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Italiadomani
PIANO NAZIONALE DI RIPRESA E RESILIENZA

terabit

The INFN Cloud platform: state of the art and services implementation

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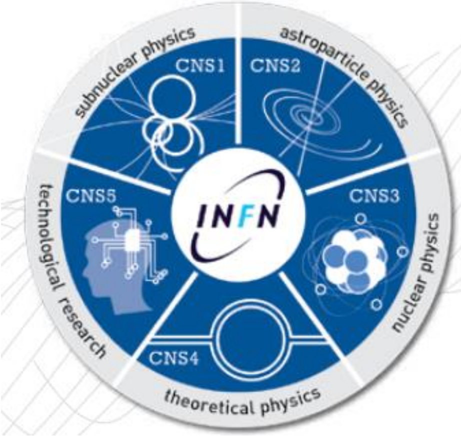
International Symposium on Grids & Clouds (ISGC) 2025 | 16-21 March 2025

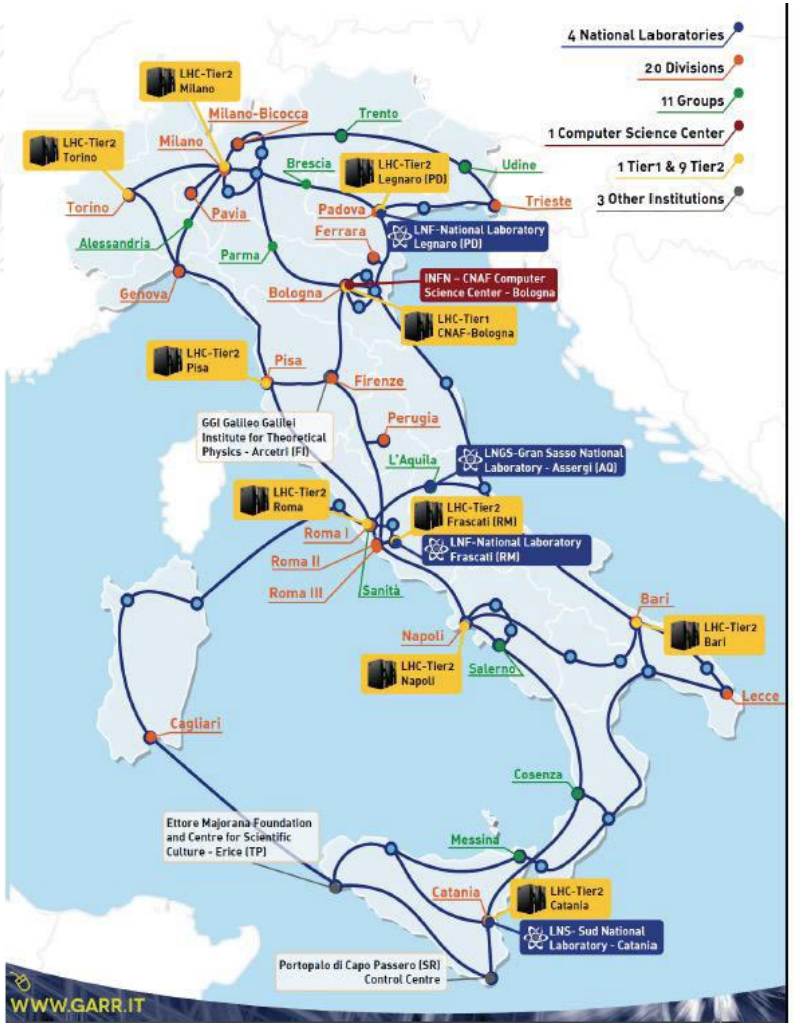
INFN and its facilities



- INFN is the coordinating institution for **nuclear, particle, theoretical, and astroparticle physics** in Italy. It promotes, coordinates, and carries out scientific research as well as the **technological development** necessary for the activities in these sectors

- INFN manages and supports the **largest public computing infrastructure for scientific research** spread throughout the country

- INFN was one of main promoters of the GRID project to address LHC computing needs. Since then INFN has been participating to **WLCG** that includes more than 170 sites around the world, loosely organized in a tiered model.
  - In Italy, there are the Tier-1 at CNAF, Bologna and 9 Tier-2 centers

