Strategies of a WLCG Tier-2 site to meet the challenge of ever growing demands on delivery of computing resources

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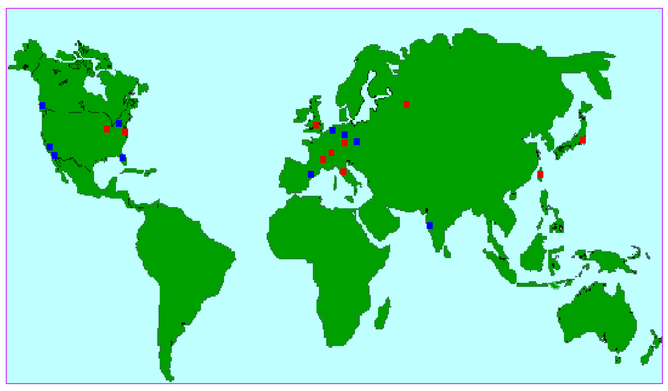
ABSTRACT: The current era of Exascale computing brings ever growing demands on the amount of available computing performance, storage capacity and network throughput. This affects also the massive computing infrastructure for management of data produced by the experiments at the LHC, the Worldwide LHC Computing Grid (WLCG). The standard financing used for many years enabling the resource growth of 10 - 20% is no more sufficient and to close the resource gap different methods are pursued. The sites involved in the WLCG are encouraged to find non-grid external resources to be used for WLCG tasks. Probably the most popular among them are High Performance Computing (HPC) Centers.
In this contribution, we present an overview of one of the WLCG sites, the distributed Tier-2 center in Prague, Czech Republic. It is a standard example of a WLCG medium size Tier-2 center concerning the hardware resources, site management and the network connections within the WLCG, so a general picture of a WLCG Tier-2 site is provided. In addition, our site complies with the current trends supported by the WLCG. First it is the use of resources of the external national HPC center in Ostrava and second providing resources not only for the LHC experiments but also other particle and astro-particle experiments. This way we follow the recently adopted strategy towards a sustainable and shared infrastructure adapted to the needs of large Exascale science projects. In addition, we make use of BOINC which provides some minor contribution to our resources.

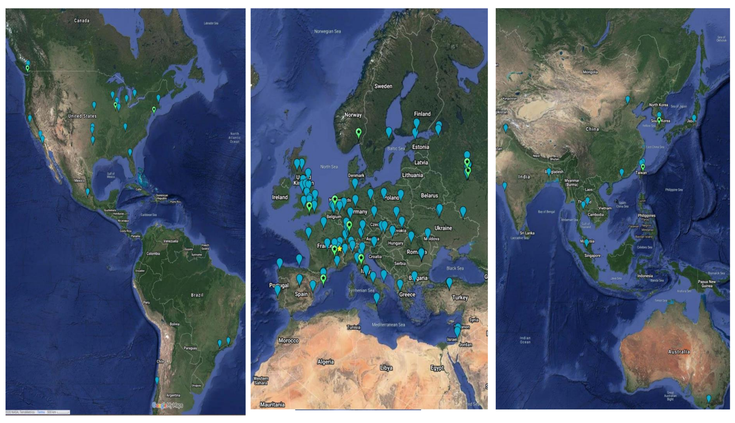
COMPUTING FOR LHC: the first considerations, 1995 - 2003

- The LHC construction had been approved in 1995, the first beams expected in 2005.
- Estimated requirements by the four experiments for LHC offline computing dramatically exceeded resources available at CERN.
- The LHC project budget had no line for computing at CERN.
- Most of the needed computing capacity must come from outside of CERN.
- Solution: The LHC Computing Grid project inspired by MONARC (1997).
- The project concept formulated in 2000 and finalized in 2001.

