Czech national e-infrastructure services for HEP

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Abstract. Czech e-infrastructure project e-INFRA CZ is the only project for ICT services defined on the Road Map of the Czech Republic for Large Infrastructures for Research, Experimental Development and Innovations. It was created by 3 national e-infrastructures: CESNET, CERIT-SC and IT4Innovations. The project provides ICT services mostly for Czech universities and research institutions. High energy physics projects belong to the most demanding users in terms of network, computing and storage capacities. We will describe usage of these three main categories for several HEP and astroparticle physics projects in which Czech institutions are involved. But not only these most visible services are provided. Other services like security CSIRT team, backup solutions, virtualization platform, identity management, Jupyter notebooks, electronic logbook and user support system are extensively used. Many concrete examples will be given on e-INFRA services usage by the Czech WLCG Tier-2 center. We will also present the important role of the e-INFRA project as a national coordinator of international activities in the grid computing (EGI), open science solutions (EOSC) or high-performance computing (EuroHPC).

1 Introduction

Modern scientific research relies extensively on cutting-edge ICT (Information and Communication Technology) infrastructure, high-performance computing, and the seamless integration and analysis of data. Universities and research institutions in the Czech Republic that are engaged in high-energy physics research have made significant investments in computing hardware and essential infrastructure to establish the WLCG Tier-2 center [1]. This distributed center not only caters to the needs of LHC projects but also extends its services to other HEP and astrophysics projects. However, the Tier-2 center's ability to provide these crucial services hinges on its robust internet connectivity with other WLCG centers.

2 Computing and storage services

2.1 IT4Innovations

The largest computing capacity in the Czech Republic is housed at the national supercomputing center IT4Innovations in Ostrava [6]. This center has been providing supercomputer

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capacities and related services to research teams, both Czech and foreign, primarily from academia, and to a lesser extent, the private sector since 2013.

IT4Innovations currently operates two mostly CPU-based supercomputers: Karolina, the Czech Republic's most powerful supercomputer (15.7 PFlop/s, installed in the summer of 2021), and Barbora (849 TFlop/s, installed in the autumn of 2019). In addition, they have a specialized GPU-based NVIDIA DGX-2 system for artificial intelligence computation (130 TFlop/s for general use and 2 PFlop/s for AI, installed in the spring of 2019), which is not utilized by the High Energy Physics (HEP) community.

Access to the Karolina and Barbora supercomputers is possible via Open Access Grant Competitions, organized three times a year. In the past, additional computing time could be obtained through Director's Discretion projects. For instance, we utilized the Director's Discretion project DD-xx during the early stages of the Karolina supercomputer when the user base was limited.

In August and September 2021, we had access to up to 80,000 computing cores out of a total of 92,160 cores. This contribution significantly boosted the overall computing capacity of the ATLAS experiment. In the 27th call in October 2022, we secured 200,000 node hours on Karolina, available for use in the first half of 2023. Our submission system, described in [2],[3], can efficiently handle a large number of concurrent jobs, enabling us to make the most of the allocated computer time within three months. An additional 100,000 node hours (50 % of the allocation) can be used for lower-priority jobs, and we also have the flexibility to use preemptive queues after the allocated time is exhausted.
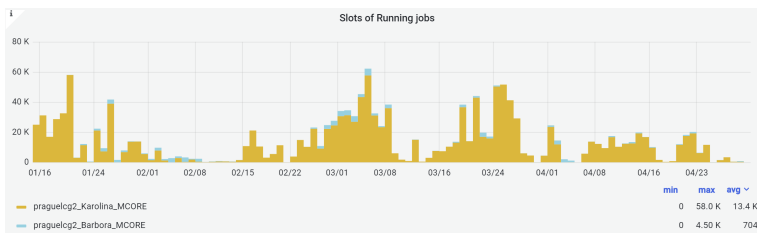

Figure 1. Slot of running ATLAS experiment jobs on IT4Innovations supercomputers Karolina and Barbora during first four months of 2023.

2.2 CERIT-SC and Metacentrum

The CESNET project Metacentrum has been operating a national distributed computing infrastructure since 1996. Currently, there are approximately 30,000 computing cores available across Metacentrum and shared CERIT-SC servers. Jobs submitted to the system are distributed by PBSPro servers, which employ a fairshare system. Initially, users are granted equal fairshare when their accounts are created, but their priorities gradually decrease as they consume more computing time. Users have the opportunity to increase their fairshare by registering publications that acknowledge the Metacentrum project, which is now a part of the larger e-INFRA CZ project. Both Metacentrum and CERIT-SC servers, integrated into PBSPro, operate on the Debian operating system, presently at version 11, running on bare metal.

The High Energy Physics (HEP) community does not utilize Metacentrum servers in PBSPro for bulk productions because it would either consume too many resources or the contribution would not be significant. Instead, these resources are made available to individual

users. Additionally, a separate computing cluster, along with attached storage, is connected to the EGI grid. This cluster provides substantial resources for the astroparticle physics project Pierre Auger Observatory and supports the entire Czech contribution to the BelleII grid computing resources.