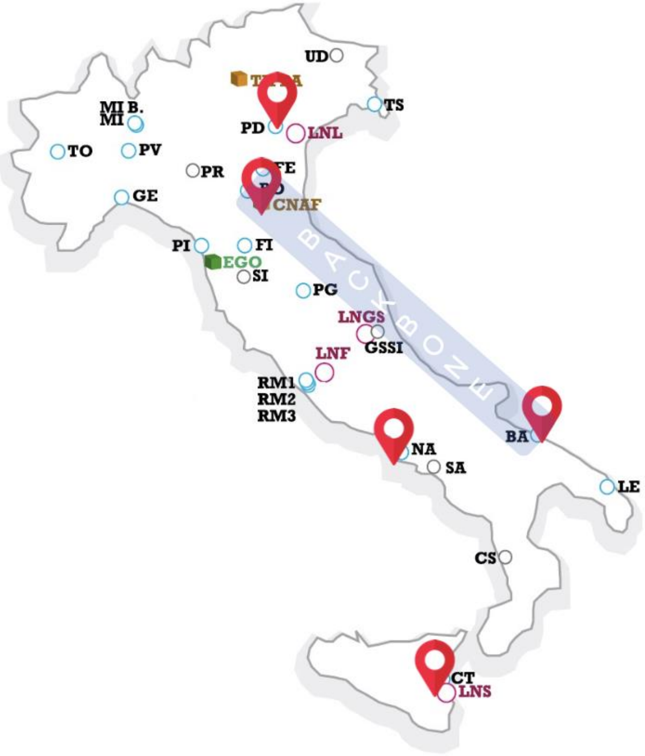


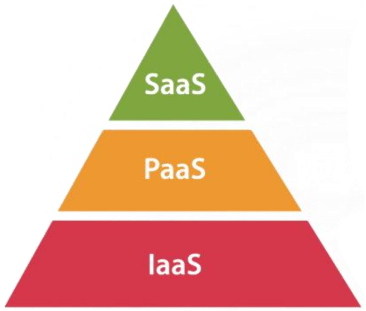
The INFN Cloud infrastructure

INFN decided to implement a **national Cloud computing infrastructure** for research

- as a **federation** of existing distributed infrastructures
- as an "user-centric" infrastructure which makes available to the final users a dynamic **set of services** tailored on specific use cases
- leveraging the outcomes of several national and European cloud projects where INFN actively participated, e.g. INDIGO DataCloud

INFN Cloud was officially made available to users in **March 2021**





e.g. Notebook as a Service

e.g. Virtual Machine, Docker compose

e.g. Start & Stop, Hostname choice

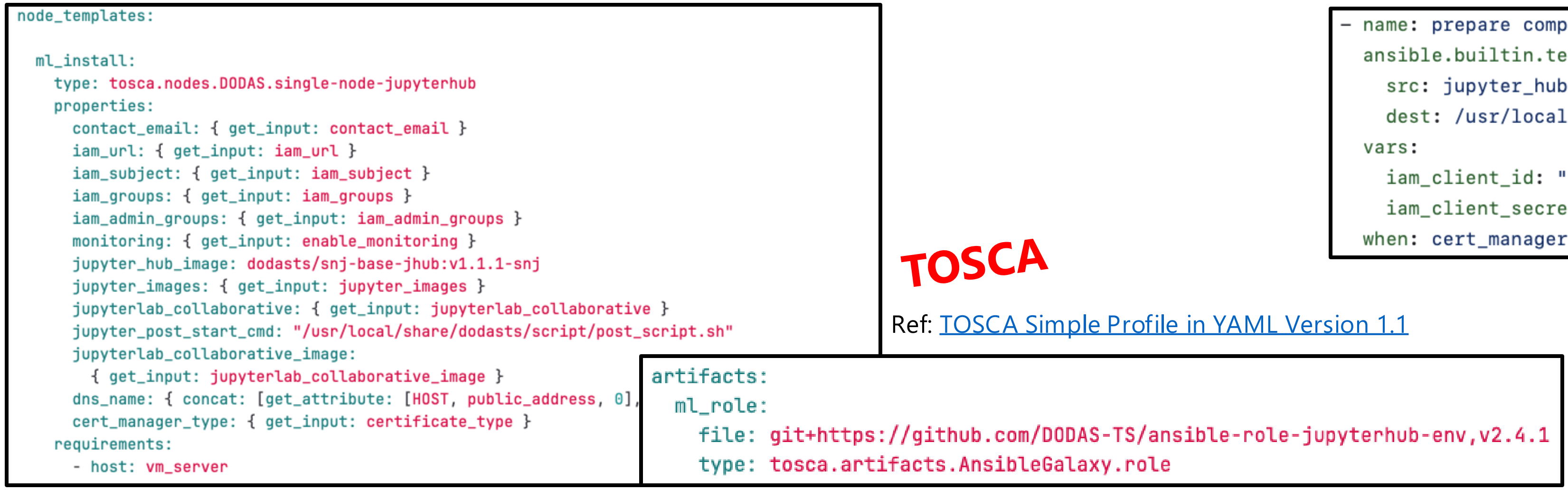
Backbone
~ 2000 vCPU
~ 15 TB RAM
~ 10 PB Storage (RAW)
~ 6% SSD