The first campaign: LCG-1 Service Opened
1st September 2003. Altogether 13 sites:
Taipei, Brookhaven, CERN, Bologna, Fermilab, Karlsruhe, Lyon, Budapest, Moscow, ***PRAGUE***, Barcelona, Rutherford UK, Tokyo

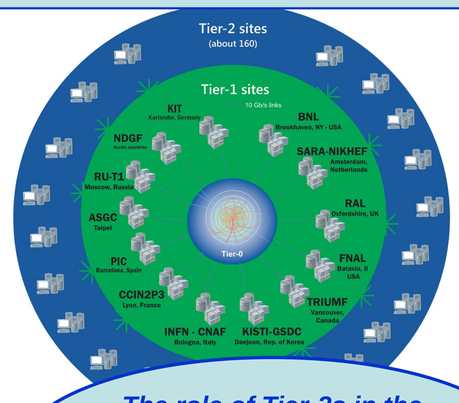


Worldwide LHC Computing Grid: since 2003



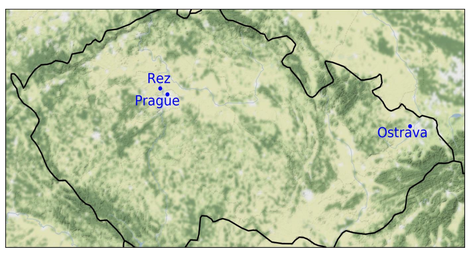
Ever since the start of the LHC operations in 2009, WLCG provides processing, management and storage of the LHC data.

The WLCG ecosystem consists of sites ranked as Tier-0, Tier-1 and Tier-2. Tier-0 is CERN, 14 Tier-1s are large computing centers and 146 Tier-2s are smaller size centers..

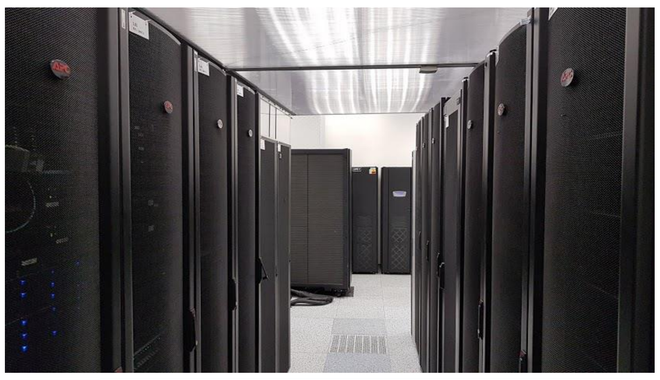


The role of Tier-2s in the WLCG ecosystem is crucial: they deliver resources same as Tier-1s.

CZ-Tier2: a distributed WLCG Tier-2 site in Czech Republic

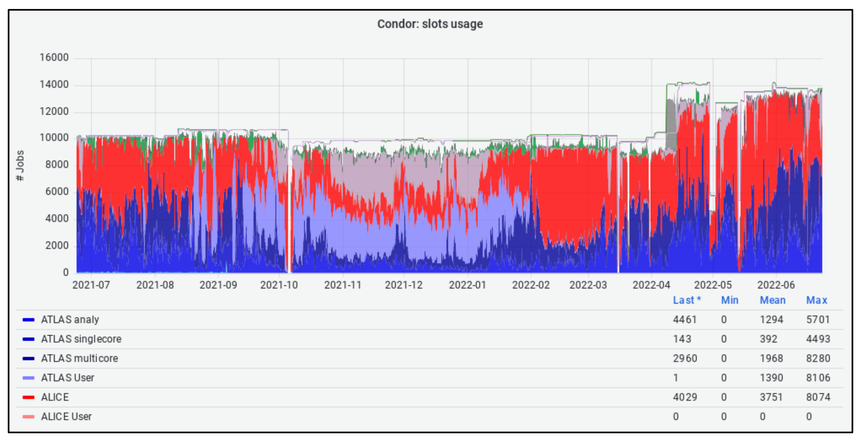


Map of locations of the individual sites contributing to CZ-Tier2 operations. Connectivity between sites is 10 Gb/s – 40 Gb/s. Connection to LHCONE is 100 Gb/s.

