Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
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ICSC Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

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Introduzione all'Offloading

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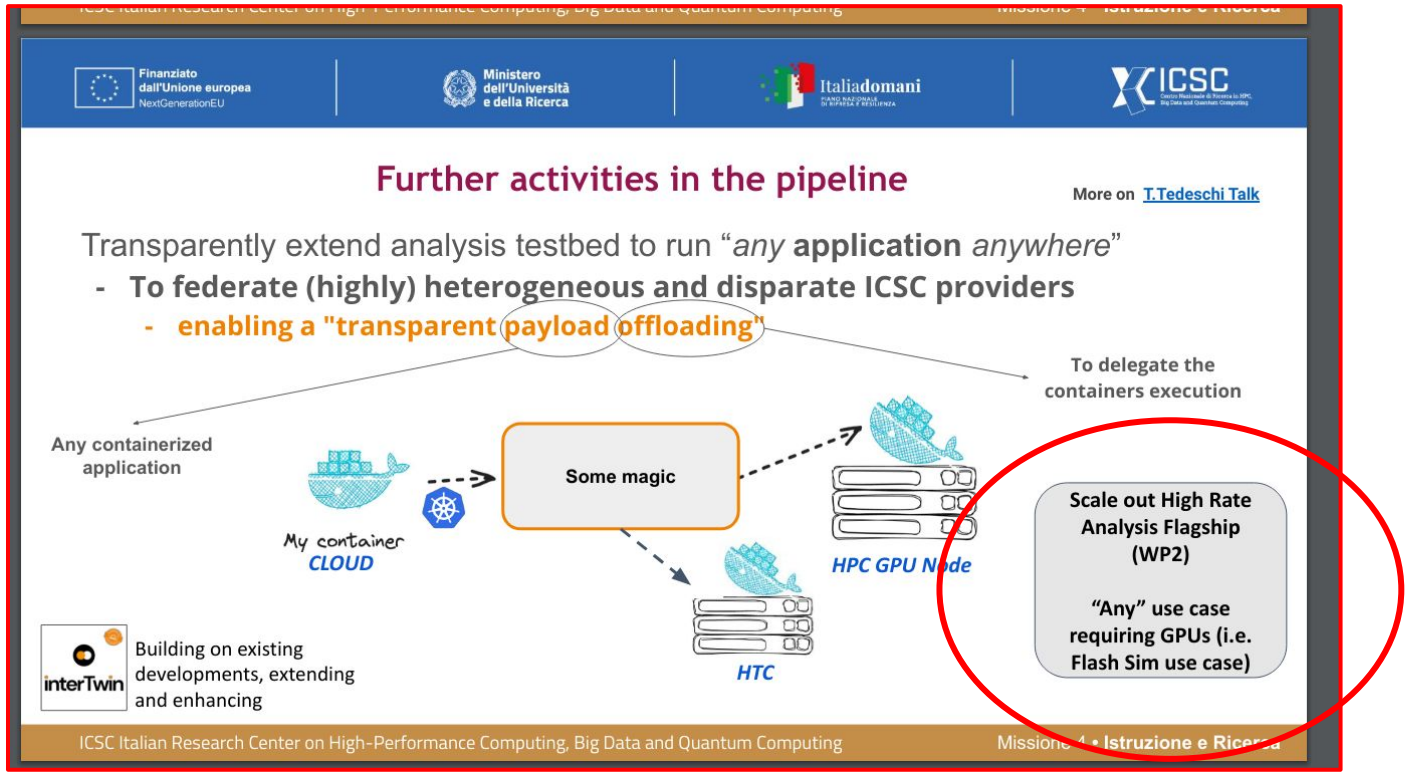
ICSC Spoke 2 WP5 meeting - 7 June 2024 - Online

Razionale: why we talk about this topic



Dare seguito a quanto abbiamo nel nostro workplan

[Spoke2 Annual meeting contributo WP5]

What is offloading?