Federated Clouds
~ 3100 vCPU
~ 15 TB RAM
~ 400 TB Storage net

The Infrastructure as Code paradigm

All PaaS services are defined using an **Infrastructure as Code** paradigm, based on a procedural paradigm that aims to reduce manual processes and increase flexibility and portability across environments, via a combination of:

- **TOSCA** (**T**opology and **O**rchestration **S**pecification for **C**loud **A**pplications) templates, to model an application stack
- **Ansible** roles, to manage the automated configuration of virtual environments
- **Docker** containers, to encapsulate high-level application software and runtime
- **Helm** charts, to manage the deployment of an application in Kubernetes clusters



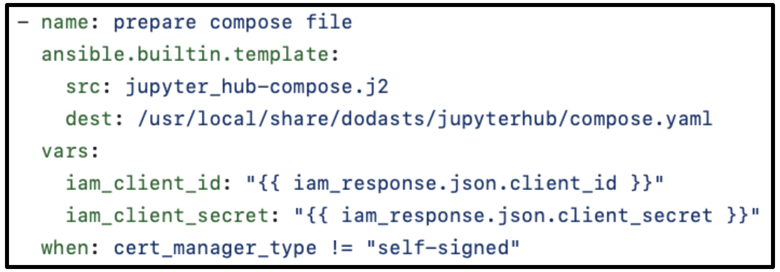
```yaml
node_templates:

  ml_install:
    type: tosca.nodes.DODAS.single-node-jupyterhub
    properties:
      contact_email: { get_input: contact_email }
      iam_url: { get_input: iam_url }
      iam_subject: { get_input: iam_subject }
      iam_groups: { get_input: iam_groups }
      iam_admin_groups: { get_input: iam_admin_groups }
      monitoring: { get_input: enable_monitoring }
      jupyter_hub_image: dodasts/snj-base-jhub:v1.1.1-snj
      jupyter_images: { get_input: jupyter_images }
      jupyterlab_collaborative: { get_input: jupyterlab_collaborative }
      jupyter_post_start_cmd: "/usr/local/share/dodasts/script/post_script.sh"
      jupyterlab_collaborative_image:
        { get_input: jupyterlab_collaborative_image }
      dns_name: { concat: [get_attribute: [HOST, public_address, 0],
      cert_manager_type: { get_input: certificate_type }
    requirements:
      - host: vm_server
```

```yaml
artifacts:
  ml_role:
    file: git+https://github.com/DODAS-TS/ansible-role-jupyterhub-env,v2.4.1
    type: tosca.artifacts.AnsibleGalaxy.role
```

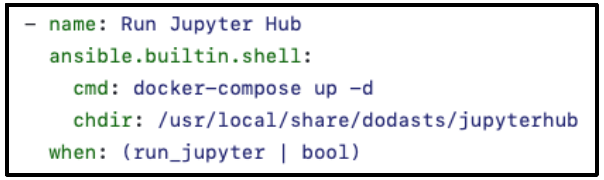
TOSCA

Ref: [TOSCA Simple Profile in YAML Version 1.1]



```yaml
- name: prepare compose file
  ansible.builtin.template:
    src: jupyter_hub-compose.j2
    dest: /usr/local/share/dodasts/jupyterhub/compose.yaml
  vars:
    iam_client_id: "{{ iam_response.json.client_id }}"
    iam_client_secret: "{{ iam_response.json.client_secret }}"
  when: cert_manager_type != "self-signed"
```

Ansible



```yaml
- name: Run Jupyter Hub
  ansible.builtin.shell:
    cmd: docker-compose up -d
    chdir: /usr/local/share/dodasts/jupyterhub
  when: (run_jupyter | bool)
```

