

ANNUAL REPORT

2023

cesnet
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CONTENTS

CESNET Association	5
CESNET e-infrastructure	11
Cooperation with large research infrastructures.....	26
Public relations	33
Financial performance	35

A WORD FROM THE DIRECTOR

In 2023 we had the opportunity to celebrate a nice, round anniversary. 15 June marked exactly 30 years since the Czech Technical University in Prague launched the CESNET academic computer network. At that time it connected ten Czech and Moravian university towns at a speed of 19.2 kbit/s, the main Prague-Brno route boasted 64 kbit/s. It was a major milestone in the introduction of the Internet to the Czech Republic.

Today, the CESNET network has a transmission capacity of hundreds of gigabits per second, 10 million times faster than back then. With its parameters and services, advanced methods of monitoring, detection and cyber protection, it is one of the most advanced scientific research networks in Europe and is a key part of the unique e-INFRA CZ national e-infrastructure for research, science and education.

The exceptional position that CESNET has maintained for three decades is not a given. It is contingent on the daily efforts of colleagues to improve the network's technology and increase its transmission capacity. This was still the case in 2023, when we completed a significant upgrade of the network that allows data transmission in its backbone structure at speeds of up to 400 Gbit/s per channel, with the possibility of further future increases towards terabit speeds.

The deployment of modern network elements has led to a significant reduction in the requirements for housing technology and a reduction in power consumption. The backbone of the network is being built over 2,240 kilometres of fibre optic paths, including advanced precision time and frequency transmissions, and is also ready for currently pursued shared media quantum key transfer (QKD) technology. Every time a network upgrade brings a major generational



technology change, we update its operational designation. Currently it is CESNET3. At the same time, we announced a further strategy to develop our network infrastructure towards the next, fourth generation.

In 2023 we became the first national research and education network in the world to deploy segment routing over IPv6 (SRv6) using the concept of micro-segments (uSID). SRv6 will contribute to the simplification of network architecture and processes, and therefore to more efficient management and operation of the network. It can also be used to improve the security of the network environment.

Another significant achievement was the commissioning of two new data repositories – the first at Mendel University in Brno and the second at the ELI ERIC facility in Dolní Břežany. Both repositories are already object-based, built on CEPH technology. The total gross capacity of the data storage infrastructure has thereby increased to almost 130 PB.

As part of the e-INFRA CZ consortium, the most advanced system for artificial intelligence computing, NVIDIA DGX H100, was made available to the entire scientific and research community in the Czech Republic through our MetaCentre. The system was installed at the CERIT-SC centre at Masaryk University in Brno.

30

**ON JUNE 15, EXACTLY 30 YEARS HAVE PASSED SINCE THE
WHEN THE CZECH TECHNICAL UNIVERSITY IN PRAGUE STARTED
OPERATION OF THE ACADEMIC COMPUTER NETWORK CESNET**

We are very active in the field of cybersecurity. Our experts are a natural and respected part of the professional community, and are invited to important strategic projects in this field, both by the ministries for their field and other important institutions. We make sure that we are a leader in the Czech Republic in the field of cybersecurity through the quality of our expert team and the technologies used. An example of success in this field is the project Analysis Flow-based Encrypted Traffic Analysis (FETA), which passed the first evaluation of the Ministry of the Interior of the Czech Republic in 2023. Thanks to the collaboration of three excellent teams (CESNET, FIT CTU in Prague and FIT CTU in Brno), a unique and highly accurate method of IoT malware detection has been developed. The results were subsequently published in the prestigious impact-factor IEEE IoT Journal.

In 2023, we were active in a number of research and development fields. Some projects can also be appreciated by

the public. For example, in cooperation with the Karel Čapek Memorial in Stará Huť near Dobříš, our experts have created digital models of objects connected with the work and life of the famous writer.

CESNET continues to play a key role in the development of a modern information society, and its services are used by many professional institutions across disciplines. This is partly because working together with our association allows them to participate in very interesting and important international projects, and thereby provides a closer link with the international scientific research community.

I would like to thank all my colleagues from CESNET, as well as its member institutions and partner organisations for their excellent cooperation and express my conviction that we will be able to build on our joint successes in the time to come.

ING. JAKUB PAPÍRNÍK
DIRECTOR OF CESNET



THE CESNET ASSOCIATION

History and current tasks of the Association

CESNET was founded by public universities and colleges and the Czech Academy of Sciences (CAS) in 1996.

CESNET's mission is to

- provide the scientific, research and education community with unique and comprehensive e-infrastructure services with a quality comparable to the world's best, and to support the Open Science concept;
- offer stable services with high added value covering the widest possible spectrum of needs of our users;
- contribute its in-house research activities towards the development of information and communications technology and to put their results into practice.

When it was founded the Association also operated as a commercial internet service provider in order to earn additional money from these activities for its principal activities. This activity ceased in 2000. Since then it has worked exclusively in the **development and operation of science, research and education e-infrastructure** and related activities.

A significant milestone in the Association's history came in 2010, when the CESNET e-infrastructure was integrated into the **Roadmap of Large Research, Experimental Development and Innovation Infrastructures of the Czech Republic**¹. Between 2011 and 2015, through the 'CESNET Large Infrastructure' project, the national research and education

network, as it was then known, was subsequently reconstructed into a comprehensive e-infrastructure for research and development in the Czech Republic. In connection with an update of the Roadmap in 2019, three e-Infrastructures (CESNET, CERIT-SC and IT4Innovations) have been merged into the single national e-Infrastructure CZ (hereinafter also referred to as e-INFRA CZ). E-INFRA CZ, of which CESNET is the host institution, is being jointly built in cooperation with partner institutions Masaryk University and the Technical University of Ostrava.

In 2020 the first **associate members, the National Museum and the Moravian Gallery in Brno**, joined CESNET.

Then, in 2021, CESNET, Masaryk University and the Technical University of Ostrava were accepted as members of the EOSC (European Open Science Cloud) association.

On 27 January 2022, a general legislative measure entered into force, under which the CESNET Association became a **critical infrastructure entity** pursuant to Section 2(k) of the Crisis Act and, at the same time, administrator of the critical information infrastructure communication system pursuant to Section 3(d) of the Cybersecurity Act (CIA).

In 2023 two more institutions, the **Extreme Light Infrastructure ERIC (ELI ERIC)** and the **Moravian-Silesian Data Centre**, joined the ranks of associate members.

¹ According to Article 2(d) of Act No. 130/2002 Coll., "a large research infrastructure is a research infrastructure consisting of a research facility necessary for comprehensive research and development activities with high financial and technological requirements, which is approved by the government and established for use by other research organisations".

According to Article 2, point 91 of Commission Regulation (EU) No 651/2014, "Major research infrastructure means facilities, resources and related services that are used by the scientific community to conduct research in their respective fields and covers scientific equipment or sets of instruments, knowledge-based resources such as collections, archives or structured scientific information, enabling information and communication technology-based infrastructures such as grid, computing, software and communication, or any other entity of a unique nature essential to conduct research".

THE CESNET ASSOCIATION

Scope of activities

The scope of the Association's main activities is:

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. undertaking the following activities for the benefit of its members, their subsidiary organisations and other entities:
4. undertaking the following activities for the benefit of its members, their subsidiary organisations and 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 from 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 relevant fiscal period, or the supplementary activity in question will be discontinued before the beginning of the following fiscal period.

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

THE CESNET ASSOCIATION

Membership of international and national organisations

CESNET was a member of the following renowned organisations in 2023:

International organisations



EOSC AISBL – an international association of institutions involved in the building of the European open science cloud concept (www.eosc.eu).



GÉANT Association – an association of European national research networks that works in the operation and advancement of the GÉANT European communications infrastructure and coordination of related activities (www.geant.org).



EGI.eu – an organisation focusing on coordinating European computing grids used for scientific computations and supporting their sustainable development (www.egi.eu).



Shibboleth – an international consortium for coordinating 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 (www.shibboleth.net).



QUAPITAL – a Central European partnership for secure communication with security at the quantum level and quantum internet (www.quapital.eu).



ELIXIR – the European ELIXIR bioinformatics infrastructure combines advanced computing environments, data resources and unique tools for the purposes of bioinformatics research across Europe (<https://elixir-europe.org>).

National organisations



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 (www.nix.cz).



CZ.NIC – association and one of the founding members of CZ.NIC, z.s.p.o., which administers the .cz internet domain and supports publicly beneficial projects and activities relating to the internet (www.nic.cz).

