continue developing the **Perun** system together with Masaryk University. The main instance of the system manages identities and access to services for 300 user communities (national and international) with about 35,000 users. Its advantages include support for the entire user life cycle, ability to integrate with existing environments and capability to delegate access and user administration.

IP TELEPHONY, VIDEO AND WEB CONFERENCING AND MULTIMEDIA STREAMING

Our videoconferencing environment, which offers custom client registration, use of virtual rooms and session recording and broadcast, was used for 5,400 hours of meetings in dozens of virtual rooms over central multi-

conferencing units (MCUs). More than 130 hardware units were registered, with other users using their own software client or a software client provided by the Association. Users can also make use of an Adobe Connect-based web conferencing system, in which 4,349 hours of meeting took place in dozens of rooms.

A major change was the deployment of a new multipoint videoconferencing element, which integrates standard videoconferencing with access from a web browser and connection to Skype for Business/Lync. The environment is implemented as software running on the CESNET virtualization platform. This allows for gradual capacity expansion as well as independent renovation of commodity hardware (servers) of the system, which currently uses two high-performance servers. Users get access to these resources primarily through a Meetings reservation portal, which runs on a system named Shongo, created by CESNET.

The environment includes live broadcasts (streaming) and recorded broadcasts. Institutions keep 17.3 TB of multimedia data in dedicated storage. In addition, CESNET still interconnects dozens of exchanges operated by institutions (members) within an IP telephony infrastructure.

UltraGrid, a high-quality, low-latency transmission solution developed by the Association has been used for a number of live broadcasts of surgeries during medical events. The solution is also used for cultural events and teaching. The Association released a new version of the UltraGrid software in October 2018; its most important new feature is a graphical user interface that will make the systems easier to use for beginners.

COLLABORATION WITH NATIONAL RESEARCH AND DEVELOPMENT INFRASTRUCTURES

CESNET holds discussions with representatives of other large infrastructures included in the **Czech Republic Roadmap for Large Research, Experimental Development and Innovation Infrastructures** and other infrastructure projects for 2016–2022. We identify their needs for information and communications technology and offer them collaboration in addressing such needs.

An example of successful collaboration is the **ELIXIR-CZ** infrastructure, which provides an advanced computing environment, data resources and unique tools for the bioinformatics scientific community in the Czech Republic and Europe. CESNET is a direct participant in two projects for the operation and development of this infrastructure: a project named **Czech National Infrastructure for Biological Data**, supported from the R&D&I Large Infrastructure Projects programme, and the **ELIXIR-CZ: Capacity Building** project, supported from the RDE OP under a Research Infrastructures call. CESNET provides project partners with expertise in information and communications technology and participates in the building of computing and storage capacities for this research infrastructure.

INTERNATIONAL INFRASTRUCTURE PROJECTS

CESNET HAS BEEN INVOLVED
IN MANY MAJOR INTERNATIONAL
INFRASTRUCTURE PROJECTS.
TOGETHER WITH OUR PARTNER
ORGANIZATIONS ABROAD,
WE BUILD AN INFORMATICS
FOUNDATION FOR THE
EUROPEAN RESEARCH AREA.





INTERNATIONAL INFRASTRUCTURE PROJECTS

AN IMPORTANT TASK OF THE CESNET E-INFRASTRUCTURE IS INTERCONNECTING THE SERVICES IT PROVIDES AT NATIONAL LEVEL WITH THE SERVICES OF EUROPEAN E-INFRASTRUCTURES. JOINTLY, THEY PROVIDE AN INFORMATICS FOUNDATION FOR THE EUROPEAN RESEARCH AREA.

GÉANT – EUROPEAN BACKBONE COMMUNICATIONS INFRASTRUCTURE

The GÉANT communications infrastructure ensures interconnection of more than 50 million users in European national research and education networks and connection to similar infrastructures such as Internet2 and ESnet in the US, CANARIE in Canada and academic networks on other continents. GÉANT is the basis of the European Digital Infrastructure (EDI), which constitutes the communications infrastructure of the developing European Open Science Cloud (EOSC) concept. The funding of this infrastructure and related activities at European level until the end of 2020 is ensured through framework support under the **GÉANT2020** project.