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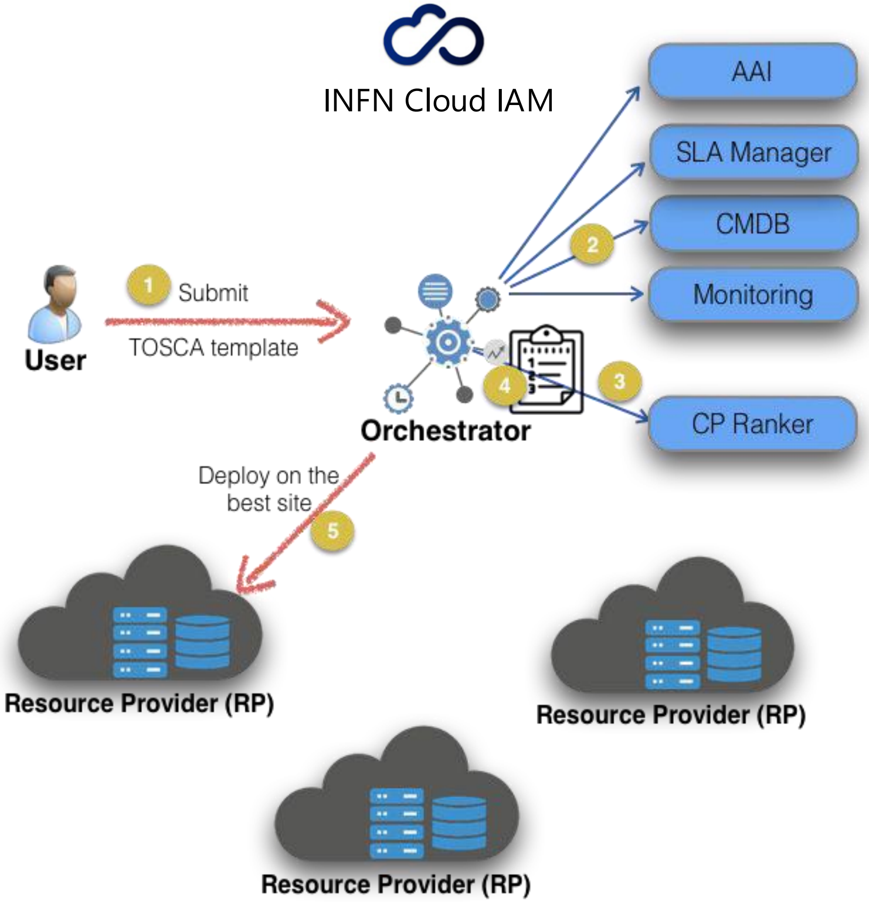
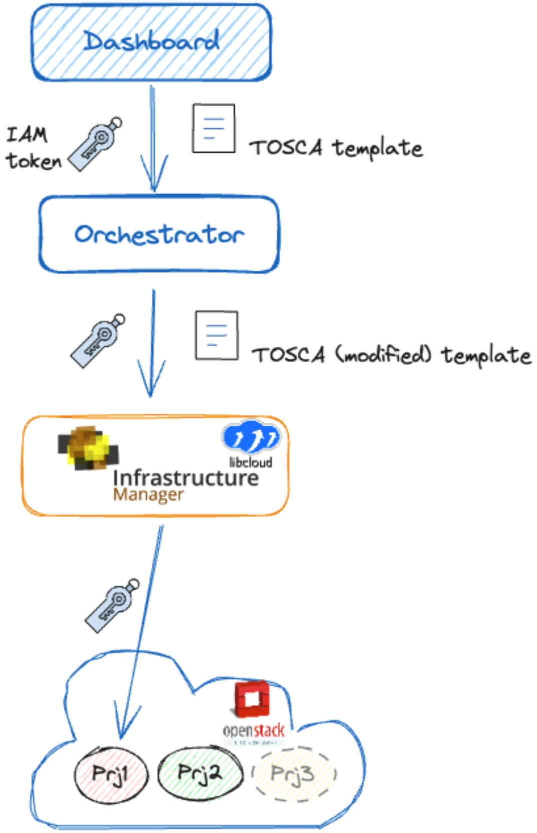
The INDIGO PaaS Orchestration system of INFN Cloud

The federative middleware of INFN Cloud is based on the **INDIGO PaaS orchestration system**, consisting of interconnected open-source microservices

- The **Orchestrator** receives high-level deployment requests in the form of TOSCA templates and coordinates the process of creating deployments
- The Orchestrator interacts with the provider services through the **Infrastructure Manager (IM)** for deploying complex and customized virtual infrastructures on the IaaS platforms made available by the federated providers (currently based on OpenStack)





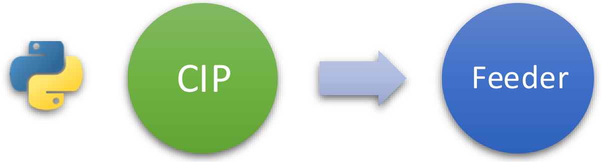
Introduction of the Federation Registry

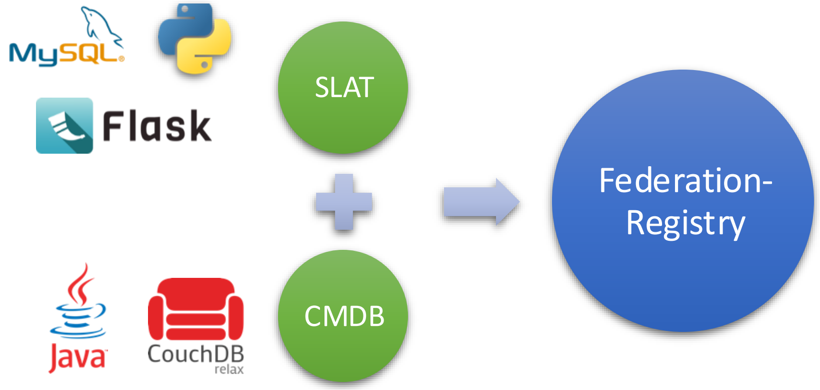
Federation Registry Feeder

- ➢ Written in Python
- ➢ Reads the configuration file of each provider
- ➢ Can use multiple IDP and through OIDC-agent retrieve the access token for the ops user
- ➢ For each project-region pair, it retrieves the available resources (flavors, images, networks, quotas and more) directly from the providers.
- ➢ Update the Federation Registry