THE CESNET ASSOCIATION

Association members

The following institutions were regular members of the Association in 2023:

- Academy of Performing Arts, Prague
- Czech Academy of Sciences
- Academy of Fine Arts, Prague
- Czech University of Life Sciences, Prague
- Czech Technical University, Prague
- Janáček Academy of Musical and Dramatic Arts
- University of South Bohemia, České Budějovice
- Masaryk University
- Mendel University, Brno
- University of Ostrava
- Police Academy of the Czech Republic, Prague
- Silesian University, Opava
- Technical University of Liberec
- University of Hradec Králové
- Jan Evangelista Purkyně University, Ústí nad Labem
- Charles University
- University of Defence
- Palacký University, Olomouc
- University of Pardubice
- Tomáš Baťa University, Zlín
- University of Veterinary Sciences, Brno
- Technical University of Ostrava
- University of Economics, Prague
- University of Chemistry and Technology, Prague
- Academy of Arts, Architecture and Design, Prague
- Brno University of Technology
- University of West Bohemia, Plzeň

Associate members:

- Extreme Light Infrastructure ERIC
- Moravian Gallery in Brno
- Moravian-Silesian Data Centre
- National Museum

THE CESNET ASSOCIATION

Internal organisational structure

CESNET comprises the following bodies:

- General Assembly
- Board of Directors
- Supervisory Board
- Director of the Association

The Board of Directors consisted of the following members in 2023:

- Mgr. Michal Bulant, Ph.D.
- RNDr. Alexander Černý
- Ing. Jan Gruntorád, CSc.
- Ing. Radek Holý, Ph.D.
- Mgr. František Potužník
- doc. RNDr. Pavel Satrapa, Ph.D.
- prof. Ing. Miroslav Tůma, CSc.

In 2023 the office of **chairman** was held by prof. Ing. Miroslav Tůma, CSc.

In 2023 the office of **vice-chairman** was held by Ing. Radek Holý, Ph.D. and Mgr. František Potužník.

The Supervisory Board consisted of the following members until June 2023:

- Mgr. Martin Maňásek
- Ing. Jaromír Marušinec, Ph.D., MBA
- prof. JUDr. Radim Polčák, Ph.D.
- RNDr. David Skoupil
- Ing. Michal Sláma

The Supervisory Board consisted of the following members from June 2023 on:

- Mgr. Kamil Gregorek, MBA
- Mgr. Martin Maňásek
- prof. JUDr. Radim Polčák, Ph.D.
- RNDr. David Skoupil
- Ing. Michal Sláma

In 2023 the **chairman** of the Supervisory Board was Ing. Michal Sláma.

In 2023 the office of **director** of the Association was held by Ing. Jakub Papírník.

Development Fund Board

The Development Fund Board consisted of the following members until June 2023:

- doc. RNDr. Eva Hladká, Ph.D.
- Ing. Jaromír Holec
- Mgr. Monika Hrabáková
- Ing. Olga Klápšťová
- doc. RNDr. Antonín Kučera, CSc.
- Ing. Tomáš Podermaňski
- prof. Ing. Zbyněk Škvor, CSc.

The Development Fund Board consisted of the following members from June 2023 on:

- doc. RNDr. Eva Hladká, Ph.D.
- Ing. Jaromír Holec
- Mgr. Monika Hrabáková
- Ing. Marek Kalika, Ph.D.
- Ing. Olga Klápšťová
- Ing. Tomáš Podermaňski
- prof. Ing. Zbyněk Škvor, CSc.

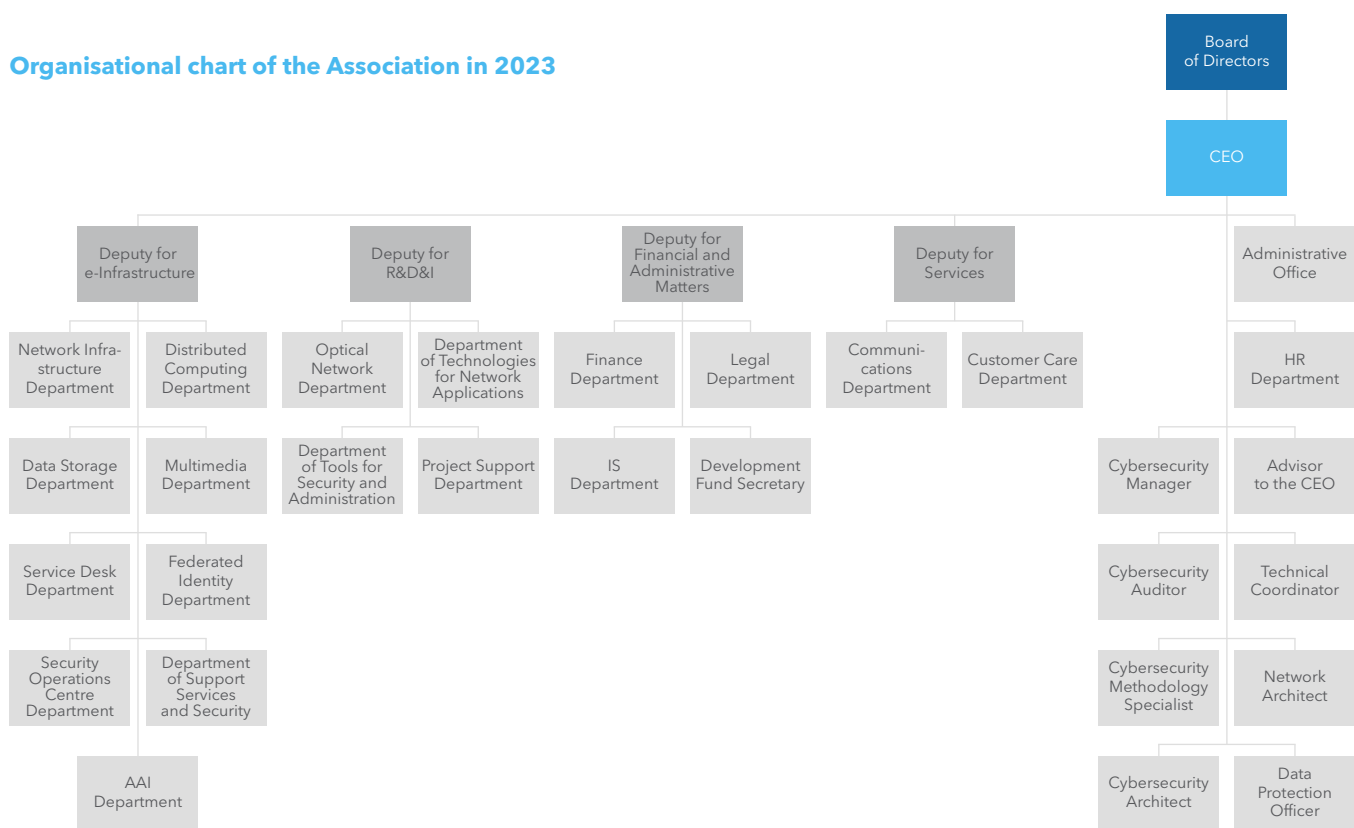
The office of the **chairwoman** of the Development Fund Board was in 2023 held by Ing. Olga Klápšťová.

THE CESNET ASSOCIATION

Organisational chart

The Association's basic organisational structure comprises departments that are grouped into sections. Management within this structure is performed by line managers. The Association had a total of 225.5 recalculated full-time jobs in 2023.

Organisational chart of the Association in 2023



E-INFRASTRUCTURE

CESNET is the host organisation of the large research infrastructure e-Infrastruktura CZ (acronym e-INFRA CZ), which is an important element of the Roadmap of Large Research Infrastructures of the Czech Republic for the years 2023 to 2026. It provides a universal environment for the transfer, processing, sharing and storage of scientific data and user collaboration that is independent of any specific field of research and indispensable today for contemporary research, development and innovation in any field.

e-INFRA CZ is the result of collaboration between three e-infrastructures:

- **CESNET e-Infrastructure** operated by CESNET,
- **CERIT Scientific Cloud** operated by Masaryk University,
- **IT4Innovations national supercomputing centre** operated by VŠB – Technical University of Ostrava.

CESNET is the host organisation in this consortium, i.e., the organisation responsible for the operation of the entire e-INFRA CZ.

CESNET is also the coordinator of two complementary projects for the development and operation of e-INFRA CZ:

- **e-Infrastruktura CZ** (LM2018140, 2023-2026) funded under the R&D&I Large Infrastructure Projects programme (2010-2026). Special-purpose aid in subsidy form is earmarked for covering a portion of operating costs associated with e-infrastructure operation.

- **e-INFRA CZ: Modernisation** (EF18_072/0015659, 2020-2023) funded from the Research, Development and Education operational programme, which is the main source of investment funds for an e-infrastructure upgrade.

The objective is to modernise and ensure the operation of individual e-INFRA CZ components. The members of the consortium therefore build on the previous operation of their e-infrastructures while striving to **align their approach to users** so that they can see the e-INFRA CZ e-Infrastructure as a coherent whole.

The CESNET e-Infrastructure is used to **provide services for Czech science, research, development and education**. The following chapters describe the development of this e-infrastructure, its portfolio of services and the associated research activities. The Association not only provides these services to its members, but also to other entities that comply with the CESNET e-Infrastructure Access Policy.



