INFN Cloud: an open, extensible, federated Cloud infrastructure and service portfolio targeted to scientific communities

ISGC 2022
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Background:
The main drivers for the next 10 years in scientific computing for INFN

• Infrastructure
  • Renew infrastructures to be ready for the High Luminosity-LHC (HL-LHC) era, up to ~2035 or more
  • Use more compact computing (from today’s ~20 kW/rack to 80 or more)
  • Lower the PUE (power usage effectiveness), be greener
  • Extend and expand networking for a future-proof infrastructure

• Hardware and Software
  • Foster the utilization of more viable technologies (Eur/task or J/task), like GPUs, FPGA, ... down to Quantum when available
  • Be more efficient, elastic and resilient
    • Pervasive use of geographically distributed storage (“the datalake”)
    • Abstract from physical machines, and form a national pool of virtualized resources and services (“the cloud”)
    • Extend elastically to external providers such as HPC@CINECA, or other cloud providers (“dynamic federations”)

INFN-Cloud @ ISGC 2022 - 25/3/2022
Davide Salomoni
Background: An history of collaborations

• The development of Scientific Computing within INFN was driven by the needs of its own theoretical and experimental communities; however, being at the forefront of computing in research seeded many projects with a much broader scope.
A long tradition in state-of-the-art distributed IT technologies and solutions, from the first small clusters to Grid and Cloud-based computing.

INFN is not interested in computing per-se, but as an essential way to support its research and mission.

INFN operates Grid and Cloud services based on its own:
- 9 medium size centers
- 1 large national center, at CNAF (Bologna) – with an area certified ISO/IEC 27001, 27017, 27018

All the INFN centers are connected through 10-100 Gbit/s dedicated links via the GARR network.

Collectively, our distributed infrastructure currently offers about 140,000 CPU cores, 120PB of enterprise-level disk space, 100PB of tape storage.
INFN Cloud, https://www.cloud.infn.it/

• The **starting point** for a National Datalake for research and beyond, building on (existing | renewed | new) e-Infrastructures.

• The **base of the evolution** of the INFN Distributed Computing vision.

• Built on a **thin middleware layer** running on top of federated clouds, decoupling physical and logical views via a **service composition** mechanism.

• In perspective, it will be the **Italian Node of the WLCG datalake** for HL-LHC.

• We mark these days **1y of production service.**
What it is

• A production-quality set of resources and solutions providing:
  • A **core backbone**, with ancillary and special-purpose services.
  • A **multi-site, federated Cloud infrastructure**.
    • INFN Cloud can transparently federate both INFN sites and public or private Clouds (e.g.: AWS, Google Compute Cloud, Microsoft Azure, and others)
  • A **customizable portfolio of services** accessible via web interfaces, terminal or API.
  • A **fully distributed organization for the support and management** of both infrastructure and services.
  • A set of **rules that define access resources and policies**, according to INFN, national and European laws.
Internal Organization

WP1
Operations, architecture & portfolio

WP2
Requirements, documentation & user support; communication & training

WP3
Monitoring, accounting

WP4
Security, policies and Rules of engagement

WP5
Evolution & new services

Feedback, new services

New requirements
Architectural pillar: the INDIGO PaaS

• The INDIGO-DataCloud PaaS is rooted on:
  1. A distributed resource orchestration framework
  2. A standard—based federated solution for identity access management (INDIGO-IAM)

• In practice:
  • Following authentication, a user requests a service via a Dashboard, APIs, or a CLI.
  • The PaaS Orchestrator is contacted, and a series of ancillary services get involved (e.g. AAI, SLA Manager, Provider Ranker, Monitoring).
  • A deployment of the required service is scheduled and eventually delivered on one of the federated resource providers.
  • All services are described through an Infrastructure as Code paradigm, via a combination of TOSCA templates (to model an application stack), Ansible roles (to manage the automated configuration of virtual environments), and Docker containers (to encapsulate high-level application software and runtime).
The INFN Cloud Backbone is a multi-site cloud infrastructure running both INFN Cloud Core Services and some user-level resources.

The topology of the INFN Cloud Backbone simplifies the implementation of geographic HA or failover for its Core Services.

The backbone infrastructure is managed by the INFN Cloud Team with extensive use of infrastructure automation tools.