CESNET is primarily involved in the project in activities relating to the building of a test environment, matters concerning network security, the provision of cloud services within the European infrastructure or the deployment of AAI. In November 2018, the GÉANT association submitted to the European Commission a proposal for two subprojects for the final stage of the **GÉANT2020** project in the period of January 2019 to December 2022. This stage will include innovating the GÉANT infrastructure, among other things. The concept of indefeasible right of use (IRU) is planned to be used for building the fibre infrastructure; transition to open systems is expected for network elements.

EGI AND EOSC – EUROPEAN INFRASTRUCTURE FOR DISTRIBUTED COMPUTING

One of the linchpins of the CESNET e-infrastructure is MetaCentrum, a distributed computing infrastructure that plays the role

of the Czech National Grid Infrastructure (NGI), officially recognized as a national part of the European Grid Infrastructure (EGI).

The objective of the EGI is coordinating national activities in the implementation of grid technologies as an important part of the European-level e-infrastructure. The operation and further development of the EGI were supported by the European Union in 2018 under the **EOSC-Pilot** and **EOSC-hub** projects, elaborating the concept of a multidisciplinary pan-European grid and cloud infrastructure and transforming it into a foundation for the EOSC. Under the **EOSC-hub** project, CESNET is involved in all primary operational activities, takes care of the operation of the national EGI node and provides computational resources comprising the Association's own computational capacities as well as capacities provided by the Institute of Physics of the Czech Academy of Sciences and CERIT-SC. We also continue to provide support for the Auger and VOCE virtual organizations as well as direct support for user groups from the Czech Republic that are interested in using the pan-European grid. The priority is an orientation on specific needs of domestic expert groups and their international projects.

ELIXIR – EUROPEAN BIOINFORMATICS INFRASTRUCTURE

The European **ELIXIR** bioinformatics infrastructure combines advanced computing environments, data resources and unique tools across Europe so as to share them efficiently for the purposes of bioinformatics research. CESNET contributes to the development of the European infrastructure by its involvement in the European **ELIXIR-EXCELERATE** project under the Technical Services activity focusing

on the establishment of a common framework for the provision of computational services and services related to data storage.

EUROPEAN SPACE AGENCY

CESNET, in coordination with the Ministry of Transport of the Czech Republic, concluded a contract for the construction of a Data Hub Relay with the European Space Agency (ESA) in early 2018. One of seven data hub nodes will be put into operation in the Czech Republic by January 2020 to synchronize and redistribute large quantities of the latest imagery from Sentinel satellites in order to reduce the load of the ESA infrastructure.

GLIF – GLOBAL LAMBDA INTEGRATED FACILITY

Organizations involved in networking research and application in Europe, North and South America, Asia and Australia that have separate testing infrastructures have created the Global Lambda Integrated Facility (GLIF) to carry out joint experiments. It is a virtual organization as well as a research environment (facility) consisting of lambdas and nodes known as GOLE (GLIF Open Lightpath Exchange) that are set up by this organization. Such an environment enables experiments and demonstrations that pose a risk of interference and destruction.

PLANETLAB AND RELATED PROJECTS

Planet-lab.org and **Planet-lab.eu** are research networks involved in global Next-Generation Internet activities. The networks are used for testing new network applications, protocols, in simulation processes, etc., as well as for teaching master's programmes at computer and information technology departments. CESNET permanently maintains four servers in the infrastructure and is responsible for the

operation of the local infrastructure, namely for the operation of servers and registration of domestic users, authentication of their affiliation with an organization and basic support activities for system use. We have created and operate twenty active virtual networks with various configurations as specified by the users themselves. All virtual networks used by CESNET users contain a total of approximately 400 nodes abroad. This gives users an opportunity to test their applications in a global context.

E-INFRA CZ

The Czech Republic Roadmap for Large Research, Experimental Development and Innovation Infrastructures categorizes large research infrastructures into six areas based on their focus. One of the areas is e-infrastructures that provide information and communications services for research and development in the Czech Republic. This category contains three infrastructures: **CESNET**, **CERIT-SC** (operated by Masaryk University) and **IT4Innovations** (operated by VŠB-Technical University of Ostrava). These infrastructures consistently cooperate and coordinate their activities in order to efficiently provide services to users. Based on a recommendation made by an international panel during an interim assessment of large research infrastructures carried out in 2017, the provider of support – the Ministry of Education, Youth and Sports of the Czech Republic – decided to support these e-infrastructures in 2020–2022 as a single national e-infrastructure, **e-INFRA CZ**, specifically by means of two consortium projects. Operating costs would be covered under the **Support for Large Research Infrastructures** programme and investments under the **RDE OP**. CESNET therefore started intensive preparation of drafts for these joint projects in the fourth quarter of 2018.