CESNET E-INFRASTRUCTURE DEVELOPMENT

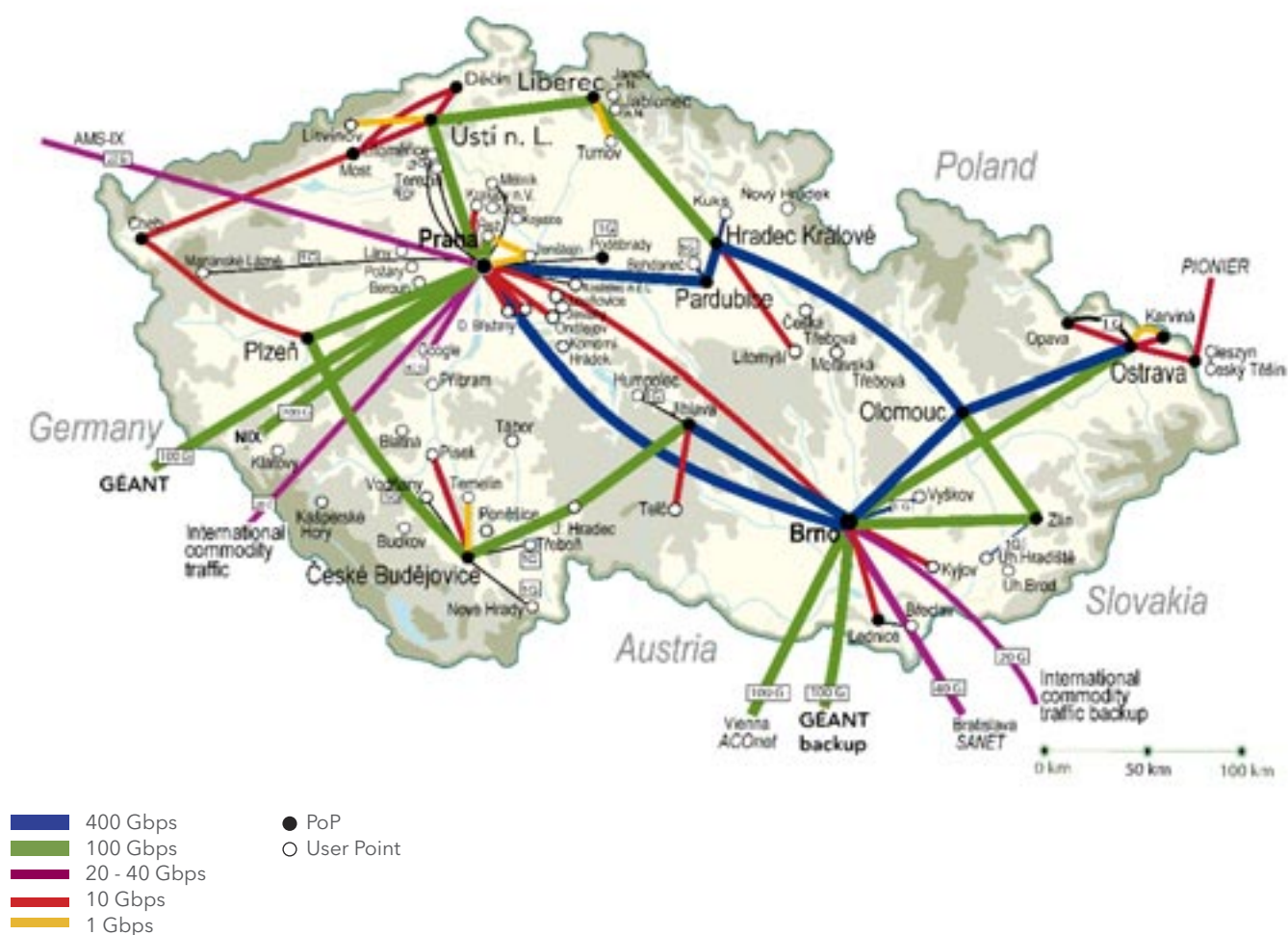
In 2023, in addition to ensuring the routine operation of the CESNET e-infrastructure, we focused on modernising the e-INFRA CZ components for which CESNET is responsible:

- completion of an upgrade of the IP/MPLS services of the CESNET3 network layer,
- modernisation of migration and modernisation of another part of the peripheral circuits of the DWDM network, which will enable data transmission at speeds of up to 400 Gb/s,
- renewal and expansion of the MetaCentre's computing capacity by installing HD clusters at Masaryk University in Brno and the Institute of Molecular Genetics of the Academy of Sciences of the Czech Republic in Prague,
- commissioning of data repositories at Mendel University in Brno and ELI ERIC in Dolní Břežany,
- making available data storage services for the international DICE project, covering a wide range of services from common 'personal data storage' for individuals and small teams to extremely sophisticated value-added solutions for long-term storage and identification of stored data, metadata management and implementation of FAIR principles for data-intensive research projects,
- launching the user portal <https://muj.cesnet.cz>, including reporting on primary member network connections,
- reaching 300,000 users of the MyAcademicId authentication and authorisation infrastructure,
- deployment of Perun AAI in the Sensitive Cloud environment for processing sensitive medical data,
- implementation of penetration tests of the MetaCentre infrastructure and CESNET backbone network infrastructure,
- deployment of new MetaCentre services in the area of GUI access and support for Jupyter notebooks.

COMMUNICATIONS INFRASTRUCTURE

The foundation of the e-infrastructure is a high quality, high speed and low latency backbone communication network with wide international connectivity. It offers many advanced functions and features, including dedicated transmission channels and non-IP services (precise time and stable frequency transmission or quantum key distribution).

Map - CESNET Network Topology



COMMUNICATIONS INFRASTRUCTURE

CESNET develops and operates a state-of-the-art communication infrastructure to connect resources, services and users of the e-infrastructure, as well as other large research infrastructures, with each other and with their international partners.

The foundation is a backbone infrastructure, which is designed to provide sufficient capacity for data transmissions and to be as resilient to link and technology outages as possible. The infrastructure is connected in a variety of ways with a capacity of over 400 Gbps. This involves global connectivity (Tier 2 operator and interconnection nodes) and links to research networks (GÉANT and several cross-border fibres) that not only provide users with connectivity having sufficient capacity and redundancy but also with specialised links for specific applications.

The offered network access services include:

- a redundant, high-capacity connection to the backbone,
- dedicated circuits and networks,
- lambda services with physically reserved capacity and a fixed delay,
- photonic services for the most demanding applications with an all-optical pathway between points,
- internet identifier administration (CESNET NIC), including a LIR sponsoring service,
- authoritative and secondary DNS services,
- Stratum 1 primary time servers with an internal time source,
- infrastructure monitoring and tracking at several levels,
- services of the internationally accredited CSIRT security team, CESNET-CERTS,
- permanent network operability monitoring (NOC),
- a 24/7 service desk – support contact point (monitoring centre and help desk).

An integral part of this is high-quality protection of the infrastructure against security incidents. **Semi-automatic protection against DDoS** attacks is deployed in the network at several levels to achieve scalable and targeted protection. Detection and reduction of unwanted traffic is based on the deep knowledge of our expert team using detailed infrastructure monitoring based on our own tools (FTAS, G3, ExaFS).

The monitoring and ExaFS service is also available to administrators of connected institutions. Through rules in a user-friendly environment, administrators of connected organisations can already influence the traffic that belongs to the institution on the backbone network routers. For example, it may be discarded or redirected for further analysis to the DDoS Protector (a result of CESNET's own research activities), which filters out unwanted traffic. Another level of protection that can be applied before traffic enters the backbone network perimeter is provided by global protection against volumetric attacks in the form of a global scrubbing centre.

In 2023 the upgrade and migration of the IP/MPLS services of the CESNET3 network layer serving the connected organisations and other e-infrastructure components (particularly data storage or compute-intensive infrastructure) was completed. The IP/MPLS services also support the integration of large research infrastructures into the European and global research area.

400 Gb/s

THE INFRASTRUCTURE IS CONNECTED IN A VARIETY
OF WAYS WITH A CAPACITY OF OVER 400 GBPS

COMMUNICATIONS INFRASTRUCTURE

The same year also saw the completion of the migration and upgrade of another part of the peripheral circuits of the DWDM network, which will enable data transmission at speeds of up to 400 Gbit/s per channel, as well as special applications such as transmission of precise time and stable frequency or quantum key distribution (QKD) in dedicated optical spectrum.

An example of the intensive use of the CESNET e-infrastructure is the record data transfers on the LHCONe (LHC Open Network Environment) infrastructure to the Institute of Physics of the Czech Academy of Sciences. The virtual private LHCONe network is used for data transfer of experiments on the CERN particle accelerator, as well as for several other particle and astroparticle physics projects. During the data consolidation of the ATLAS experiment in early 2023, more than 1 PB of data was transferred to the Tier-2 centre at the Institute of Physics of the Czech Academy of Sciences over this line in 3 days. The maximum volume of data transferred in 24 hours exceeded 600 TB.