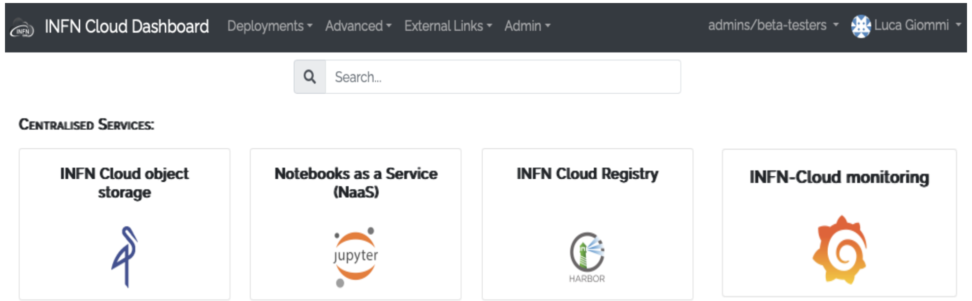
Federation Registry

- ➢ Written in Python
- ➢ Uses FastAPI for API definition
  - Automatic API documentation
- ➢ Uses the flaat library to secure the REST API. It uses OAuth for authentication and authorization
- ➢ Uses Neo4j as graph database
  - Efficient horizontal scaling to handle high-throughput and very large data sets





The PaaS Orchestrator Dashboard



CENTRALISED SERVICES:

INFN Cloud object storage

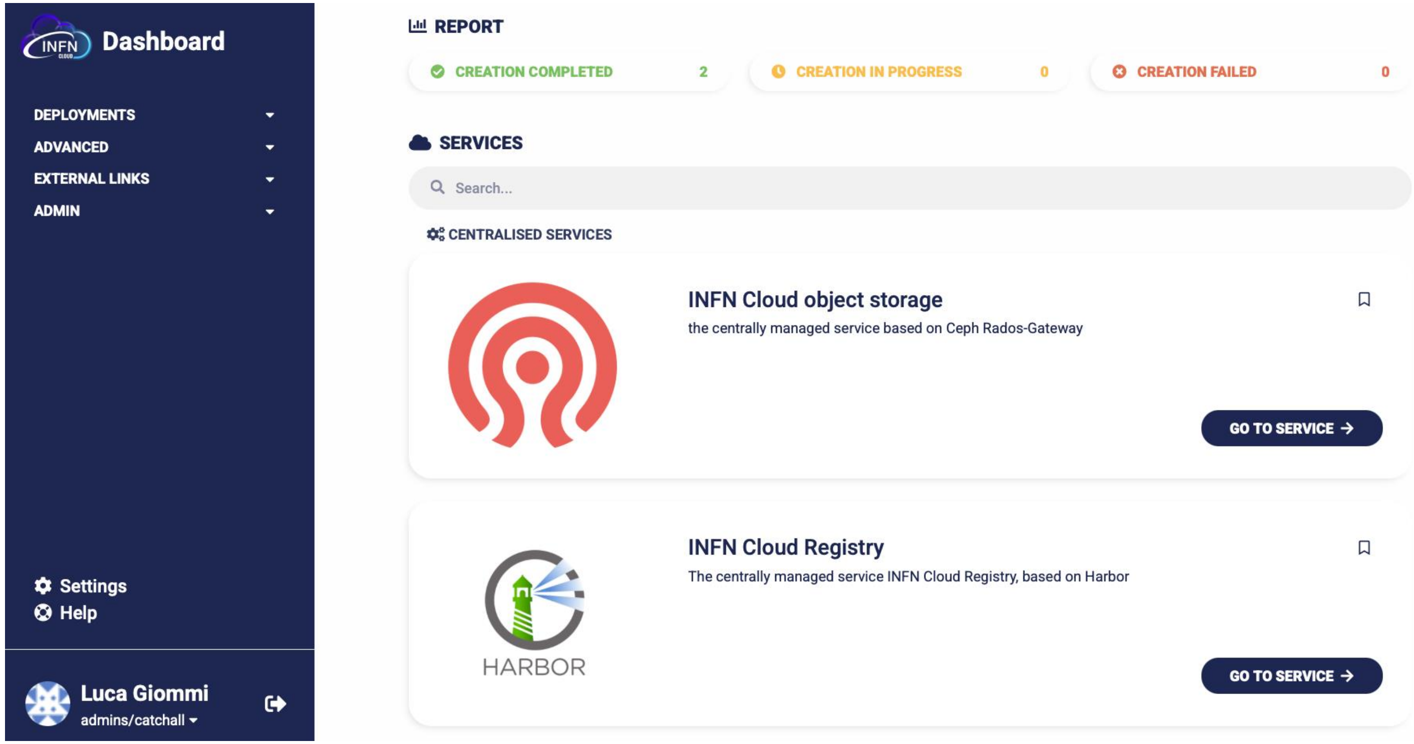
Notebooks as a Service (NaaS)