THE ASSOCIATION'S RESEARCH ACTIVITIES

IN RESEARCH AND DEVELOPMENT,
CESNET COLLABORATES NOT
ONLY WITH ASSOCIATION
MEMBERS BUT ALSO WITH
INTERNACIONAL AND
NATIONAL PARTNERS.





THE ASSOCIATION'S RESEARCH ACTIVITIES

THE DEVELOPMENT OF A RESEARCH AND DEVELOPMENT E-INFRASTRUCTURE REQUIRES AN INNOVATIVE APPROACH. THAT IS WHY CESNET, IN ADDITION TO BUILDING AND OPERATING ITS E-INFRASTRUCTURE, IS ALSO ENGAGED IN RESEARCH AND DEVELOPMENT IN THE FIELD OF INFORMATION AND COMMUNICATIONS TECHNOLOGY, MOST IMPORTANTLY IN THE AREAS MENTIONED BELOW.

We collaborate on research and development not only with Association members but also with international and national partners.

E-INFRASTRUCTURE SECURITY

CESNET has long been committed to network security. In addition to developing tools for ensuring user privacy and security of their data or tools for sharing information on security incidents, we have also been intensively developing tools for network monitoring and detection of operating anomalies as potential sources of attack.

CESNET WAS INVOLVED IN THE FOLLOWING PROJECTS IN 2018:

- **Network Feature Virtualization Acceleration Platform (NFV200).** This project under the TACR's EPSILON2 programme aims to create a platform that will enable easy deployment of virtualized network features in the fastest network and data centre environments.
- **Network Diagnostics from Intercepted Communication (DISTANCE).** This project under the TACR's EPSILON2 programme aims to create a software solution capable of intercepting traffic of interest based on various criteria and their combinations. The project result will be integrated into CESNET's existing network monitoring tools.
- **Detection of Infrastructure Security Threats (DOBI).** The project is implemented under the Czech Republic Security Research 2015–2020 programme of the Ministry of the Interior of the Czech Republic. The aim of the project is to develop and test methods for preventive protection of fibre infrastructures, which are frequently threatened during various construction works as well as by line theft.
- **National Cyberspace Security Event Sharing and Analysis (SABU).** The project is implemented under the Czech Republic Security Research 2015–2020 programme of the Ministry of the Interior of the Czech Republic. The aim of the project is to create a pilot system for timely submission and analysis of events relating to the national cyberspace. The system will enable information mining and sharing among involved security teams, including the Czech Republic's national and governmental teams, so as to predict the progress of an attack and warn the involved infrastructures.
- **Adaptive Management of Data Collection and Analysis in High-Speed Networks (FOKUS).** The project is implemented under the Czech Republic Security Research 2015–2020 programme of the Ministry of the Interior of the Czech Republic. It aims to create a system that will enable a higher threat detection rate and better data collection in networks by implementing feedback from detection systems to probes. Based on analysis of measured data, detection systems will ask probes for more detailed analysis of selected parts of traffic. The project will involve the development of a probe for processing the 400 Gbps Ethernet protocol.
- **Secure Gate for Internet of Things (SIoT).** This project under the Czech Republic Security Research 2015–2020 programme of the Ministry of the Interior of the Czech Republic aims to enhance security in ever-growing Internet of Things (IoT) networks, which currently incorporate hazardous and easy-to-attack elements.
- **Cyber Threat Intelligence (CTI) System Building and Pilot Operation.** This project under the Security Research for State Needs 2016–2021 programme of the Ministry of



the Interior of the Czech Republic aims to enhance the protection of critical information infrastructures and reduce damage caused by cybercrime by building an efficient system for the detection, identification and prediction of cyber threats and evaluation of cybersecurity incidents (Cyber Threat Intelligence).

- **Proactive Risk Management through Situation Awareness (PROTECTIVE)** is an international H2020 project that aims to create a pilot system for collecting and processing security-related data and information within an organization or network and sharing relevant data with stakeholders at national and international level.