CESNET continues to participate in the hSOC (Hospital SOC) initiative, which aims to provide connected hospitals with better protection against cyber threats and attacks. It is a dedicated network within the CESNET e-infrastructure, isolated from standard traffic, with specific policies and rules, complemented by a number of security tools for monitoring and managing communication with involved entities. The isolation allows for more comprehensive and more detailed protection of hospitals. Participants in the hSOC initiative comprise 56 healthcare organisations, 8 hospital authorities and 8 other entities (such as the National Cyber and Information Security Agency [NÚKIB], the National Agency for Communication and Information Technologies [NAKIT] and the Czech Ministry of the Interior). The separate hospital network hSOC-VRF connects 16 hospitals (University Hospital Brno, Bulovka University Hospital, Olomouc University Hospital, St. Anne's University Hospital in Brno, Liberec Regional Hospital, Ústí nad Labem Regional Hospital, Jihlava Hospital, Na Homolce Hospital, Nové Město na Moravě Hospital, Pelhřimov Hospital, Tomáš Baťa Hospital in Zlín, Třebíč Hospital, Mladá Boleslav Regional Hospital, Central Military Hospital in Prague, Olomouc Military Hospital and General University Hospital in Prague).

56

**PARTICIPANTS IN THE HSOC INITIATIVE
COMPRISE 56 HEALTHCARE ORGANISATIONS**

DEMANDING COMPUTATIONS

MetaCentre map



DEMANDING COMPUTATIONS

The expansion and upgrade of MetaCentre computing capacities ran on schedule and in accordance with users' needs:

- Expansion of the computational capacity of the MetaCentre by installing HD clusters at Masaryk University in Brno and the Institute of Molecular Genetics of the CAS in Prague. The upgrade was aimed at acquiring an efficient and powerful CPU platform. AMD processors with AMD 3D V-Cache technology won the selection procedure, with a total of 6144 cores. The 96 nodes acquired were placed in Brno and Prague as two new clusters; 12 nodes strengthened the MetaCloud service. The parameters of each node are 64x AMD EPYC 7543@2.80GHz CPU, 512 GB RAM, 7 TiB NVME disk.
- Based on an assessment of long-term trends and needs (expected development of hardware performance, user needs and the nature of applications), the MetaCentre designed and developed a corresponding part of the development project submitted to the OP JAK Large Research Infrastructures call. The MetaCentre then developed the first stage of this project into a public procurement bid at the end of the year.
- Activities relating to the modernisation of the CESNET backbone network continued, with the MetaCentre's computing capacities gradually being connected according to a new concept inspired by the principles of Science DMZ (100Gb/s network speed at nodes, connection of important research data sources and e-INFRA.CZ services directly to the CESNET aggregation layer).
- CESNET's virtualisation platform has prepared for a major upgrade with a selection procedure for new hardware during 2023 that will expand capacity in early 2024. These are servers with 1TB RAM equipped with a combination of Xeon-Gold 6444Y (3.6GHz 16-core) and Xeon-Gold 6442Y (2.6GHz 24-core) Intel processors. This configuration allows support for single-threaded tasks and therefore better parameters for older software. The upgrade also includes brand new Fortigate IPS/IDS security features.

Development in the MetaCentre went in the following direction:

- In 2023 the MetaCentre launched a new and sophisticated questionnaire survey among users and scientific groups. Given the link with annual reports and account renewals, it achieved very good participation and received valuable feedback.
- New GUI access services. A new version of the Open OnDemand web portal, support for OIDC and a range of new features including enhanced data transfer support.
- Development of the Galaxy platform and the usegalaxy.cz service for managing scientific workflows, working with data and the entire process of preparing and evaluating calculations.
- In cooperation with CERIT-SC, a new generation of Open-Stack cloud middleware distribution was completed and tested in cooperation with IT4I by implementing a new cloud environment using IT4I resources.
- Launch of the new managed Kubernetes service, which is provided as an extension of the cloud environment.
- The next step in improving the cybersecurity parameters of MetaCentre in the form of penetration tests and follow-up measures. Modernisation of the work node (new OS), optimisation of operating parameters and power consumption, and modernisation and upgrading of the network connection in Plzeň.
- In 2023 the core of the grid computing environment, the PBS computational task scheduler, was upgraded. This will further unify and simplify user access to computing resources.

DEMANDING COMPUTATIONS

MetaCentre projects and collaborations:

- In cooperation with the Data Storage Department, the MetaCentre is gradually deepening its support for object-based storage in the computing environment.
- The computing infrastructure is actively cooperating in the implementation of the Open Science concept, specifically by being responsible for the preparation of the key activity linking the NRP (National Repository Platform) and computing capacity in the upcoming project for the OP JAK Open Science call 1.
- Preparation and acquisition of new international projects (GreenDIGIT, ENVRHI-hub NEXT, EOSC Beyond) and a role in the successful consortium that participated in the EOSC procurement procedure. Successful completion of the C-SCALE and EGI-ACE projects.
- The range of new and innovative services is complemented by a full spectrum of support for users and research groups. One particularly important event was the organisation of the Grid Computing Workshop 2023. We are continuously installing new software versions and developing a system of modules to simplify and automate work with different software versions and their combinations. The popular Singularity tool remains an important component for running containers within the batch system.
- As a result of the integration work and a significant step for users, the MetaCentre has prepared new MetaCentre documentation connected with e-INFRA.CZ (<https://docs.e-infra.cz>). The documentation maintains the opportunity for community input and reflects comments and findings from the user needs survey.
- In connection with the installation of the cloud environment in Ostrava, the MetaCentre used the advanced services of the CESNET network for optimised and secure connection of the cloud environment instances in Brno and Ostrava.
- As part of the cooperation of e-INFRA.CZ computing environments, the MetaCentre has expanded and improved its range of commercial software; a notable new feature is the availability of the full portfolio of Matlab and Simulink toolboxes.

DATA REPOSITORIES

Map of data repositories



DATA REPOSITORIES

The infrastructure of object-based data repositories for unstructured data was expanded by two new systems - at Mendel University in Brno and at ELI ERIC in Dolní Břežany. Users of hierarchical storage in Ostrava, which is planned to be shut down in early 2024, were moved to these systems.

In addition to equipment purchases, attention was turned to continuity of operations, development of services and international cooperation, and support of application communities. All storage services, i.e., access to file systems and object-based storage, as well as tools for data transfer and for synchronisation and sharing, are in operation.

The international projects CS3MESH4EOSC and DICE have been successfully completed. The former created a prototype infrastructure for easy establishment of trust between users of sync'n'share systems. The DICE project provided storage capacity to the international community.

The role of data storage for unstructured data has shifted towards storage of voluminous data for computations, for which standard disk arrays directly attached to compute clusters are insufficient. Data repositories will increasingly take over the role of archival repositories.

Data repositories were very heavily involved in the implementation of EOSC in the Czech Republic. Work was carried out on the overall architecture of the data repository system,

which is directly reflected in the upcoming National Repository Platform project. This will support the creation of a high-capacity, metadata-rich data repository environment for storing data from the broader scientific community in the spirit of FAIR principles. Although repositories are today understood mainly as repositories for archiving scientific data, the repository infrastructure will not only be an archive, but will also be prepared for active work with data.

While the National Repository Platform consortium project was in the preparation phase, the six-year IPs EOSC-CZ project started in 2023. Within the framework of the project, components of the National Data Infrastructure forming the basis of the National Repository Platform were being prepared. Most of these systems represent the technical foundation of the infrastructure, and will rather be hidden from users. The visible output (to be launched in spring 2024) will be the National Metadata Directory, which will aggregate metadata from repositories both from the National Repository Platform and its surroundings, and will therefore serve as a central search point for scientific datasets in the Czech Republic.

CESNET E-INFRASTRUCTURE SECURITY

Since 2018 CESNET has held internationally recognised certification of its information security management system (ISMS) in accordance with technical standard ČSN EN ISO/IEC 27001:2014, which specifies requirements for information security management systems within an organisation's activities and provided services with the aim of eliminating the risks of loss of data availability, confidentiality and integrity.

In the field of security incident prevention and facilities for efficient handling of identified security incidents, an important component consists in technology complexes for **backbone network monitoring, security event and incident detection, and sharing such information through the FTAS, G3, Warden and Mentat services**. All of those systems were under continuous development, which reflected requirements both of the association as the e-infrastructure operator and of users (members and subscribers). All systems are still proving to be stable and useful projects that have potential to serve, among other things, as means for fulfilling requirements imposed by the Cyber Security Act (CSA) on either CESNET or connected institutions that are subject to the CSA.

Security services (**Operations Centre**) continue to be developed in 2023, and several CSIRT working group meetings have been held to address operations and security issues. A new service called Phishingator has been launched to conduct mock preventive phishing campaigns.

The CESNET Forensic Laboratory (FLAB) handled **five penetration test contracts** in 2023 and conducted several Forensic Analysis training sessions.

The **Network and Services Security Workshop**, which focused on the operation and security of networks, services and internet applications, was also held.

For the occasion of Cybersecurity Month (October), FLAB prepared, as it does every year, **The Catch**, an educational competition in which over 520 contestants took part.

NETWORK IDENTITY

The purpose of authentication infrastructure services is to provide a trusted electronic identity and easy access to e-infrastructure services.

The infrastructure is based on eduID.cz, the Czech academic identity federation whose members use shared information about the identity of their users to facilitate their access to various network services. Every full member of the federation can have either or both of the following roles:

- An identity provider (IdP), who administers user names, passwords and other user data and makes selected information available to service providers.
- A service provider (SP), who runs a web application or network service and uses information about users' identity and other properties, if applicable, to control access to it.

