INFN-Cloud: a national distributed and federated cloud infrastructure supporting scientific communities

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On behalf of INFN DataCloud Team

Outline

- New PNRR projects supporting Italian Cloud infrastructure
- New planned investments
- HW Planned acquisition
- National Organization for INFN compute infrastructure
- Available services and foreseen developments

https://www.supercomputing-icsc.it/

Next Generation EU funds

191.5 B€ in Italy

- 30.88 B€ for research and education
  - 11.44 B€ "From research to business"
    - 1.6 B€ for R&D *Champions* in Key Technologies
      - **320 M€ for ICSC**
    - 1.58 B€ for Research Infrastructures
      - **41 M€ for TeRABIT**
    - ...

ICSC Working model

Networks of universities, research institutions, public and private entities aggregated in consortia in «HUB&SPOKE» mode

Started: September 2022

Hub & Spoke model

- Governance structure: Hub and Spokes
- Hub purpose: management and coordination
- Spokes purpose: CN activities execution (research, development, infrastructures and research material hosting, etc.).
- Spoke Leader/Co-Leader: lead the scientific activities coordination. The initial set of Spoke Leader e Co-leader will remain in charge for 4 years and each person could be nominated again only once

L'ICSC includes
10 thematic spokes
1 infrastructure spoke

0 SUPERCOMPUTING CLOUD INFRASTRUCTURE

High-level teams of experts integrating
the Spokes working groups (mixed cross-sectional teams)

ISTRUZIONE E FORMAZIONE, IMPRENDITORIALITÀ, TRASFERIMENTO DI CONOSCENZE, POLICY, OUTREACH

1 FUTURE HPC & BIG DATA

2 FUNDAMENTAL RESEARCH & SPACE ECONOMY

3 ASTROPHYSICS & COSMOS OBSERVATIONS

4 EARTH & CLIMATE

5 ENVIRONMENT & NATURAL DISASTERS

6 MULTISCALE MODELING & ENGINEERING APPLICATIONS

7 MATERIALS & MOLECULAR SCIENCES

8 IN-SILICO MEDICINE & OMICS DATA

9 DIGITAL SOCIETY & SMART CITIES

10 QUANTUM COMPUTING

ICSC founders: a public-private partnership

25
Universities

12
Research institutes

14
Strategic private companies

Public Research Institutions Founding members:

a widespread initiative throughout Italy

National institutes

INFN Istituto Nazionale di Fisica Nucleare
CINECA
ENEA
Consiglio Nazionale delle Ricerche
INAF Istituto Nazionale di Astrofisica
Istituto Nazionale di Geofisica e Vulcanologia
Consortium GARR

HUBs

UNIMORE Università degli Studi di Modena e Reggio Emilia
Università di Parma
OGS

Annual budget by partners:

6.325 M€

Private companies Founding members:
strategic players for digital transformation

Highly-qualified group of large leading companies covering most of the strategic industrial sectors involved by digital transformation in Italy

fondazione innovazione urbana

Strategic partner to implement and develop the digital twin pilot case of an urban complex system

iFAB INTERNATIONAL FOUNDATION BIG DATA & ARTIFICIAL INTELLIGENCE FOR HUMAN DEVELOPMENTE

Industry-driven not-for-profit international organization aimed at: (1) aggregating companies, including SMEs, to engage with ICSC through a structured partnership, (2) funding research and innovation projects, (3) promoting the Big Data Technopole

ICSC: resources to bring **Research results to Business**

1.500
Personnel shared by partners

320 M€
Total funds

32 M€
Innovation grant

250+
New researchers

250+
New PhDs

32 M€
Open call

Role of INFN and HEP

INFN has been chosen by the Italian Ministry for University and Research (MUR) for driving the preparation and execution of the ICSC project

Acknowledgement of the experience in computing technologies and Big Data in particular of **INFN** and **HEP** in general

Strategic partners for the Supercomputing Infrastructure Cloud:

- **CINECA** for HPC
- **GARR** for networks

INFN leading role also in spoke 2 and 3:

- Fundamental Research & Space Economy
- Astrophysics & Cosmos Observations

https://www.terabit-project.it/

TeRABIT: Terabit Network for Research and Academic Big Data in ITaly

TeRABIT is a Research Infrastructure project synergic with ICSC

Partners are the same of the ICSC Spoke-0 (Supercomputing Cloud Infrastructure):

INFN, CINECA and GARR

Covers areas complementary to those of the ICSC infrastructure

HPC

GPU Module Lisa
500 compute nodes
4x GPUs / node
>100 PF HPL
CPU Module Lisa
1000 compute nodes
2x CPUs + HBM / node
>6 PF HPL
Data Centric Module
1536 compute nodes
2x Intel SPR CPUs,
512 GB DDR5, NVM
9 PF HPL
Booster Module
3456 compute nodes
4x NVIDIA A100-64 GPUs
240 PF HPL
Low Latency Interconnect 400Gb/s
Low Latency Interconnect 200Gb/s
Storage Lisa data-lake Tier 100 PB
Storage Fast Tier 5.4 PB, 1.4 TB/s
Storage High performance Tier 106 PB, 620 GB/s
Front-end partition
Login nodes
Visualiz. nodes
Gateway 2.5 Tb/s
Ethernet Interconnect 400Gb/s
Facility distribution and routing
Internet and Geant
DC Casalecchio
Leonardo
Lisa
Ethernet
InfiniBand

CINECA

Network

GARR-T
Upgrade of the optical network centre-north OLS+DCI (100G+, 400G+)

ICSC
Upgrade of the GARR-X Progress network (OLS) upgrade (100G+, 400G+)

TeRABIT
Acquisition of optical fibre in Sardinia and interventions in souther

Consortium GARR

Big Data and Federated Cloud

INFN WLCG Tier-1 & Tier-2 infrastructure

- Currently about 100,000 CPU cores, 100 PB disk (net), 150 PB tape
- About 100,000 more CPU cores, 80 PB disk (net), >30 PB tape + a new library at CNAF
  - 30 M€ investment in ICSC
- HPC bubbles: HPC systems in a selected number of sites, equipped with CPUs, GPUs (Nvidia H100), FPGA, fast storage, Infiniband
  - ~10 M€ investment in TeRABIT

New data centres for Disaster Recovery (Gran Sasso) and Space Economy (Frascati)

- 9 M€ investment in ICSC

INFN
Istituto Nazionale di Fisica Nucleare

A *data lake for research* – High-level view

The proposed model is based on:

1. Existing infrastructures aggregation, upgraded and made available to scientific domains
2. A dynamic model, where infrastructures and domains can also be temporary
3. A clear separation between the physical and the logical levels
4. A high speed network interconnection to hide the actual resource locations
5. A unified vision (when needed) of an Italian research data-lake

INFN Cloud implementation

- The infrastructure is based on a core backbone connecting the large data centers of CNAF and Bari and on a set of loosely coupled distributed and federated sites connected to the backbone
  - backbone's sites are high speed connected and host the INFN Cloud core services.
- A site can join the INFN Cloud infrastructure accepting the Rules of Participation and after the approval of the INFN Cloud project management board.
  - Rules define access to resources and policies, according to INFN national and European laws.
- INFN Cloud's distributed organization provides support and management of both infrastructure and services.

Architectural key points

- Open source, vendor neutral architecture.
- Dynamic orchestration of federated resources
  - via the INDIGO PaaS Orchestrator across all participating Cloud infrastructures, according to agreed SLAs, hardware available, data location and Rules of Participation.
- Consistent authentication and authorization technologies and policies at all Cloud levels
  - via OAuth and OpenID-Connect, supporting also legacy AAI solutions, via INDIGO-IAM (Identity and Access Management).

INFN Cloud portfolio

- INFN Cloud helps researchers in their daily analysis work that requires ever more complex workflows and computing knowledge.
- It provides a customizable and extensible portfolio of services
  - computing and storage services spanning the IaaS, PaaS and SaaS layers, with dedicated solutions to serve special purposes, such as ISO-certified regions for the handling of sensitive data.
- Services are instantiated through TOSCA templates and implemented using the “lego-like” approach, building on top of reusable components.