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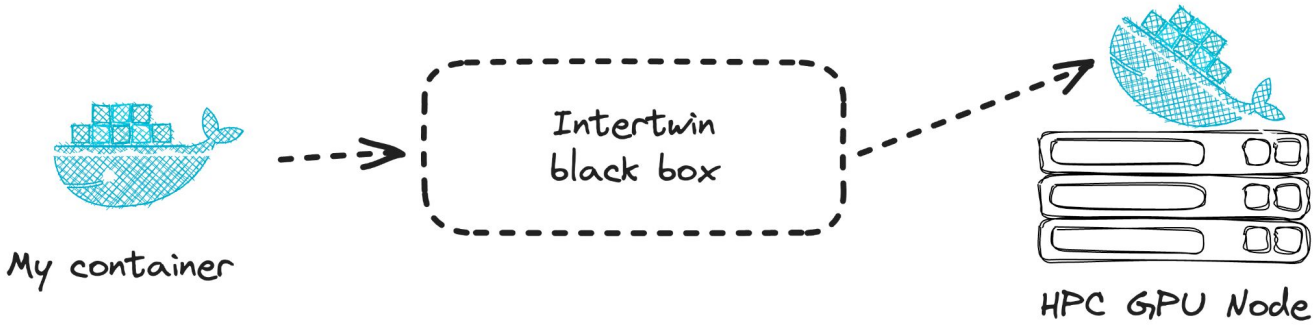
- **Delegate the execution of a container/workflow on remote resources while keeping the user interface unchanged.**
- Example:
  - "I have my own ML training container, and I want to run it on a node with 4 A100s"



How can we implement offloading?

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We want a NATIVE integration with the Kubernetes primitives, acting underneath as a virtual node.

N.B. We aim to use Kubernetes as the workhorse for the "offloading", NOT as the user interface though

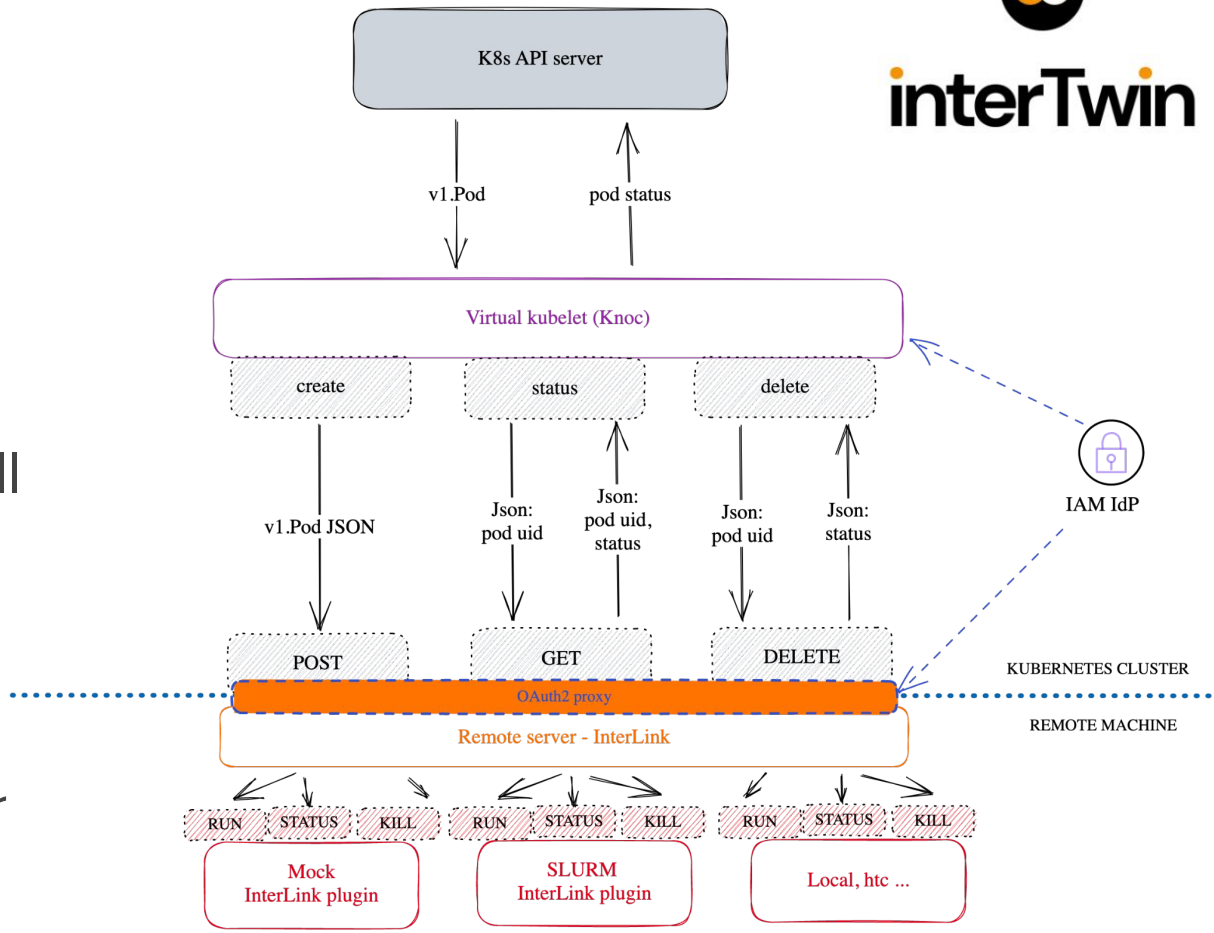
Offloading should be transparent for the users