There are currently 267 identity providers in the eduID.cz federation – 44 belong to universities, 49 to institutes of the Czech Academy of Sciences, 14 to hospitals, 112 to libraries and 34 to other institutions such as international research groups, museums, archives and regional authorities.

For members of the eduID.cz federation, federated authentication has been activated for the FABRIC, O'Reilly and SciFlow services. After the service update, federated authentication was reactivated at CEEOL. Following changes to DNNT, ScienceDirect, Elsevier, GENI, Ovid, JSTOR, and Science and Knovel, we have updated the eduID.cz manuals for these services. Changes that affect federated authentication are continually being made in web browsers. For that reason, in eduID.cz news we have issued information on the possibility of configuring Seamless Access after changes to Chrome. Pilot implementation of support for new REFEDS categories – Anonymous Access, Pseudonymous Access and Personalised Access – was successfully carried out at Tomáš Baťa University in Zlín as part of a project supported by the

CESNET Development Fund. Part of the project solution was to create documentation for the needs of eduID.cz. Documentation and pilot implementation as a use-case are used in eduID.cz according to the needs for use of new categories by eduID.cz members and for the needs of coordinating category support within the international federation eduGAIN.

The field of public key cryptography did not remain unchanged last year. We have started issuing the CESNET CA 4 certificate using federated registration for server certificates, so that it is now possible to apply for personal CESNET CA 4 certificates via the portal, and we have said goodbye to registration clerks. The new CESNET CA Root 2 signed using the SHA512 algorithm has been created, and we are currently waiting for its certification by the grid association EU-GridPMA. At the same time, we have also created a portal for issuing certificates for access to the CESNET internal network. With the arrival of the new eduVPN, we have discontinued use of the certification authority for OpenVPN. A new certification authority has been created for the eduroam project to meet the needs of the new national infrastructure. In the new version of the TCS portal, we have designed and implemented an API for communication with RemSig, so that it is now possible to request a personal TCS certificate from RemSig and to pool user certificates in one place in a virtual token. The new version of the TCS portal also performs a more thorough review of server certificate requests. So now the DNS checks the CAA record, the encryption keys used and the authentication status of the second-level domain. This makes it possible to reject an application that would then be rejected by the CA, unnecessarily prolonging the application and subsequent issue of a certificate. The deployment of the new version is also related to the upgrade of the framework version and the update of the operating system.

NETWORK IDENTITY

In the eduroam project, we have deployed a new version of the application `pokryti.eduroam.cz`, designed for administrators of participating organisations, which is used to mark locations covered by the eduroam wireless network. We have also modified monitoring, rewriting old parts, adding new checks, modifying dependencies and reducing the number of tests for more efficient running and faster response in the web interface for users. The new national infrastructure under preparation is in test mode and the documentation is being debugged. We are currently waiting for the final placement of the national RADIUS server in a geographically separated location to increase availability. The new infrastructure will operate in parallel with the old infrastructure after switching to production mode, so that the organisations involved can be migrated gradually according to their and our capacities. This avoids having to switch everything at once, which would be technically almost impossible. The old infrastructure will be switched off until all members have been switched over to the new infrastructure. The configuration generator for the national RADIUS has also been rewritten, which will make the automatic deployment of the new configuration, for example, when another organisation is connected, much faster. Last year, 21 new organisations joined eduroam, bringing the total to 542 realms.

When we moved our offices to the Telehouse building, we switched to 802.1x authentication for the local network. However, devices that do not support this protocol must be exempted from this rule. Since these devices are managed by other departments, we have developed a web application called Makovec, where the responsible persons can manage the devices without interacting with our department. This simplifies things considerably, and the devices can be operational immediately after registration.

The eIDAS service has continued in production mode, and other information systems (6 new systems, 26 in total) from 16 connected organisations (3 of them new) have gradually been connected to it. Virtual tokens for Windows and Linux have been joined by macOS, which was put into production at the end of the year. In 2023 the HSM equipment was refurbished as the old equipment was coming to the end of its support. Over the course of 2023, nearly 230,000 documents were signed or sealed (an increase of 160,000) and 173,000 qualified time stamps were issued (an increase of 141,000). In the same year, 816 valid qualified certificates (an increase of 301) and 28 qualified seals were managed.

816

**IN THE SAME YEAR, 816 VALID QUALIFIED
CERTIFICATES (AN INCREASE OF 301)
AND 28 QUALIFIED SEALS WERE MANAGED.**

AUTHENTICATION AND AUTHORISATION INFRASTRUCTURES (AAIS)

The Perun software system developed in-house and compliant with the international standard AARC Blueprint (Authentication and Authorisation for Research and Collaboration) is deployed and operated in production mode (24/7, 99.9% availability) for several international and national research infrastructures and for two universities.

In order of number of users, these are:

- MyAcademicID, including Erasmus+, a project for student mobility (myacademic-id.eu)
- Masaryk University in Brno (muni.cz)
- e-INFRA CZ / EOSC CZ (e-infra.cz)
- LifeScience Login for ELIXIR, GDI, BBMRI and EJP RD infrastructures (lifescience-ri.eu)
- GÉANT, a pan-European organisation linking national research and education networks (geant.org)
- Academy of Arts, Architecture and Design, Prague (umprum.cz)
- SURF, a Dutch national research and education network (surf.nl)
- MyAccessID, an association of supercomputing centres
- EGI – European Grid Infrastructure (egi.eu)
- Umbrellaid, a digital identity for photon and neutron users (umbrellaid.org)
- FENIX Research Infrastructure, an association of supercomputing centres (fenix-ri.eu)
- European Consortium for the Development of Fusion Energy (euro-fusion.org)
- eduTEAMS Service (eduteams.org)
- Integrated European Long-Term Ecosystem, critical zone and socio-ecological Research (eLTER, elter-ri.eu)

The Perun AAI system consists of two components:

- IdM – an Identity Management system providing login management, user account management, user data registration, user group creation, and authorisation data setting on managed computers
- Proxy IdP – a component linking user logins with identity providers from the Czech academic federation eduID.cz, the global inter-federation of research and educational organisations eduGAIN, and selected social accounts (Google, Microsoft, Apple, ORCID, GitHub) to web-based services

In 2023 there was a significant 68% increase in registered users of the AAI instance for MyAcademicID, from 197,620 users in January 2023 to 332,052 users in January 2024. The number of registered users of the LifeScience Login instance increased significantly by 36.6% to 17,641 users, the instance for Masaryk University by 10.5% to 170,669 users, and the instance for e-INFRA CZ by 8.7% to 102,909 users.

During 2023 a new instance of Perun AAI was added for the European eLTER environmental research infrastructure, with a view to use for other environmental research infrastructures.

The same year also saw the continued evolution of the use of Multi-Factor Authentication (MFA), which authenticates user ID by a separate independent means, typically using fingerprints, facial recognition, a hardware USB token, an unlocking gesture or a one-time OTP code. More detailed documentation on setting up and using MFA has been created, including a graphical interactive tool for selecting the most appropriate authentication method for a given user. The number of users with activated MFA in e-INFRA CZ increased 6 times in 2023.

During 2023 AAI's operational security was enhanced both by introducing centralised log storage to enable security analysis of log correlations from multiple machines, and by continuing to convert AAI instance management to automated management with Ansible.

In the area of new standards, work continued on the development of the GA4GH Passport standard for authentication and authorisation in genomic data processing. This standard has been in use since 2019 in the LifeScience Login instance for ELIXIR, and its intensive use is planned by the emerging GDI (European Genomic Data Infrastructure).

As part of the integration of services of the Czech national e-infrastructure e-INFRA CZ, the synchronisation of projects from IT4Innovations systems was added to the AAI operated by CESNET, which enabled the management of the new instance of the OpenStack cloud system in Ostrava using a single AAI.

USER COLLABORATION AND MULTIMEDIA

In 2023 we hosted 100,000 meetings for more than 600,000 users on our video conferencing infrastructure. Statistics show that hybrid and remote learning, which we have promoted extensively on our video-conferencing infrastructure in the past years, have been replaced by a return to face-to-face learning.

But users have clearly come to like the hybrid and remote ways of working. Compared to the time before the COVID-19 pandemic, even without the impact of remote and hybrid learning, we have seen a more than fifty-fold increase in traffic volume.

The CESNET Streaming service is showing a steady increase in user interest. In 2023 users viewed 3,000,000 streams. That equates to more than 750 TB of data streamed and a 50% rise in interest in streaming compared to 2022. Further expansion of video conferencing and streaming services is planned for 2024.

Our IP telephony service, through which we connect the traditional telephone exchanges of connected members and organisations, remains practically as popular as in previous years. Last year, our infrastructure once again handled 500,000 phone calls.

In 2023 we released a new version of the UltraGrid software tool for low latency, very high-quality video and audio transmissions. The development responds to current trends in the libraries used for working with graphics and video. Among other improvements, we have completed support for running UltraGrid on networks that implement network address translation (NAT).