INFN Cloud Registry

INFN-Cloud monitoring

Old style

New style



REPORT

CREATION COMPLETED	CREATION IN PROGRESS	CREATION FAILED
2	0	0

SERVICES

CENTRALISED SERVICES

INFN Cloud object storage
the centrally managed service based on Ceph Rados-Gateway

INFN Cloud Registry
The centrally managed service INFN Cloud Registry, based on Harbor

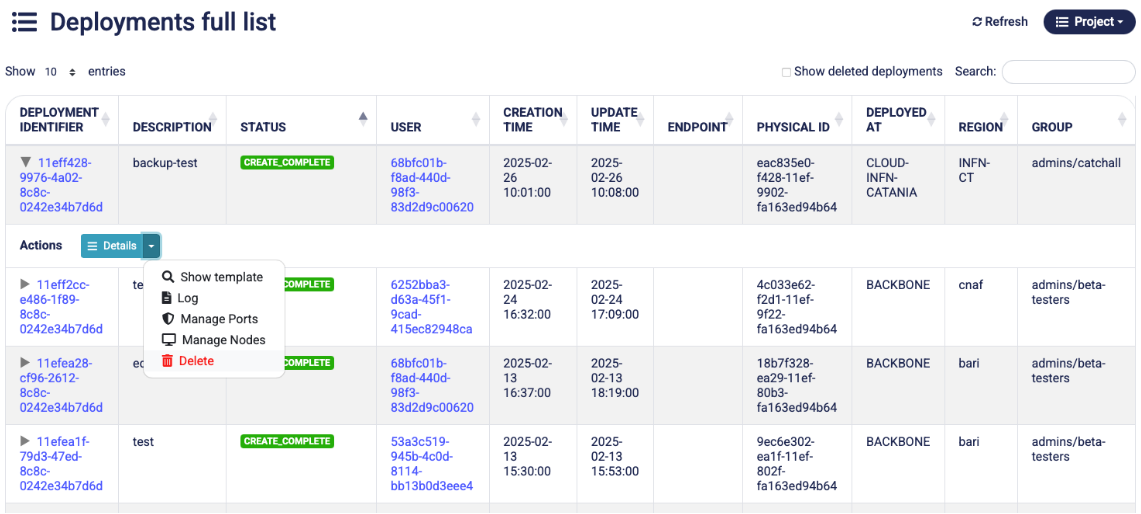
https://my.cloud.infn.it

Updates on the production services

- **Transition from SLAT + CMDB + CIP to Federation Registry + Feeder v1.0.1**
- **Orchestrator v4.0.1**
  - Integration with the Federation Registry
  - Dependencies moved to CNAF Nexus
- **Orchestrator Dashboard v4.3.0**
  - Integration with the Federation Registry
  - Fix for port management related to pre-configured rules
  - Reset of deployments in inconsistent states
  - Retry of failed deployments
  - Check on S3 bucket names
- **Tosca Templates v1.1.1**
  - Migration of PaaS services to Debian 12
  - Integration with the Federation Registry

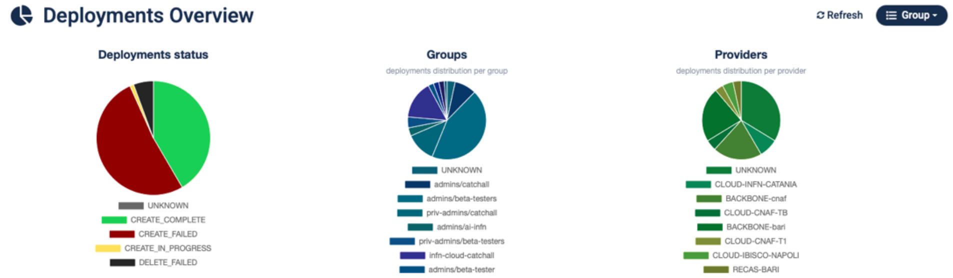
Updates and new features in testing phase