A possible solution: InterLink

InterLink aims to provide an abstraction for the execution of a Kubernetes pod on any remote resource capable of managing a container execution lifecycle.

The project consists of two main components:

- **A Kubernetes Virtual Node**: based on the VirtualKubelet technology. Translating request for a kubernetes pod execution into a remote call to the interLink API server.
- **The interLink API server**: a modular and pluggable REST server where you can create your own container manager plugin (called sidecar), or use the existing ones: remote docker execution on a remote host, singularity Container on a remote SLURM or **HTCondor batch system**, etc...

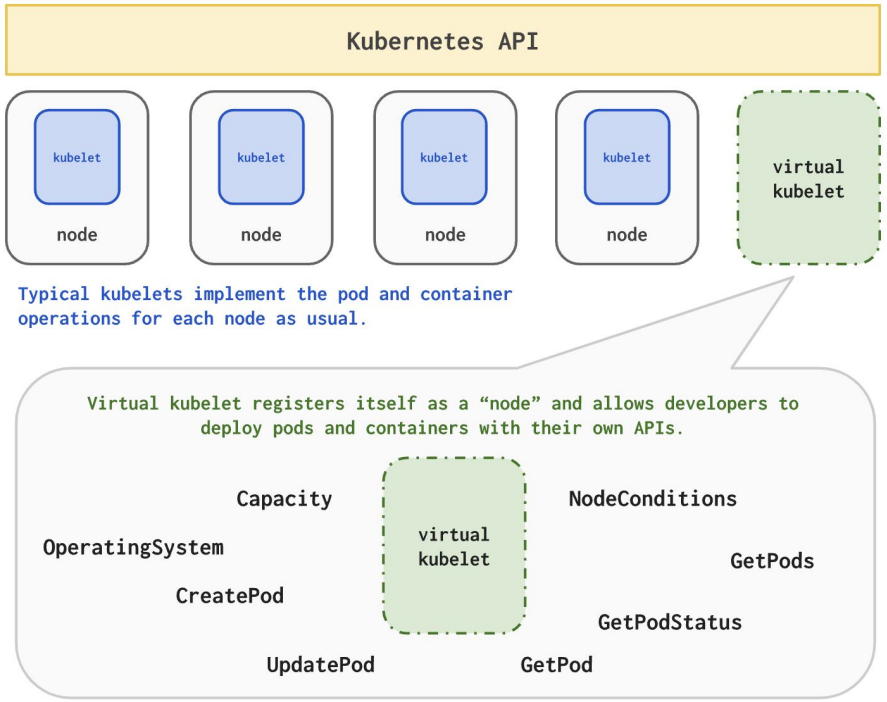


https://github.com/interTwin-eu/interLink

Components: VK

https://virtual-kubelet.io/

- **Virtual kubelet (VK)**:
  - "Open-source Kubernetes kubelet implementation that masquerades as a kubelet. This allows Kubernetes nodes to be backed by Virtual Kubelet providers"
- Can be imagined as a translation layer:
  - "I take your pod and run your container wherever I want"
- Registers virtual node and pulls work to run
- The pod lifecycle is managed via interlink rest calls
- Oauth2 via service token kept "refreshed"