The dynamic catalog of services

- From a simple VM to the setup of a complex platform configured for experiments.
  - INFN Cloud provides also some centrally managed services such as the Harbor open-source registry, S3 Object Storage and Notebook as a Service.

The dashboard

- Services can be deployed by users via the INFN Cloud easy-to-use web dashboard or via CLI.
- The dashboard hides to the final user all the details about infrastructure and resources allocation complexity. No knowledge about Tosca is required.

Dashboard https://my.cloud.infn.it/

The “Cloud-Data lake” model

- It is the evolution of the computing infrastructure for both Hep and not Hep experiments.
- Resources no longer provisioned only through dedicated grid sites
  - inclusion of HPC systems and commercial clouds as part of the resources we must be able to take advantage of
    - INFN already demonstrated the capability to execute LHC workflows on HPC systems (in particular @ CINECA) and on commercial clouds (e.g. ARUBA).
- Optimize storage access and management
  - reduce the number of replicas, few big sites high speed connected;
  - cpu and storage no longer coupled together;
  - deploy caches where needed.

INFN Cloud is the initial seed of a national data lake infrastructure for research and beyond. It also has a central role in the Italian National Recovery and Resilience Plan (PNRR) computing related initiatives.

EPIC Cloud

Enhanced Privacy and Compliance Cloud – The INFN Cloud partition for personal and confidential data processing

- The GDPR states that Clinical and medical data (for instance, genomic) is personal data; i.e., it fits in the Art.9 special categories of personal data.
  - Genomic data is mostly impossible to be anonymized → GDPR shall always be applied
  - ISO/IEC 27001 is the main certification mechanism compliant with GDPR requirements (Art. 43, 58, 63)
- In order to comply with the requirements of health research projects INFN is involved in, we created **a region of the INFN Cloud infrastructure**, applied specific organizational and technical security measures, and certified it ISO/IEC 27001, 27017, 27018.
  - This is **EPIC Cloud**: a reference Cloud implementation for the treatment of sensitive data at INFN.

From the Data Controller side, the fact that EPIC Cloud is ISO-certified is a way to demonstrate that processing is performed in accordance with the GDPR.

Terabit project will provide “HPC Bubbles”

- Founded on TERABIT PNRR project we will acquire HPC-Bubbles on several INFN data centers
- **CPU clusters:**
  - > 1.5TB / server
  - > 200 core / server)
  - InfiniBand Connected
- **CPU+GPU clusters:**
  - At least 4 x GPU [h100] / server
  - InfiniBand Connected
- **CPU+FPGA Clusters:**
  - 2 vendors FPGAs
  - FPGA-mesh
- **Fast storage Clusters**
  - > 1 PB ssd+hdd

- Services specification:
  - Perfectly integrated with **INFN-Cloud Services**
  - Connections among the **HPC Bubbles** (Virtual HPC Bubbles)
  - Connections among **HPC Bubbles and HPC traditional centres** (i.e. Leonardo, PRACE-Italy, VEGA and others)

The *continuum* from Edge, to Cloud, to HPC

The new INFN computing organization

- INFN decided to reorganize its computing management structure to better cope with these new challenges.

One of these WGs is the "infrastructure" WG, labeled DataCloud, responsible to manage and evolve the INFN distributed infrastructure and services.

DataCloud WG main activities

- Development, implementation and management of the INFN Cloud Data lake architecture.
  - Integration between the traditional WLCG Tiers infrastructure and the “Cloud Native” model represented by INFN Cloud.
  - Support to users and to the management and operation of INFN sites (Grid and Cloud).
  - Development of ISO-Certified solutions.
  - Prototyping, development and support of services starting from use cases.
  - Definition of sustainability models.
  - Cybersecurity: prevention, detection and management of security problems.
  - Taking in account legal and ethical requirements.

Thank you

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