CERIT-SC also operates a Kubernetes cluster. This cluster has made contributions to ATLAS simulations through the BOINC project known as ATLAS@Home [7].

3 Computing and storage services

Czech High Energy Physics projects rely on data services provided by the CESNET storage department [8] , which operates a distributed storage infrastructure across four locations within the Czech Republic. Two of these solutions utilize traditional disk arrays with RAID6 systems and POSIX file systems, while the other four installations employ CEPH technology.

The WLCG CZ Tier-2 center utilizes these capacities for remote backups of local users' home directories and several databases. In the past, we also employed a dCache server operated by CESNET to back up the ATLASLOCALGROUPDISK spacetoken. This spacetoken is used by local users to store the results of ATLAS analyses conducted on the grid. Currently, we are testing another solution based on a RADOS-exported block device mounted on a local dCache server.

4 Network

As the Czech National Research and Education Network (NREN), CESNET connects all Czech institutions involved in High Energy Physics (HEP) research. The Czech Tier-2 center is linked to CESNET via a dedicated direct 100 Gbps connection, which further connects to GEANT through a shared 100 Gbps link. This connection serves the LHCONE VPN [4] and experiences heavy usage, with occasional peaks reaching the full 100 Gbps capacity. In early April 2023, we recorded a data transfer of more than 1 PB in less than three days.
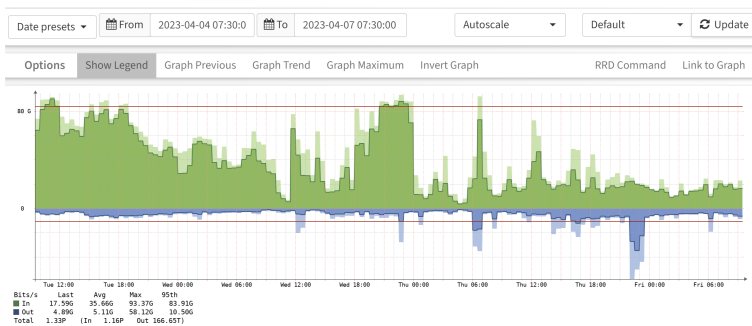

Figure 2. 1 Petabyte of data transferred to CZ Tier-2 via LHCONE link in less than 3 days

CESNET also provides links of sufficient capacities (10 – 30 Gbps) to other two locations of the distributed CZ Tier-2 centers.

5 Other services

A complex grid environment necessitates a multitude of services for operational and infrastructure monitoring. We employ the VMWARE virtualization platform to host redundant

VOMS servers, an electronic logbook to track operational events and issues, as well as alerts from the CSIRT team. Additionally, we utilize the Perun system for managing user identities, groups, and access to resources and services. This system is widely adopted by numerous projects at both national and international levels, with CESNET actively collaborating on its design and development.
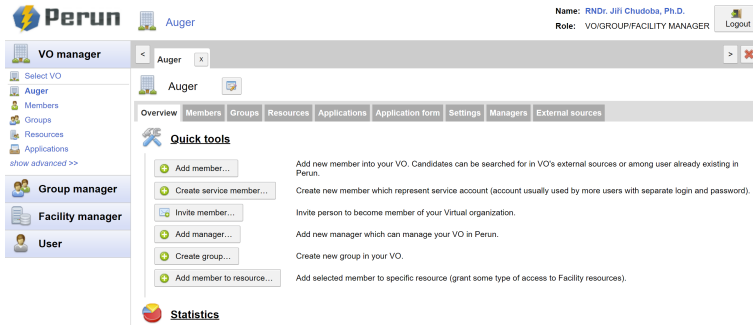

Figure 3. Perun provides AAI services for VOs managed by CZ groups

Metacentrum represents the Czech Republic in the European Grid Initiative project (EGI) and operates NGI services. IT4Innovations is a member of the European supercomputing infrastructure EuroHPC. All members of the e-INFRA project are active in preparation of the national response to the European Open Science Cloud (EOSC) initiative. HEP community also relies on services used by individual users. Among those quite often used we can name Filesender (a web service for the exchange of files between users), videoconferencing services (CESNET provides Zoom licences, Adobe Connect, solutions based on SIP and H.323 communication protocols), Request tracking system RT for user support.

6 Summary

The Czech national e-Infrastructure project, e-INFRA CZ, offers critical computing-related services for high-energy physics and astroparticle physics. The primary beneficiaries of these services include the LHC data experiment ALICE (currently uses only network) and ATLAS (uses network, CPU and disk space), as well as the Pierre Auger Observatory (uses all services). Without the dependable e-INFRA services, these projects would be unable to conduct data analyses within the Czech Republic.

7 Acknowledgments

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