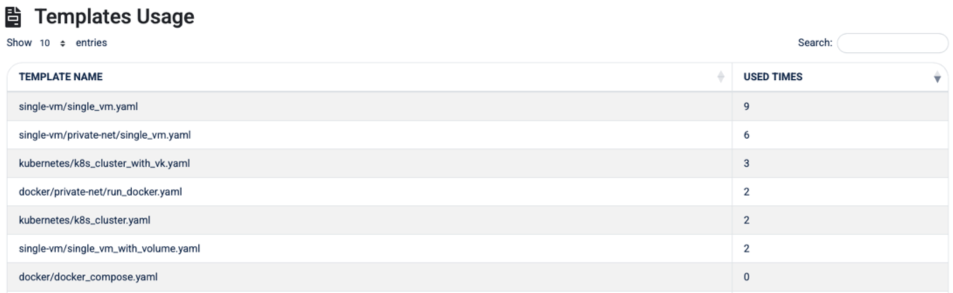
- Admins can access other users' deployments, view logs, and delete them if needed
- Admins can view the full list of deployments of all users
- Added *Usage statistics* section to see the deployments distribution by type, user group, and provider
- Lists of flavors/images that users can choose from are now retrieved from the providers, rather than being hardcoded
- Info about deleted deployments remains saved in the Dashboard DB



Deployments full list

DEPLOYMENT IDENTIFIER	DESCRIPTION	STATUS	USER	CREATION TIME	UPDATE TIME	ENDPOINT	PHYSICAL ID	DEPLOYED AT	REGION	GROUP
11eff428-9976-4a02-8c8c-0242e34b7d6d	backup-test	CREATE_COMPLETE	68bfc01b-f8ad-440d-98f3-83d2d9c00620	2025-02-26 10:01:00	2025-02-26 10:08:00		eac835e0-f428-11ef-9902-fa163ed94b64	CLOUD-INFN-CATANIA	INFN-CT	admins/catchall
11eff2cc-e486-1f89-8c8c-0242e34b7d6d	te	COMPLETE	6252bba3-d63a-45f1-9cad-415ec82948ca	2025-02-24 16:32:00	2025-02-24 17:09:00		4c033e62-f2d1-11ef-9f22-fa163ed94b64	BACKBONE	cnaf	admins/beta-testers
11efea28-cf96-2612-8c8c-0242e34b7d6d	ec	COMPLETE	68bfc01b-f8ad-440d-98f3-83d2d9c00620	2025-02-13 16:37:00	2025-02-13 18:19:00		18b7f328-ea29-11ef-80b3-fa163ed94b64	BACKBONE	bari	admins/beta-testers
11efea1f-79d3-47ed-8c8c-0242e34b7d6d	test	CREATE_COMPLETE	53a3c519-945b-4c0d-8114-bb13b0d3eee4	2025-02-13 15:30:00	2025-02-13 15:53:00		9ec6e302-ea1f-11ef-802f-fa163ed94b64	BACKBONE	bari	admins/beta-testers





Templates Usage

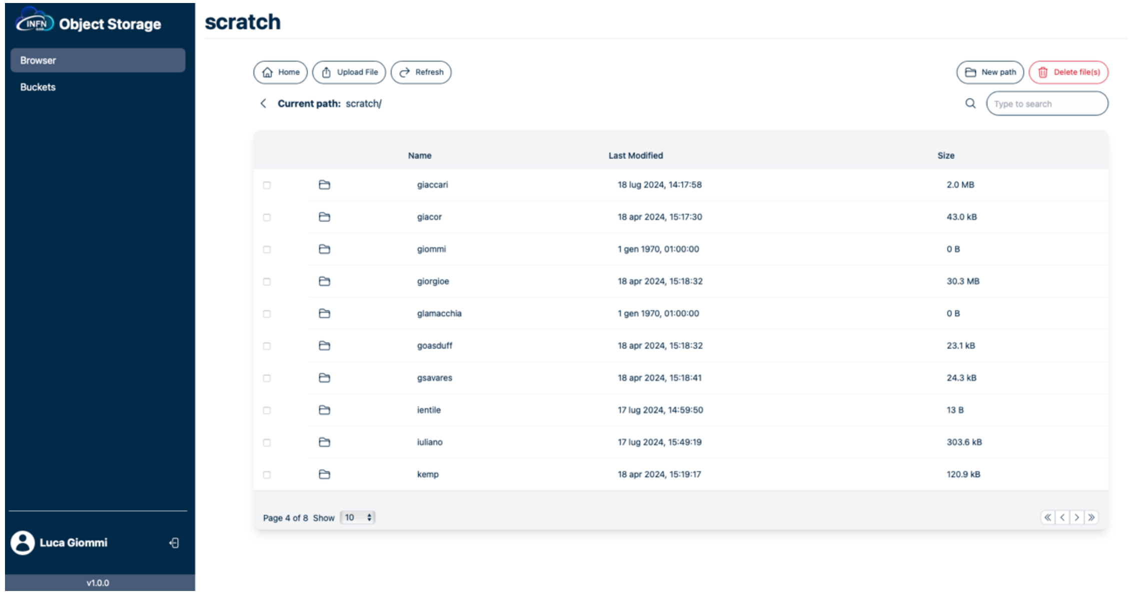
TEMPLATE NAME	USED TIMES
single-vm/single_vm.yaml	9
single-vm/private-net/single_vm.yaml	6
kubernetes/k8s_cluster_with_vk.yaml	3
docker/private-net/run_docker.yaml	2
kubernetes/k8s_cluster.yaml	2
single-vm/single_vm_with_volume.yaml	2
docker/docker_compose.yaml	0