NETWORK IDENTITY

An important e-infrastructure component is mechanisms for controlling access to individual services. That is why the Association also develops and implements an infrastructure for federalized sharing of services and resources. Its main purpose is to allow users from various home institutions to use resources operated by partner institutions. These resources may be either miscellaneous network applications or network connectivity as such. International coordination of these activities is a prerequisite for acting on challenges in this field. CESNET was involved in a European project named **Authentication and Authorisation for Research and Collaboration (AARC2)** under the H2020 programme in 2018; the aim of the project is to design a general authentication and authorization infrastructure for the broad user base of research infrastructures.

GRIDS AND CLOUDS

As part of its activities associated with the operation of the computational part of its e-infrastructure, CESNET participates

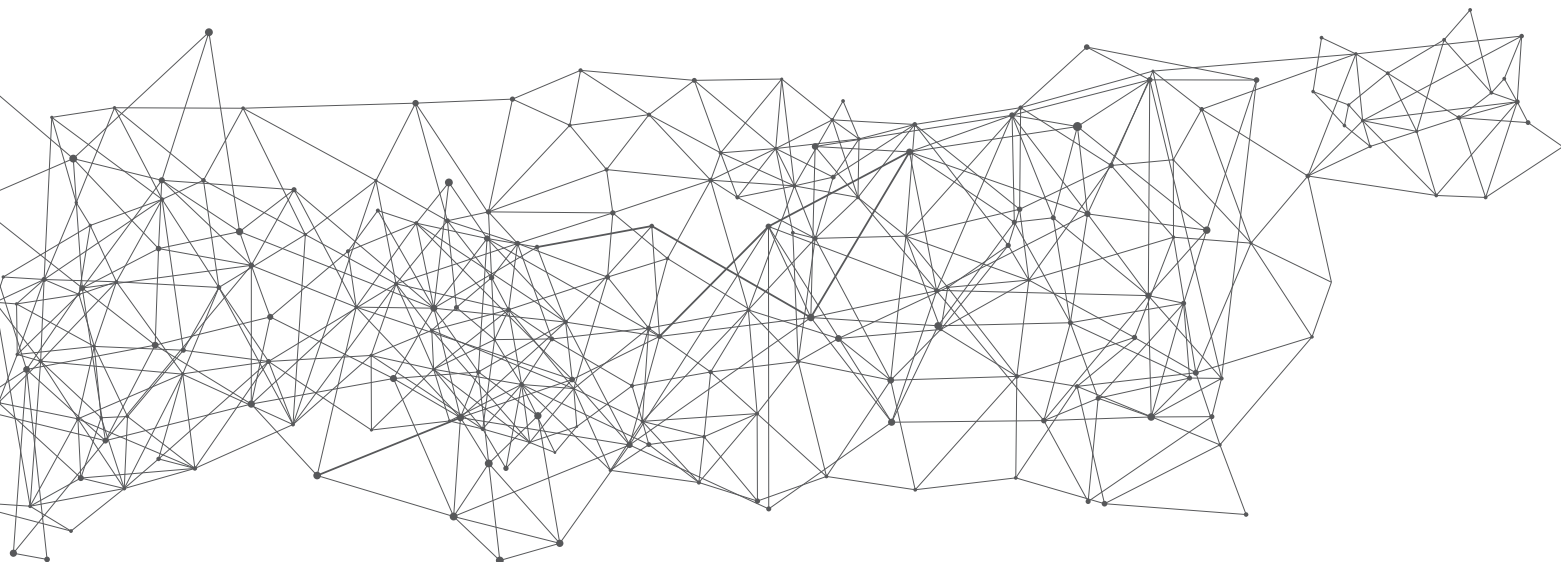
intensely, mainly within EGI.eu activities, in the development of middleware relating to task scheduling as well as some components related to the operational security of grid and cloud infrastructures. International cooperation in this field is exemplified by an international H2020 project named **Designing and Enabling e-infrastructures for Intensive Processing in a Hybrid DataCloud (DEEP-HybridDataCloud)**, which focuses on the development and subsequent implementation of cloud services to support demanding computations, use of GP-GPU cards and support for deep-learning applications in this environment. The main objective of the project is to create a hybrid cloud providing researchers with access to resources to which they do not have necessary and easily available access in the existing European e infrastructure. CESNET is developing virtual router components under the project.