COOPERATION WITH LARGE RESEARCH INFRASTRUCTURES

The CESNET e-Infrastructure is part of relevant European e-infrastructures, forming a communications and information environment for national large infrastructures in other scientific fields and facilitating their cooperation with their foreign partners:



GÉANT - the European backbone communications infrastructure ensures inter-connection of European national research and education networks and connection to similar infrastructures on other continents. CESNET is the national node of this infrastructure - a national network for research and education. Up until the end of 2024 collaboration within GÉANT is being funded through the **GN5-1** project, where CESNET is mainly involved in activities relating to the construction of specialised network environments (for example, for precise time and stable frequency transmission or QKD) and AAI issues.



ELIXIR is a European bioinformatics infrastructure that combines advanced computing environments, data resources and unique tools for the purposes of bioinformatics research across Europe. CESNET contributes to the development of the European infrastructure under the Technical Services activity of the ELIXIR Compute Platform, focusing on the establishment of a common framework for the provision of computing services and services related to data storage and to the building of the Life Science AAI. CESNET is also directly involved in national activities in this field - it is one of the founding members of the ELIXIR CZ infrastructure, which provides an advanced computing environment, data resources and unique tools to the bioinformatics science community in the Czech Republic and in Europe. CESNET is a direct participant in the project Czech National Infrastructure for Biological Data from the Large Research Infrastructure Projects programme, which ensures the operation of this infrastructure.



EGI.eu, the European infrastructure for distributed computing coordinates national activities for the implementation of grid technologies at European level. The members of this infrastructure particularly work together within the intentions of the EOSC-Future project and EGI-ACE programme H2020. CESNET's collaboration involves participating in all primary operational activities, ensuring the operation of the national EGI grid node and providing computing resources comprising both its own computing capacities and those of the Institute of Physics of the Czech Academy of Sciences. The capacities involved are also part of the MetaCentre and use its virtualised infrastructure. We continue to support the virtual ELIXIR (bioinformatics), Auger (cosmic rays), Belle (particle physics) and CTA (gamma astronomy) organisations, and directly support user groups from the Czech Republic interested in the use of the Pan-European grid. Focusing on specific needs of these groups and their international projects is a priority.



QUAPITAL is a Central European partnership for secure communications with quantum-level security and a QUAPITAL quantum internet. The initiative's goal is to build a quantum-compatible infrastructure interconnecting quantum experiments between various research facilities throughout Central Europe.



EOSC a. i. s. b. l. is an international association of institutions involved in the implementation of the European Open Science Cloud concept. Within this organisation, CESNET represents the Czech Republic as a 'mandated organisation'. CESNET representatives are also involved in specific working groups, namely 'AAI Architecture', 'Long-Term Data Preservation' and 'Financial Sustainability'.

COOPERATION WITH LARGE RESEARCH INFRASTRUCTURES

National large research infrastructures

In addition to the above-mentioned close collaboration with national e-infrastructures and participation in the ELIXIR CZ large infrastructure, CESNET also holds continuous negotiations with representatives of other large infrastructures, which are listed in the Roadmap of Large Research Infrastructures of the Czech Republic for 2023 to 2026, provides for their information and communications technology needs and offers collaboration in addressing them. Examples include:

- cooperation between the Institute of Molecular Genetics of the Czech Academy of Sciences and CESNET on the operation of the European Chemical Biology Database (ECBD),
- collaboration between e-INFRA CZ, ELIXIR CZ and EATRIS on procuring high-performance computer technology for the Institute of Molecular and Translational Medicine of the Faculty of Medicine and Dentistry of Palacký University in Olomouc.



EOSC

CESNET, as part of e-INFRA CZ, is involved in the **implementation of the Open Science concept in the Czech Republic**, the aim of which is to create a national data infrastructure as an environment for storage, accessibility and further work with FAIR (Findable, Accessible, Interoperable, Reusable) data in the Czech Republic.

The national data infrastructure includes a national repository platform, a metadata repository, disciplinary repositories and a national EOSC administrative office. In this concept, CESNET and e-INFRA CZ are expected to participate in the creation of the national repository platform and support for the national EOSC administrative office. The construction of the national data infrastructure is planned from the funds of the OP JAK programme.

At the beginning of the year, the e-INFRA CZ consortium started the implementation of the first of the projects called European Open Science Cloud Czech Republic, which aims to build a comprehensive common facility by the end of 2028, comprising an administrative office, a national metadata directory and a training centre. Following the call of the OP JAK Open Science I programme, we have also started to prepare the National Repository Platform project, which will lay the foundation of the data repository infrastructure for FAIR data in parallel with the EOSC-CZ project.

In connection with the launch of the EOSC-CZ project, we and our project partners organised a one-day meeting for the professional public, where the key activities of this project as well as the basic features of the project under preparation were presented.

RESEARCH, DEVELOPMENT AND INNOVATION

The development of CESNET e-infrastructure requires an innovative approach. That is why the association, in addition to building and operating its e-infrastructure, is also dedicated to research and development in the field of information and communications technology, most importantly in the areas specified below.

Optical transport systems

CESNET has long looked into the software management of optical networks, transfer of precise time and stable frequency, quantum transfer of cryptographic keys and use of optical networks as physical quantity sensors.

CESNET e-Infrastructure security

CESNET has long been committed to e-infrastructure 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. The association continues to develop its own **DDoS protector** system.

Network identity

In the field of identity management and access control, CESNET and Masaryk University jointly develop **Perun**, a system that enables organising users into virtual organisations and groups, allocating resources and controlling access to them.

New applications

CESNET is constantly looking for possible applications of its e-infrastructure in new fields such as medicine, culture or architecture. Research in the area includes the development of two platforms, a hardware platform named **MVTP** and a software platform named **UltraGrid** (in collaboration with Masaryk University), for working with high-definition video (up to 8K) while maintaining low latency. The Association is also heavily involved in the digitisation and presentation of cultural heritage objects and the internet of things.

PROJECTS UNDERTAKEN IN 2023

International projects

Acronym	Project name	Programme	Provider
Large infrastructures			
GN5-1	Research and Education Networking - GÉANT	Horizon Europe	EU
EOSC			
C-SCALE	Copernicus - eoSC AnaLytics Engine	H2020	EU
DICE	Data Infrastructure Capacity for EOSC	H2020	EU
EGI-ACE	EGI Advanced Computing for EOSC	H2020	EU
EOSC-FUTURE	EOSC-FUTURE	Horizon Europe	EU
EuroScienceGateway	leveraging the European compute infrastructures for data-intensive research guided by FAIR principles	Horizon Europe	EU
GraspOS	GraspOS: next Generation Research Assessment to Promote Open Science	Horizon Europe	EU
Cybersecurity			
PRIVILEGE	PRIVacy and homomorphIc encryption for artificial intelliGencE	H2020	European Defence Agency
SECRET	Secure and Industrialized Quantum Key Distribution for European Telecom Networks	Digital Europe	EU
SOCCER	Developing and deploying SOC capabilities for the academic sector - a teamwork of Universities and RTOs in the CEE region	DIGITAL JU SIMPLE	EU
Advanced technologies and applications			
GreenDIGIT	Greener Future Digital Research Infrastructures	Horizon Europe	EU
GREAT	The Green Deal Data Space Foundation and its Community of Practice	Digital Europe	EU
HPLT	High Performance Language Technologies	Horizon Europe	EU
interTwin	An interdisciplinary Digital Twin Engine for science	Horizon Europe	EU
SUBMERSE	SUBMarine cabLeS for ReSearch and Exploration	Horizon Europe	EU

PROJECTS UNDERTAKEN IN 2023

National Projects

Acronym	Project name	Programme	Provider
Large infrastructure			
e-INFRA CZ	e-infrastruktura CZ	Large Research Infrastructure Projects	MEYS
e-INFRAMod	e-INFRA CZ: Modernisation	OP VVV	MEYS
ELIXIR-CZ	Czech National Infrastructure for Biological Data	Large Research Infrastructure Projects	MEYS
EOSC			
EOSC-CZ	European Open Science Cloud Czech Republic	OP JAK	MEYS
Cybersecurity			
CYBYRTHREATS	CYBERTHREATS - Using artificial intelligence to defend against cyber attacks	Ambition	MO
CZQCI	Czech National Quantum Communication Infrastructure	Digital Europe	EU
DoSIX	Distributed DDoS Mitigation in a Critical Infrastructure Environment	SECTECH	MI CR
FETA	Flow-based Encrypted Traffic Analysis	IMPAKT 1	MI CR
FlowTest	FlowTest: Testing Network Monitoring Devices	SECTECH	MI CR
HALOGEN	Hardware acceleration of high-speed DPDK SmartNIC	TREND	TA CR
NeSPoQ	Network Cybersecurity in the Post-Quantum Era	IMPAKT 1	MI CR
NU-CRYPT	Quantum encrypted communication with enhanced physical layer security	OPSEC	MI CR
Advanced technologies and applications			
HFT	Acceleration platform for low-latency exchange trading	TREND	TA CR
JPEGXS	Equipment for Low-latency Transmissions of JPEG XS Video	TREND	TA CR
VR wardrobe	Virtual digital wardrobe	ÉTA	TA CR

We would like to thank all subsidy providers for funding the undertaking of projects.