Components: Interlink + Oauth2 proxy

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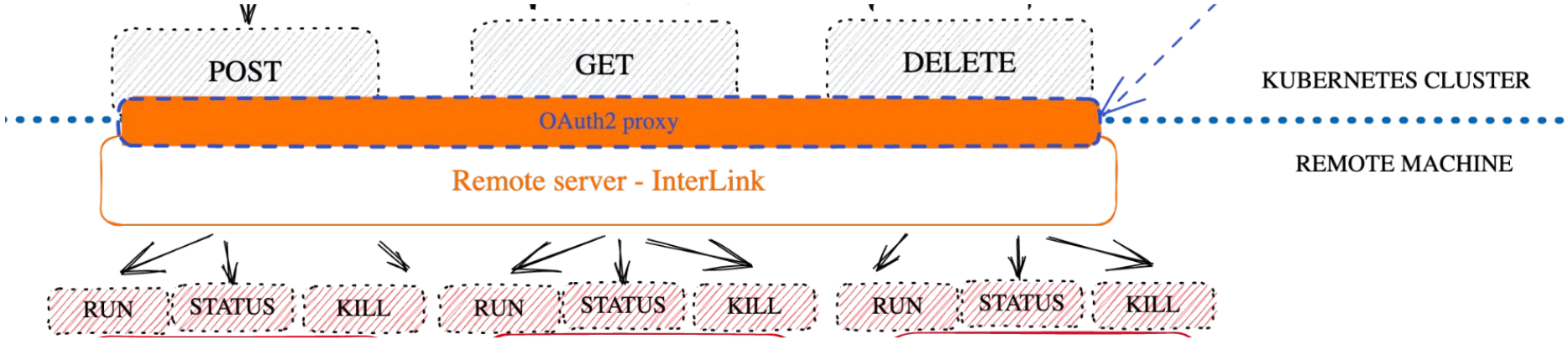
- Oauth2 proxy: authN with IAM and authZ configurable on aud and groups
- "Digests" and manipulates calls from VK to the sidecar
- Self contained binary, distributable on all OS without dependencies



Components: Sidecar/Plugin

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- Agent that must expose a REST with defined specs, but which can be implemented in the language and with the methods you prefer:
  - creation of the pod: run local docker or submit a job on htc, slurm etc
  - collect the execution states
  - collect and forward logs upon request
  - kill
- Existing plugins: local Docker (Go), SIurm (Go), HTCondor (python), ARC (python), Kubernetes (python), Kueue (python)

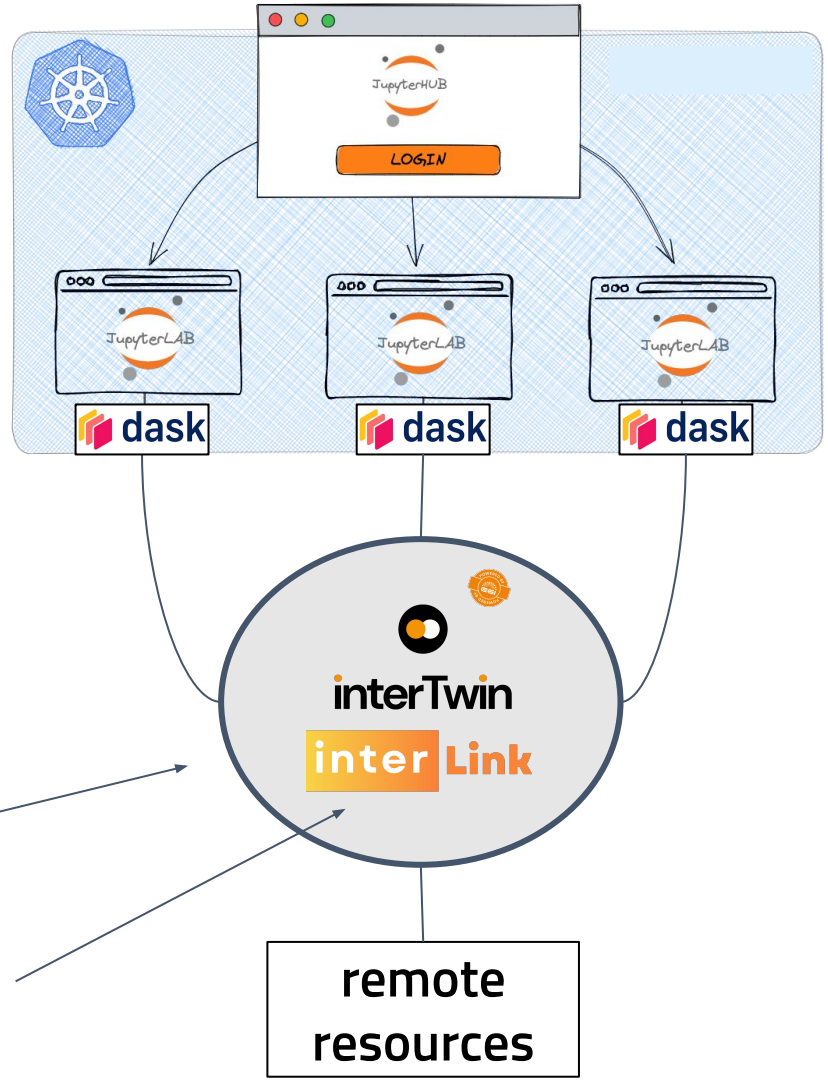
Offloading high rate analysis platform

Current general-purpose infrastructure:

- analyzers can scale up computations **within the cluster that possibly scale within the provider**
- Potentially, **a huge amount of users with diverse use cases may join**

Plan to enable the platform to dynamically exploit all kinds of resources (HTC, HPC, Cloud) transparently for the user

- looking for a synergy with active developments in this context, **to delegate container execution on remote resources** while keeping the very same user interface
  - Possible solution: **InterLink**, which provides execution of a Kubernetes pod on almost any remote resource



Flagship AI - AI_INFN Platform use case

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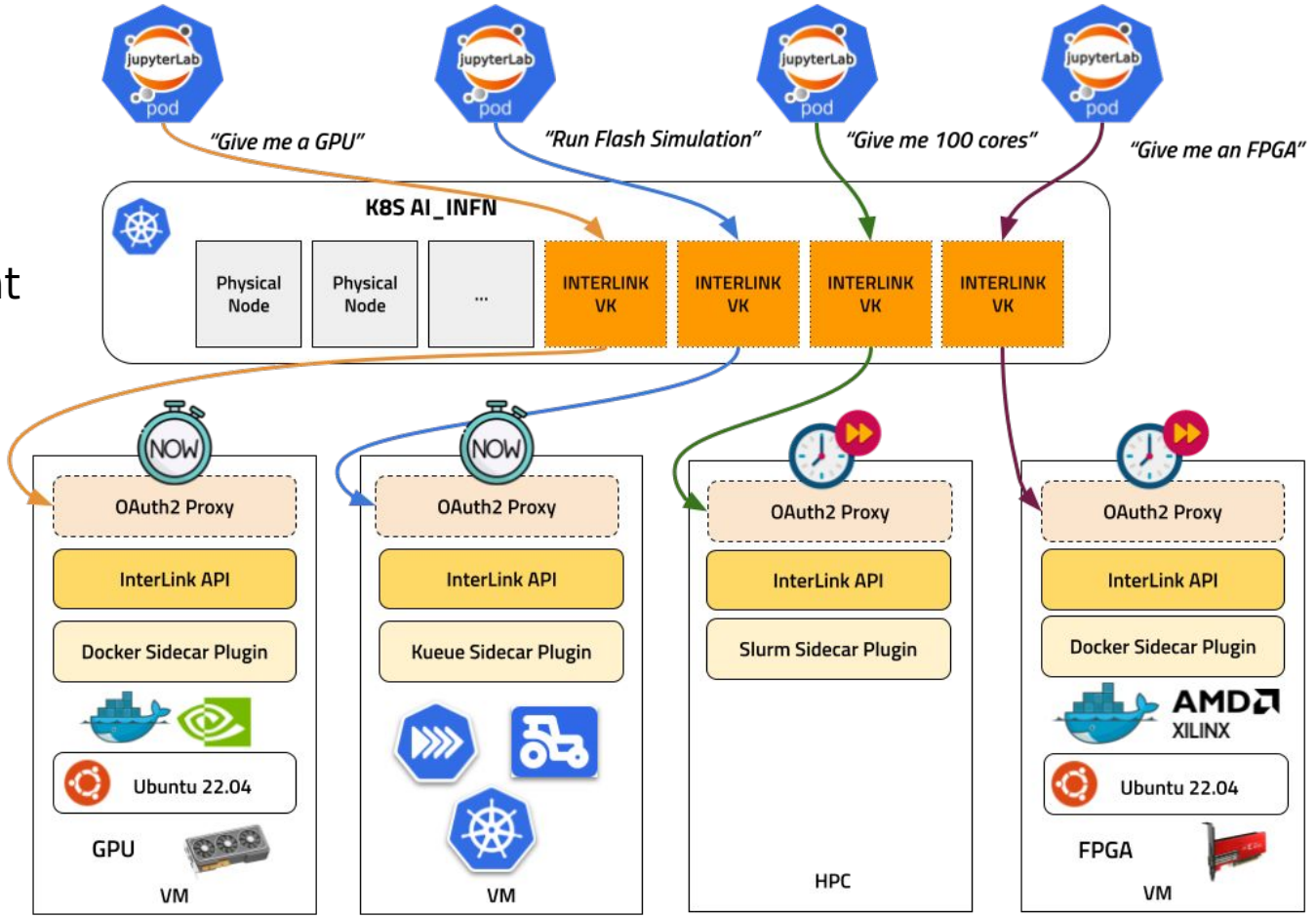
- The **AI_INFN platform provides a complex cloud-native use case** to test InterLink with:
  - Interactive access via offloading
  - Heterogeneous computing (CPU, GPU, FPGA...)