OPTICAL TRANSMISSION SYSTEMS

CESNET has been researching and developing optical technologies for a long time. We have developed the **CzechLight** series of original fully optical transmission systems, whose greatest advantage is openness. This means that the owner or administrator of a device can make software modifications directly without asking CESNET or the manufacturer to do so. This makes them independent in terms of decisions on further network development.

THE ASSOCIATION PARTICIPATED IN THE FOLLOWING PROJECTS IN THIS FIELD IN 2018:

- **Set of Elements for Photonic Communication (EPCOM II)** is a project under the TACR's EPSILON programme. It aimed to create a set of optical and electronic elements that would enable the



operation of a photonic service on fibre and wireless communications links with a high degree of compensation for traffic delays in transmitted information.

- **CLOCK NETWORK SERVICES (CLONETS)** is an international H2020 project aiming to prepare studies and specifications for the construction of a pan-European optical network to provide high-quality services for.

NEW APPLICATIONS

Just like the most interesting research results often emerge from interdisciplinary research today, innovative network applications often require combining many technologies. Often, this involves combining premium network access, storage capacities, special transmission hardware and software and visualization and interaction resources, including a method of use in the field in question. The benefit of new network applications is better e-infrastructure utilization in new areas and new possible ways of collaboration in research, development and education in various fields such as medicine, culture or architecture.

- **Laterna magika. The Past and the Present, Documentation, Preservation and Accessibility.** The goal of this project under **NAKI II – Support for Applied Research and Experimental Development for the National and Cultural Identity in 2016–2022**, a programme supported by the Ministry of Culture of the Czech Republic, is to restore the archives of Laterna Magika films, create a storage methodology, build pilot storage and present the films.
- **8K Studio over IP Bridge (8KSVIP)** was a project under the European EUROSTARS2 programme which aimed to design, implement and experimentally verify an

architecture and components for scalable image transmission devices.

- **Monitoring of Sensitive Objects over the Internet of Things (Mon-IoT).** The project is undertaken under the TRIO programme of the Czech Ministry of Industry and Trade. Its main objective is to develop an integral system for monitoring the condition and movement of precious and sensitive objects using Internet-of-Things (IoT) elements.
- **Use of Digital Models for the National Infrastructure of Memory Institutions.** This project under the TACR's ÉTA programme aims to extend the current manner of collection item registration at museums and archives to include interactive 3D models.
- **Remote Collaboration in Artist Education Using Modern Transmission Technology.** The aim of this project under the TACR's ÉTA programme is to create a model facility for remote collaboration, the first of its kind in the Czech Republic, to allow interconnecting the physical and virtual worlds in fine arts.

RESEARCH AND DEVELOPMENT OUTCOMES

CESNET's research activities resulted in six articles in peer-reviewed scientific journals, thirty-six papers in conference proceedings, five functional specimens and nine SW outcomes in 2018.

IN ADDITION, TWO PATENTS WERE GRANTED:

- CESNET, z. s. p. o. **Modular kit of a device for monitoring the spectral offset of two channels in networks with optical wave multiplexes.** Radan SLAVÍK, Josef VOJTĚCH, Vladimír SMOTLACHA, Jan RADIL, no.: US9941956B2, granted by

- US001 – United States Department of Commerce – United States Patent and Trademark Office (USPTO), 10 April 2018
- CESNET, z. s. p. o. **A connection for quick search of regular expressions in data.** Viktor PUŠ, Vlastimil KOŠAŘ, Jan KOŘENEK, Denis MATOUŠEK, no.: US 9,978,451 B2, granted by US001 – United States Department of Commerce – United States Patent and Trademark Office (USPTO), 22 May 2018

CESNET DEVELOPMENT FUND

In late 2017, the Development Fund Board prepared and launched a tendering process for projects for 2018 in accordance with newly adopted rules approved by the General Assembly on 21 December 2017. Its topics had been chosen in cooperation with the Association.

The following topic areas were announced in 2018:

- Utilization and advancement of CESNET e-infrastructure services and modern information and communications technologies in teaching and learning processes, creative and scientific research

- work and management of public universities and the Czech Academy of Sciences
- Advanced applications utilizing the CESNET e-infrastructure

An information workshop on this call for interested parties was held on 10 January 2018. Out of the 13 project applications submitted in that round, nine projects were admitted for co-funding, including four projects admitted after rewriting. The contribution requested for one project was reduced compared to the amount requested. An overview of accepted projects is shown in the table.