Renovation of the S3 Web App for the Object Storage Service

- The object storage service of INFN Cloud is now based on **CEPH / Rados Gateway** (previously MinIO)
  - Uses Open Policy Agent (OPA) for fine-grained Authorization
  - Two zones (CNAF and Bari) with independent Ceph Storage Clusters
  - Three instances of RADOS Gateway run in high availability within each zone

- Developed a new version (v1.0.0) of the **Web App** used as a GUI for the Object Storage Service
  - Built on Next.js and React.js
  - OIDC protocol with IAM to generate Json Web Token (JWT)
  - Uses IAM Access Token to perform STS with RGW
  - S3 operations using AWS SDK library
  - New graphical UI to be consistent with other INFN web applications

https://s3webui.cloud.infn.it



scratch

Current path: scratch/

		Name	Last Modified	Size
□	🗀	giaccari	18 lug 2024, 14:17:58	2.0 MB
□	🗀	giacor	18 apr 2024, 15:17:30	43.0 kB
□	🗀	giommi	1 gen 1970, 01:00:00	0 B
□	🗀	giorgioe	18 apr 2024, 15:18:32	30.3 MB
□	🗀	glamacchia	1 gen 1970, 01:00:00	0 B
□	🗀	goasduff	18 apr 2024, 15:18:32	23.1 kB
□	🗀	gsavares	18 apr 2024, 15:18:41	24.3 kB
□	🗀	ientile	17 lug 2024, 14:59:50	13 B
□	🗀	iuliano	17 lug 2024, 15:49:19	303.6 kB
□	🗀	kemp	18 apr 2024, 15:19:17	120.9 kB

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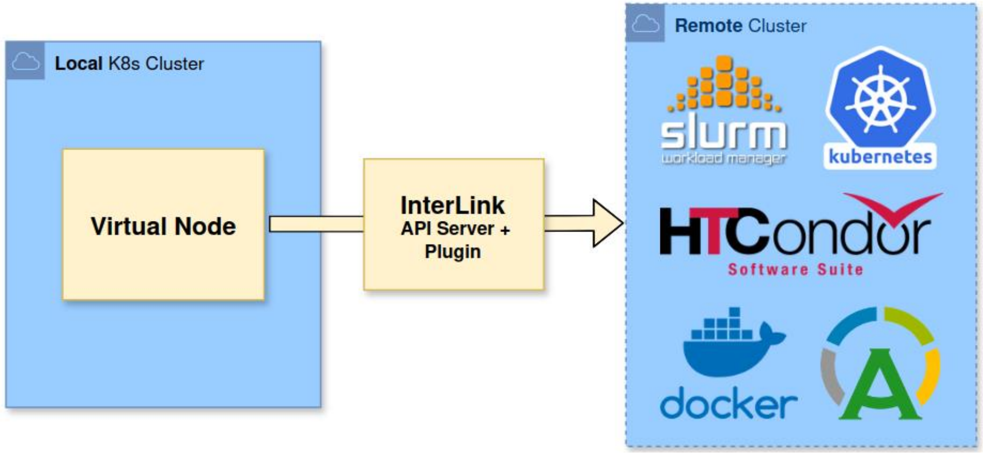
New PaaS service: Kubernetes cluster with an InterLink Virtual Node

- **It creates a Kubernetes Cluster that enables the transparent offloading of Kubernetes workloads to remote computation systems**
- It uses the interLink plugin developed within the interTwin project
  - **interTwin**: project funded by the EU for the development of an open-source platform, called Digital Twin Engine (DTE), to handle "digital twins" of selected scientific communities
  - **interLink**: allows transparent offloading of resources to heterogeneous computing providers

- Workload offloading
  - specify requirements, e.g. the number of GPUs
  - resources may not be available on the local cluster
  - workload can be opportunistically offloaded to a remote cluster where resources are available
- InterLink main components
  - **Virtual Node**: translate requests for a Kubernetes POD execution into a remote call to the InterLink API server.
  - **InterLink API Server**: a pluggable REST server that talks to the remote cluster



Thank you

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