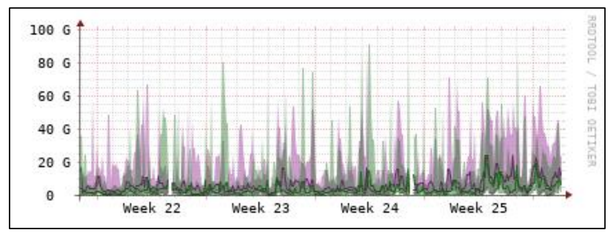


A look into the main site at the FZU in Prague

- **CZ-Tier2** was one of the first computing centers included in WLCG. Its operations started already in 2003 and have been running steadily ever since delivering services of ever-growing capacity.
- Currently CZ-Tier2 is a modest size Tier-2 site with distributed resources. The main part is installed at the Institute of Physics of the CAS (FZU) in Prague, additional resources are provided by two other institutions in Prague, by Nuclear Physics Institute of the CAS (NPI) in Rez near Prague and by the CESNET association and HPC center IT4I in the city of Ostrava (cf. the map).
-The complete stack of resources involves ~ 13,850 CPUs, 10.21 PBytes of disk space and network connectivity of the range between 10 Gb/s and 100 Gb/s.
-The compute, storage and data management services provided by CZ-Tier2 are used predominantly by ATLAS and ALICE @LHC but also by other HEP and astro-particle physics experiments.
- IPv6 is deployed at all disk servers and worker nodes

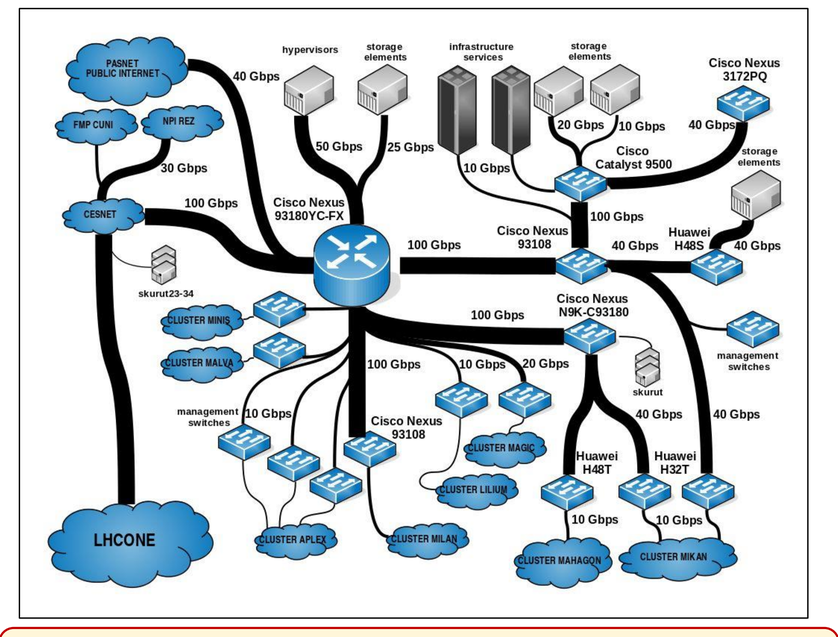


Running jobs profile for the last year provided by the local monitoring at the central site in Prague. Main CPU consumers are ALICE and ATLAS.

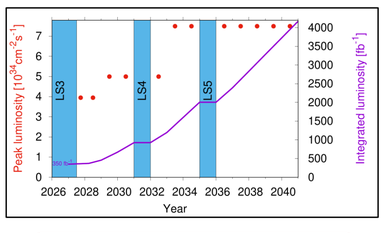


External network traffic from the main site via LHCONE link during June 2022. Maximum throughput reaches to 91 Gb/s, the nominal capacity is 100 Gb/s.