Four rounds of opposition procedures for completed projects took place over the course of 2018 – a total of 19 projects were completed successfully. One project was not defended and the provided funds were returned. When evaluating achieved results, a public presentation of two projects was held and several completed projects were recommended for wider presentation to allow other Association members to make use of the results. Final reports for projects carried out under the CESNET Development Fund are available on the Association's website.

CESNET DEVELOPMENT FUND: OVERVIEW OF ACCEPTED PROJECTS

PROJECT NUMBER	PROJECT HOLDER	PROJECT TITLE
622/2018	VŠB – Technical University of Ostrava	Development of an Experimental CESNET IoT Network on the LoRa-WAN Platform
624/2018	University of West Bohemia	IT Security Training for UWB Network Users
625/2018	University of West Bohemia	UWB Open Data
626R1/2018	University of West Bohemia	Modern IT Infrastructure Monitoring
629R1/2018	Jan Evangelista Purkyně University	Using the IoT for a Pilot Building Energy Management Project for Jan Evangelista Purkyně University in Ústí nad Labem
630R1/2018	University of South Bohemia	Verifying the Performance and Reliability of a Ceph Distributed Storage System in an Environment of Geographically Separated Locations in the CESNET e-infrastructure
631/2018	Czech Academy of Sciences	Enhancing Network Infrastructure Security at the Institute of Physiology by Deploying Security Tools and Honeypond in Collaboration with CESNET and HaaS
632/2018	Academy of Performing Arts	Adding Perceptual Assessment of Image and Video Recordings to PsychotestEditor
634R1/2018	Czech Academy of Sciences	Using e-infrastructure Photonic Services to Transmit Optical Frequencies Produced by Fibre References

PUBLIC RELATIONS

CESNET ORGANIZED A NUMBER OF
EXPERT SEMINARS, CONFERENCES
AND WORKSHOPS FOR THE
ACADEMIC AND PROFESSIONAL
PUBLIC IN 2018.





PUBLIC RELATIONS

THE ASSOCIATION CONTINUED WITH ACTIVITIES HIGHLIGHTING ITS INDISPENSABLE ROLE FOR THE SCIENTIFIC AND RESEARCH INFRASTRUCTURE IN THE CZECH REPUBLIC IN 2018. WE ALSO WORKED ON ACTIVITIES AIMED AT SHARING EXPERIENCE WITH THE INTERNET COMMUNITY.

The Association organized seminars, conferences and workshops for the academic and professional public, each one dealing with a specific topic. We organized 16 events, including 13 national and three international, in 2018.

In February 2018, CESNET organized another annual **Network and Services Security Workshop** (see Fig. 1). It focused on the operation and security of networks, services and Internet applications. Traditionally, it dealt with current security topics and issues from the past months that are addressed in the administration of the CESNET e infrastructure. Its main feature was a presentation by the CESNET Forensic Laboratory named **A Thin Red Line, aka Hacking Show 2**.

Two courses of **Forensic Training**, led by experience experts from the CESNET Forensic Laboratory, took place in 2018. During two days, training participants acquired not only a theoretical but also a practical background in

forensic analysis of information technologies.

A hot topic of 2018 was the introduction of the new European regulation General Regulation on the Protection of Personal data (GDPR, General Data Protection Regulation).

The Association organized a seminar on this topic, several weeks before its implementation in practice to let participants get a clearer understanding of the matter in question.

Another traditional CESNET Day, an informal meeting between Association experts and representatives of member organizations, took place in 2018, this time in Olomouc (see Fig. 2). Its main objective was to present the Association's activities and build closer links with both the university and organizations in the Olomouc Region.

CESNET also held customary workshops and conferences such as the **IPv6 Workshop**, **Grid Computing Seminar** (see Fig. 3), **Security Fest** or **Proactive Security**.

1



- 1 Network and Services Security Workshop
- 2 CESNET Day in Olomouc
- 3 Computing Seminar in Prague



2



3

4



5



6



4 Booth at the TIP Summit in London

5 The Catch contest

6 Tribute to the Brave concert

The Association hosted eight international workshops, such as a work meeting of Disk Pool Manager developers and administrators, the **42nd international meeting of members of the European Policy Management Authority for Grid Authentication** or a consortium meeting and workshop for participants of the Clonets – CLOck NETwork Services project.