Research and development outcomes

Research activities in 2023 resulted in 10 papers in peer-reviewed scientific journals, 25 papers in collections, 1 functional specimen, 9 pieces of software and 1 pilot test.

CESNET DEVELOPMENT FUND

Before the end of 2022, the Development Fund Board prepared and launched the first round of a selection procedure for projects for 2023. As well as full members of the Association, the selection procedure was also open to associate members.

The following topics were chosen in cooperation with the Association:

- Utilisation 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 utilising the CESNET e-infrastructure

A more detailed specification of the objectives and focus was provided in the text of the announcement.

The selection procedure saw the submission of 28 projects. Twenty of those projects were accepted for co-funding, including six projects admitted after revision. An overview of the projects accepted for undertaking is shown in the table below.

Project number	Project holder	Project name
717/2023	Technical University of Ostrava	Further development of the LoRaWAN experimental network using CESNET infrastructure
718/2023	Technical University of Liberec	Web application for accessing and managing CESNET S3 using federation identity, S3Point
720R1/2023	Masaryk University	Introduction of tools for processing logs of MU operational systems using the data lake in the CESNET infrastructure
721/2023	Masaryk University	Searching large sets of proteins based on the similarity of their structures built on a learned metric index
722/2023	Masaryk University	Applications for working with data across different storage services
724R1/2023	Masaryk University	Green computing in an academic data centre
725/2023	University of Pardubice	Possibilities for replacing Google Analytics with the Matomo tool in multi-tenant mode through a CESNET-operated service
726/2023	Czech Academy of Sciences	ENVision: a platform for analysing natural ecosystems using aerial and satellite data
727/2023	Masaryk University	Mapping performance and characteristics and performance portability on GPUs in the CESNET infrastructure
730R1/2023	Technical University of Ostrava	New applications using a 5G campus network with mmWave and CESNET infrastructure support
732/2023	Masaryk University	Long-term archiving and evaluation of IAM data
734/2023	University of West Bohemia	Storage, transfer and processing of large scientific research financial data in the e-INFRA CZ environment
736/2023	University of West Bohemia	Pilot verification of passwordless authentication in the environment of information systems of the University of West Bohemia
737/2023	Masaryk University	Tool for supporting cyber and information security management in an organisation
738/2023	Czech Academy of Sciences	Polarisation-independent detector for distribution and synchronisation of remote optical frequency sources
739R1/2023	Czech Academy of Sciences	Optical frequency transmission with induced phase noise suppression
740/2023	Silesian University	Astrophysical media database
742R1/2023	Tomáš Baťa University	LibKey integration for efficient delivery of electronic scientific articles to Tomáš Baťa University users
743/2023	Technical University of Ostrava	Study of service limit parameters on VHCN networks within the scope of the CESNET measurement polygon
744R1/2023	Masaryk University	Portal solution for managing life-science datasets and their metadata in the Onedata system

FOND ROZVOJE SDRUŽENÍ CESNET

The final opposition procedures of completed projects also took place in the course of 2023. In total, 24 projects were successfully completed. The Development Fund Board recommended that the findings and conclusions of some projects be presented at a suitable conference. At the same

time, it recommended supplementing the outputs of some projects so that they could be used by other members of the Association. Final reports for projects carried out under the CESNET Development Fund can be found on the Association's website at <https://fondrozvoje.cesnet.cz/zpravy.aspx>.

PUBLIC RELATIONS

In 2023 the Association continued its activities underlining its unique role as a scientific and research e-infrastructure in the Czech Republic. It also held events directed at the transfer of experience to the user community, professional and non-professional public. The Association prepared thematic seminars, conferences and workshops for academic and professional public.

In 2023 we had a total of 22 peer-to-peer opportunities with almost 4,000 attendees, who heard interesting information from our colleagues in 155 lectures at 15 locations in the Czech Republic over 710 hours!

We opened the year 2023 with our perennial star and most popular seminar – the Network and Service Security Seminar. In April we organised the traditional Grid Computing 2023 – MetaCentre Seminar, followed by the EOSC Seminar, where the main goal was to inform the scientific community about the key activities and direction of the IPs EOSC-CZ project. May was dedicated to Multimedia Services and their introduction, while in June the eighth IPv6 seminar was held. Training events and workshops were ongoing, ranging from Forensic Training and CESNET Days to the international CEF workshop. We were partners in many events – CSNOG 2023, Digital Science Week and Linux Days, where we and our colleagues from the consortium e-INFRA CZ prepared an interesting exhibition stand, met with numerous participants and discussed expert topics.

This year, we once again held the traditional CTF competition 'The Catch', which we organise as part of Safety Month. The 2023 winner was a player from Norway, who expanded the ranks of award-winning contestants from the Czech Republic, Slovakia and France. A total of 520 players took part.

We connected choirs by remote means as part of the SMART Gospel benefit concert. Thanks to our MVPT technology, we established a live connection between the choir in a church in Plzeň and artists at HAMU in Prague. For the first time, the church was connected by wireless technology without installing roof antennas.

In 2023 we celebrated a jubilee of the CESNET network. Reliable fast connectivity is essential for professional workplaces in an academic environment, and we have been providing it for 30 years. When we started out, 10 universities joined the network and it was a big step. CESNET now provides connectivity to dozens of universities and institutions at speeds that are 10 million times faster.

We continue to provide the latest news, present employee activities and achievements, and publish information on upcoming activities and other events on our website, our social media accounts and in our newsletter.

We manage the websites of Large Research Infrastructures of the Czech Republic and the e-INFRA CZ consortium.

Over the course of 2023 we published 12 press releases and made 253 media appearances.

4000

NUMBER OF PARTICIPANTS AT EVENTS

PUBLIC RELATIONS

Network
and Service
Security
Seminar



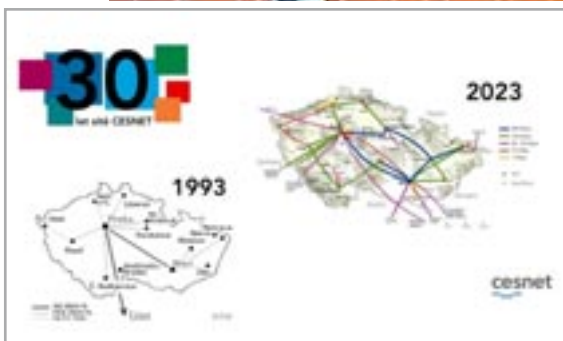
EOSC
Seminar

e-INFRA CZ at
Linux Days



SAGElab
during the Week
for Digital
Science.

Graphics
for the
CESNET
annual
network



Forensic
training

ECONOMIC RESULTS

FINANCIAL PERFORMANCE IN 2023

CESNET's activities are divided into two categories in accordance with its statutes: Principal activities and Supplementary (Economic) activities.

Principal activities

As part of its principal activities, the Association continued to build the qualitatively new CESNET e-infrastructure to provide a comprehensive set of services to Association members and other entities eligible for connection to the CESNET network.

The Association also participated in international research projects under the Horizon 2020 programme, Horizon Europe, national projects supported by the Ministry of Education, Youth and Sports, the Technology Agency of the Czech Republic, the Ministry of the Interior and the Ministry of Culture, and projects supported by the CESNET Development Fund Board, as already mentioned in the previous section of this Annual Report.

The Association's principal activities in 2023 resulted in an accounting loss of CZK 22,122,000 before tax. The Association's principal activities generated a revenue of CZK 791,217,000, while costs reached an amount of CZK 813,339,000.

The income tax base for principal activities in 2023 was negative, at a sum of CZK -15,090,000.

Economic activities

The Association's economic activities in 2023 consisted primarily in holding a prevalingly bond-based portfolio of the Development Fund Board, 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 2023 generated an accounting profit of CZK 31,057,000 before tax (CZK 28,003,000 after tax). The revenues of the Association's economic activities in 2023 amounted to CZK 177,751,000, while the costs amounted to CZK 149,748,000, including tax.

The income tax base of the Association's economic activities in 2023 was positive, amounting to CZK 31,123,000.

Total accounting and taxable profit

The total reported book value of the CESNET Association in 2023 was a profit of CZK 8,935,000 before tax.

The Association's total income tax base was CZK 16,031,000. The Association's total legal entity income tax for 2023 amounted to CZK 3,054,000, giving a profit of CZK 5,881,000 after tax.

Conclusion

In the past year the CESNET Association managed the entrusted funds responsibly and properly, meeting all of its obligations resulting from legislation, decisions of the Ministry of Education, Youth and Sports of the Czech Republic and concluded contracts.

BDO Audit s. r. o., an auditing company with its registered office at the address V Parku 2316/12, Prague 4, Chodov, Chamber of Auditors Authorisation No. 018, audited our financial statement.

The Auditor's Report, together with the Association's financial statement, forms part of this Annual Report.

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Prague 4, Chodov

148 00

Independent Auditor's Report**To the members of the CESNET Association, interest association of legal entities****Auditor's opinion**

We have conducted an audit of the Financial Statements of the CESNET Association, interest association of legal entities, with its registered office address: Generála Píky 430/26, Dejvice, 160 00 – Prague 6; Association ID Number: 638 39 172 (hereinafter referred to as the 'Association'), compiled based on Czech accounting regulations and consisting of a balance sheet as at 31 December 2023, a profit and loss statement for the period from 1 January 2023 to 31 December 2023, and annexes to these Financial Statements, which contain a description of the basic accounting methods used and other explanatory information.