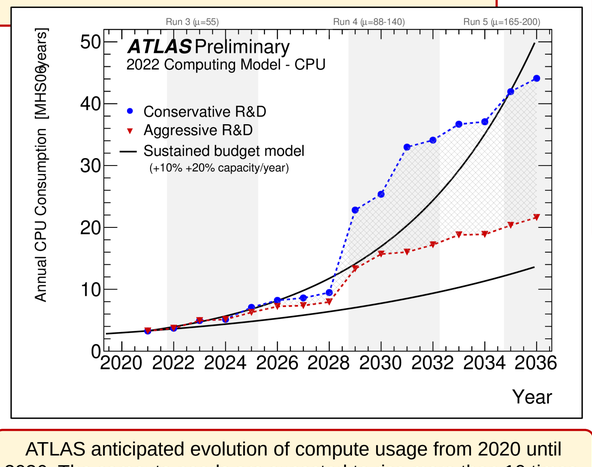
CZ Tier-2 : The preparations for the challenges of Run3, HL-LHC and beyond



Schema of the on-site network connectivity with the links to WAN. There are 100 Gb/s links on-site, 100 Gb/s to LHCONE and 40 Gb/s to the public internet. Upgrade of the link to LHCONE to 2*100 Gb/s is in preparation.



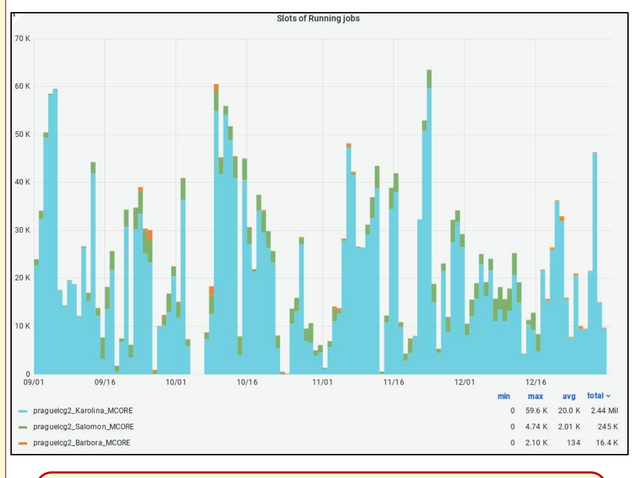
Prediction of the growth of LHC luminosity towards HL-LHC.



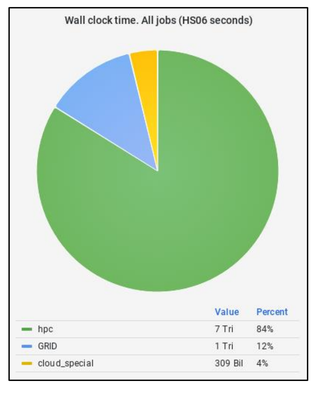
ATLAS anticipated evolution of compute usage from 2020 until 2036. The compute needs are expected to rise more than 10 times.

-The data volumes anticipated in HL-LHC time span will be dramatically larger than those currently managed, supposed to reach the multi-Exabyte scale.
-The estimated amount of resources needed for the management of this data will be about 10 times larger than allowed by the flat budget policy.
-In different strategy documents, a number of R&D projects is proposed that will contribute to the development of a high-performance ecosystem for HL-LHC.
-From the point of view of our Tier-2 site, some of developments are crucial.
-First, there is a need to upgrade the network throughput to allow for a smooth streaming of data for processing at different sites.
-Second, there is a **need for using external opportunistic resources especially HPC centers** to add up to the WLCG resources.
-And of course, a **steady growth of the on-site resources is mandatory**.

The Top500 supercomputer Karolina (IT4I, Czech Republic), acquired as part of the EuroHPC Joint Undertaking, installed in 2021.
Used by CZ-Tier2 as an external resource for the ATLAS experiment.



Slots of running ATLAS jobs at the HPC IT4I clusters Karolina, Salomon and Barbora via PRG Tier-2 center.
09/2021 – 12/2021



Contributions from the external resources to the praguelcg2 ATLAS operations in **2021: HPC: 84%,** Grid: 12%, BOINC: 4%. In **2020: HPC: 47%,** Grid: 52%, BONIC: 1%.

This work is supported by INTER-EXCELLENCE LTT17018 project Ministry of Education, Youth and Sports (MEYS) of the Czech Republic. The IT4I resources and outside network connectivity were supported through the project e-INFRA CZ (ID:90140) supported by the MEYS.