We became a partner for several events such as the **Science and Technology Week**, **TSP 2018** conference or **InstallFest**. We set up our own booth at the second annual **TIP Summit** in London (see Fig. 4), the **Science Research Innovation** fair in Brno and **Linux Days** in Prague.

In the second half of 2018, CESNET, in collaboration with Trend Micro, organized the second annual **The Catch** contest (see Fig. 5). It tested the analytical and 'hacking' skills of 449 players. Contest winners flew to Japan to take part in an international contest, in which their team came in sixth.

In early 2018, Association experts, in collaboration with AV MEDIA, set up an audiovisual connection for sports grounds holding an **Olympic Festival**, namely the Brno Exhibition Centre and ČEZ Arena in Ostrava. During the **Tribute to the Brave** gala concert held on the occasion of the presentation of the **Václav Havel Human Rights Prize** in October, CESNET specialists set up a live connection for artists from the Czech Republic and Slovakia. The concert was also available for watching online on the Czech Television website (see Fig. 6).

The Association also presented its activities on its website, which was kept updated throughout the year. In addition, we continue to administer a website for large research infrastructures in the Czech Republic in collaboration with the Ministry of Education, Youth and Sports of the Czech Republic. The Association also used social media to present itself, sharing its latest news, its employee's achievements and information on conferences and other events.

We issued 20 press releases in 2018, informing about the Association's current activities.

We registered a total of 230 media outputs, either printed or online, in 2018. For example, Association Director Jan Gruntorád made an appearance in the ČT24 studio on Czech Television or on Czech Radio Plus.

ECONOMIC RESULTS

THE ASSOCIATION MANAGED THE FUNDS ENTRUSTED TO IT PROPERLY IN 2018. ITS FINANCIAL STATEMENTS WERE REVIEWED BY AN AUDITOR AND GIVEN AN UNQUALIFIED OPINION.





ECONOMIC RESULTS

ECONOMIC RESULTS IN 2018

CESNET'S ACTIVITIES ARE DIVIDED INTO TWO CATEGORIES IN ACCORDANCE WITH ITS STATUTES: NON-ECONOMIC AND ECONOMIC.

PRINCIPAL (NON-ECONOMIC) ACTIVITIES

The four-year CESNET e-infrastructure project was in its third year in 2018.

As part of its principal activities, the Association continued building an e-infrastructure of a new quality to provide Association members and other entities eligible for connection to the CESNET2 network with a comprehensive set of services. The Association was also involved in the execution of international research projects under the EU Horizon 2020 programme, grants from the Technology Agency of the Czech Republic, Ministry of the Interior of the Czech Republic and Norway Grants and projects of the Development Fund Board, as already mentioned in the previous section of the Annual Report.

The Association's principal activities in 2018 generated an accounting profit of CZK 12,311 thousand before tax. Revenues from the Association's principal activities amounted to CZK 467,175 thousand; expenditures were CZK 457,812 thousand.

The income tax base for the Association's principal activities in 2018 was positive, amounting to CZK 17,759 thousand.

CZK 122,310 thousand; expenditures on economic activities were CZK 123,130 thousand.

The income tax base for the Association's economic activities in 2018 was negative, in the amount of CZK 2,085 thousand.

TOTAL ACCOUNTING AND TAXABLE PROFIT

CESNET had a total accounting profit of CZK 11,461 thousand before tax in 2018. Its total income tax base after deducting tax base-reducing items was CZK 14,674 thousand. The Association paid income tax of CZK 2,918 thousand for the year 2018, resulting in an after-tax profit of CZK 8,543 thousand.

CONCLUSION

The Association managed the entrusted funds properly in 2018, meeting all of its obligations resulting from legislation, decisions of the Ministry of Education, Youth and Sports of the Czech Republic and concluded contracts. Its financial statements for 2018 were reviewed by an auditor and given an unqualified opinion.

ECONOMIC ACTIVITIES

The Association's economic activities in 2018 consisted primarily in holding a prevalently bond-based portfolio of the Development Fund, comprising financial resources obtained by selling the commercial part of the CESNET network in 2000, and in managing financial resources in other funds.

The Association's economic activities in 2018 generated an accounting loss of CZK 850 thousand. Revenues from the Association's economic activities in 2018 amounted to