Federated clouds connect directly to the backbone.
Excerpt from the INFN Cloud portfolio

In-memory data store: Redis

Secure storage: MinIO

Secure backup: TSM

PaaS Orchestrator: Indigo IM

Selectable storage QoS levels: fast (SSD), normal (HDD), archive (tape-backed), remote replicas
Training

- **Documentation**
  - https://www.cloud.infn.it/training/
  - "INFN Cloud Users and application" => https://l.infn.it/survey2021

- **Courses**
  - https://www.cloud.infn.it/training/

- **Webinar/mini-tutorials**
  - YouTube Channel
SaaS-level monitoring

- Docker-level Monitoring
- GPU-level Monitoring
- Host-level Monitoring
Status, Dashboards

Basic/Advanced per-service Configuration options

Per-user/per-group View of the main dashboard

Kubeapp-level Service dashboard

INFIN Cloud Status
This page shows the high level status of the INFIN Cloud services.

2022-03-25 → 2022-03-28 - Power shutdown @ CLOUD-VENETO
due to start in about 17 hours

1. INFN Cloud
- Object Storage
  - Operational
- Backbone - Cloud Compute (Bari)
  - Operational
- Backbone - Cloud Compute (CNAF)
  - Operational
- Authentication
  - Operational

2. Federated Cloud - Cloud@CNAF
- Cloud@CNAF - Cloud Compute
  - Operational

3. Federated Cloud - ReCaS-Bari
- RECAS-BARI - Cloud Compute
  - Operational

4. Federated Cloud - Cloud@CNAP
- Cloud@CNAP - Cloud Compute
  - Operational

5. Paas services
- Infrastructure Manager
  - Operational
- Orchestrator
  - Operational
- CPR
  - Operational
- CMDB
  - Operational
- Dashboard
  - Operational
INFN Cloud as federated datalake for health-related use cases

- Possible scenarios:
  1. Central harvesting of data collected remotely
  2. Local anonymization and central ingestion and analysis of data
  3. Local Feature Extraction and central ingestion and analysis of features
  4. Federated learning (training at local sites and algorithm publishing)


@ISGC2022, see also: D.Spiga, “Open-source and cloud-native solutions for managing and analyzing heterogeneous and sensitive clinical Data”
Toward the Future...
The “Big Data Valley”

• In 2017, Bologna won a bid to host the “European Centre for Medium-Range Weather Forecasts” (ECMWF)

• The Emilia-Romagna region decided to repurpose the “Manifattura Tabacchi *” area in Bologna to host a technology district, for ECMWF and more: the Tecnopolo

(*a former tobacco factory)
What will be at the Tecnopolo?

Each of the 6 “botti” (barrels) is ~5000m² of usable IT space.

Same architect and design of the “Sala Nervi” in the Vatican.

We estimate that the Tecnopolo will host about 80% of the Italian total computing power and a significant fraction of the European one.
The INFN + CINECA project

- ECMWF is running!

- The CINECA ("C2") and INFN ("B5") barrels are expected to be ready by
  - ~mid 2022 (CINECA)
  - ~first months of 2023 (INFN)

- Two phases expected
  - Phase-1 (2023-2025): Leonardo + T1-CNAF relocated. Total 13 MW
  - Phase-2 (2025+): infrastructure up to 24 MW ready for post-exascale and for HL-LHC

14 September 2021: new ECMWF data centre opens in Bologna, Italy
Cloud national infrastructure for supercomputing

Hub & Spoke organization:
10 vertical spokes for technology developments and software applications

400 M€ Total Budget
188 M€ Cloud Infrastructure
40 M€ Open Call
40 M€ Innovation & TT
42% Investment South Regions

34 MUR Universities
and Research institutions
15 Private Companies
1575 Researchers and Engineers
250 New Temporary positions
250 New PhD
40 % Female

Bologna Tecnopolo
The scientific domains

• 10 scientific domains have been chosen to represent top research activities which can benefit from state-of-the-art computing infrastructures.

• INFN leads or participates at the infrastructure level and in 4 scientific domains, fully aligned with its mission.
Conclusions

• **INFN Cloud** is at the basis of the INFN vision for the evolution of its computing infrastructure and expertise towards the challenges expected in the next 10+ years, covering HL-LHC and beyond, GW and Astroparticle experiments, and the many additional initiatives in line with its mission. Tecnopolo and ICSC are precious opportunities here.

• While doing so, INFN has the ambition to build and operate centers and services that serve much more than INFN use cases alone, becoming a central asset for research (base, applied and industrial) in Italy.