In our opinion, the Financial Statements present a true and fair view of the Association's assets and liabilities as at 31 December 2023 and the expenses and revenues of its economic activities during the period between 1 January 2023 and 31 December 2023, in compliance with Czech accounting regulations.

Basis for the opinion

We conducted the audit in compliance with the Act on Auditors and the standards of the Chamber of Auditors of the Czech Republic for audit, which are International Standards for Audit (ISA), where appropriate supplemented and amended by the relevant application clauses. Our responsibilities established by these regulations are described in more detail in the Auditor's Responsibilities for Auditing the Financial Statements section. In compliance with the Act on Auditors and the Code of Ethics adopted by the Chamber of Auditors of the Czech Republic, we are independent of the Association, and we have also fulfilled other ethical obligations ensuing from the specified regulations. We believe that the audit evidence we have gathered provides a sufficient and suitable basis for expressing our opinion.

Other information presented in the Annual Report

In accordance with Section 2(b) of the Act on Auditors, other information presented in the Annual Report is outside the scope of the Financial Statements and our Auditor's Report. This information is the responsibility of the Association's Board of Directors.

Our opinion on the Financial Statements does not concern this other information. Nevertheless, a part of our obligations relating to the audit of the Financial Statements is to familiarise ourselves with the other information and to consider whether there are any significant discrepancies between this information and the Financial Statements or our knowledge of the accounting unit acquired while conducting the audit, or whether this information appears to be significantly inaccurate in other regards. We also assess whether this other information has been prepared in compliance with applicable legislation in all significant regards, especially whether the other information meets legal requirements for formal matters and the procedure for preparing other information in the context of significance, i.e., whether any failure to comply with these requirements could influence judgments made on the basis of the other information.

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Prague 4, Chodov

148 00

Based on the procedures performed, to the extent that we can judge, we report that:

- other information describing facts that are also presented in the Financial Statements are consistent with the Financial Statements in all significant regards,
- the other information has been prepared in compliance with the law.

We are further obliged, based on the knowledge and awareness of the Association that we have acquired while conducting the audit, whether the other information contains any significant misrepresentation of facts.

The procedures we performed when obtaining the other information did not identify any significant misrepresentation of facts.

Responsibility of the Association's Board of Directors and Supervisory Board for the Financial Statements

The Association's Board of Directors is responsible for compiling Financial Statements that provide a true and fair view in compliance with Czech accounting regulations, and with such an internal control system that it deems necessary for compiling Financial Statements that are free of any significant misrepresentations caused by error or fraud.

When compiling the Financial Statements, the Association's Board of Directors is responsible for assessing the Association's ability to continue as a going concern and, if relevant, to describe in the annex to the Financial Statements matters relating to its ability to continue as a going concern and use of the going concern assumption when compiling the Financial Statements, unless the Board of Directors either plans to liquidate the Association or to cease its activities, or has no realistic alternative but to do so.

The Supervisory Board is responsible for overseeing the Association's financial reporting process.

Responsibilities of the auditor for auditing the Financial Statements

Our objective is to obtain reasonable assurance that the Financial Statements as a whole are free of significant misrepresentations caused by error or fraud, and to issue an Auditor's Report which includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in compliance with the above-mentioned regulations will always detect any significant misrepresentations that may exist in the Financial Statements. Misrepresentations may be caused by error or fraud and are deemed significant if it can be realistically assumed that, individually or in aggregate, they could influence economical decisions that users of the Financial Statements make on their basis.

When conducting an audit in compliance with the abovementioned regulations, it is our responsibility to exercise professional judgment and to maintain professional scepticism throughout the audit. We are further obliged:

- to identify and assess the risk of significant misrepresentations in the Financial Statements caused by error or fraud, to propose and conduct audit procedures responding to those risks, and to obtain audit evidence that is sufficient and suitable for us to base our opinion upon.

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The risk of failing to detect a significant misrepresentation caused by fraud is greater than the risk of failing to detect a significant misrepresentation caused by error, as fraud may include collusion, falsification, intentional omissions, false declarations and circumvention of internal controls.

- to familiarise ourselves with the Association's internal control system relevant to the audit so that we may propose audit procedures that are suitable for the circumstances, but not in order to express an opinion on the effectiveness of the Association's internal control system.
- to assess the suitability of the accounting rules used, the reasonableness of the accounting estimates made and related information disclosed by the Association's Board of Directors in the annex to the Financial Statements.
- To assess the suitability of the Board of Directors' use of the going concern assumption when compiling the Financial Statements and, based the gathered audit evidence, whether there is a significant uncertainty ensuing from events or conditions that could cast significant doubt on the Association's ability to continue as a going concern. If we conclude that such a significant uncertainty exists, it is our duty to draw attention in our report to the relevant information provided in the annex to the Financial Statements or, if such information is insufficient, to express a modified opinion. Our conclusions regarding the ability of the Association to continue as a going concern are based on the evidence that we have gathered up until the date of our report. However, future events or conditions may cause the Association to lose its ability to continue as a going concern.
- to assess the overall presentation, structure and content of the Financial Statements, including the annex, and further whether the Financial Statements represent underlying transactions and events in a manner that presents a fair image.

It is our duty to inform the Board of Directors, among other things, about the planned scope and timing of the audit, and any significant findings that we make during the audit, including findings of any significant deficiencies in the internal control system.

In Prague, 30 May 2024

Auditing Company

BDO Audit s.r.o. [handwritten]

BDO Audit s.r.o.

Registration No.: 018

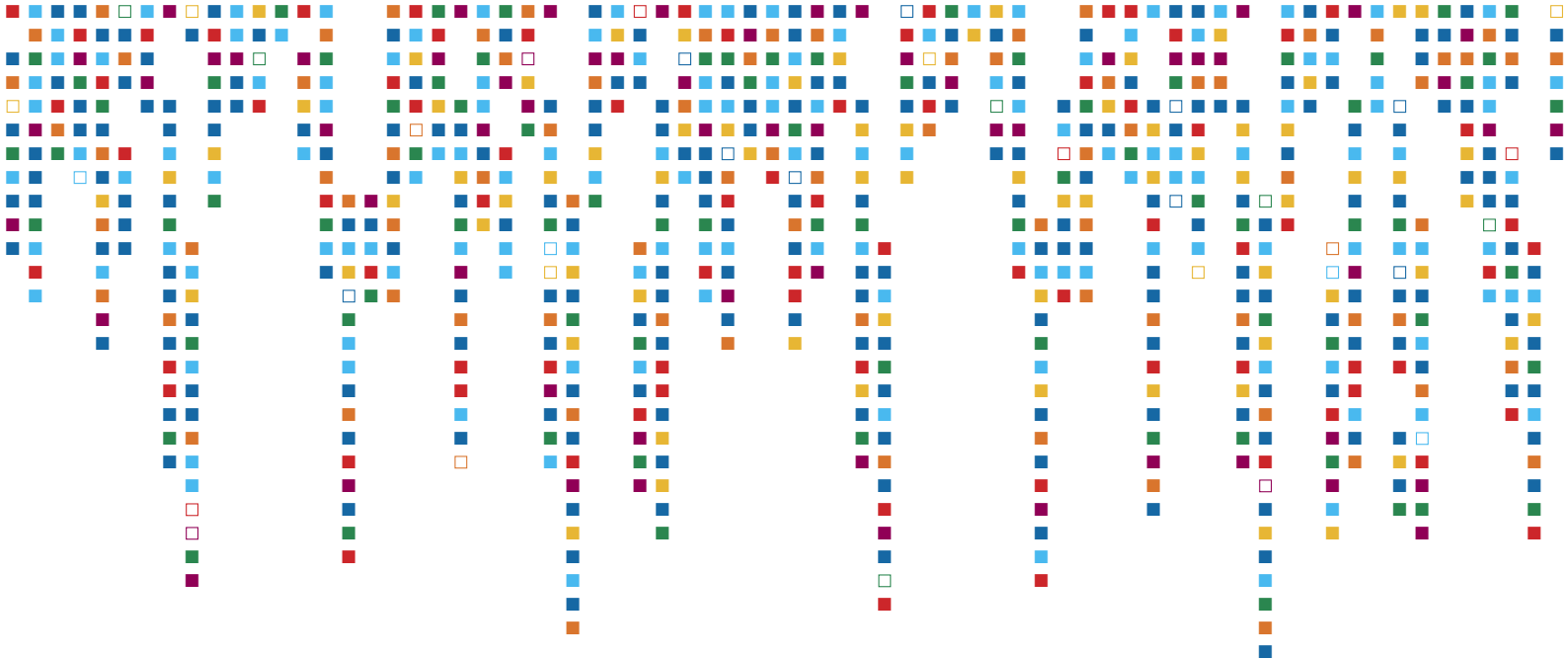
Statutory Auditor

[signature]

Ing. Ondřej Snejdar

Registration No.: 1987

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