- We are proceeding in parallel with the development of two plugins (**docker and kueue**) to demonstrate decoupling from the backend.

- **The docker plugin** has already been validated for GPU provisioning and **can similarly support FPGA provisioning**.

- In concrete actions, the AI_INFN platform could already leverage this offloading system for spawning JupyterLab instances with some limitations (NFS).



InterLink: development context and ICSC related activities

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The technical solution (interLink) has been initially prototyped by INFN in the context of the interTwin EU Funded project and is now enhanced within the ICSC development/research programme.
In particular

- **It is part of the Spoke0** infrastructural toolkits. As such it is under consolidation, testing and improvement
- **It is part of the Spoke2 - WP5 work plan**
  - in this respect there is a ongoing integration effort to extend the High rate analysis platform over HTC/HPC computing resources
- **Also part of the Spoke3 integration plan**
  - idea is to benefit of the interLink capabilities to offer highly dynamic access to specialized HW (i.e. over Leonardo)
  - integrating offloading with data retrieval from the data-lake prototype

Many fruitful sinergies should lead toward a generic technical solution, versatile and extendible based on specific needs.

What's next

- WHEN RAC resources become available:
  - Prepare the setup
  - Tutorial/hands-on on how to access them
- BEFORE RAC resources become available:
  - Discuss and converge on the integration with current high-rate platform
  - Come up with a prototype
    - Test on resources:
      - HTC for high-rate platform scaling out
      - HPC for AI/ML to allow access to many GPUs

BACK UP

Use cases

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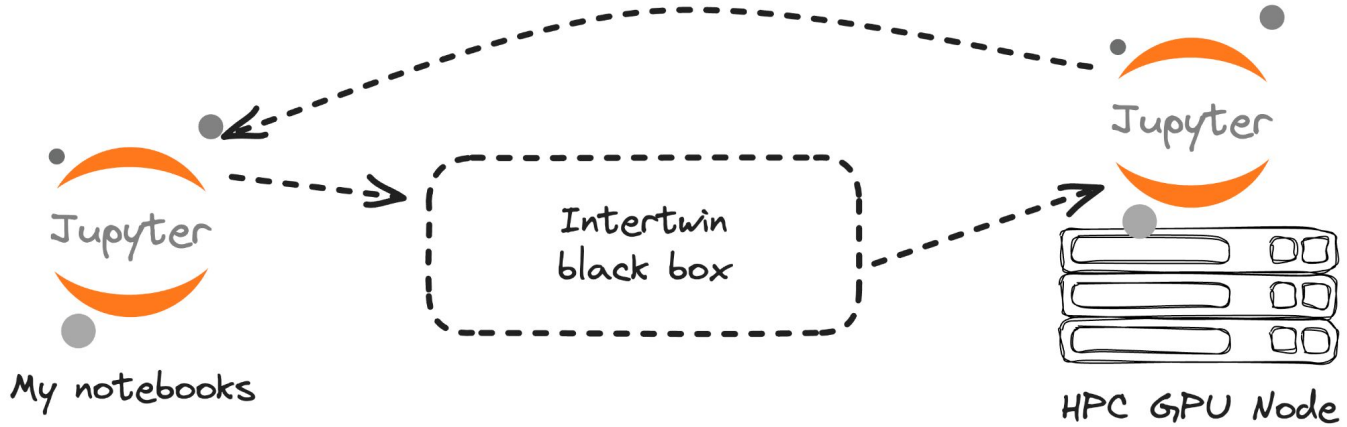
- Interactive session on HPC nodes:
  - I have my image to work interactively and I want through a JupyterHUB to select a node with GPU on HPC to run it



Use cases

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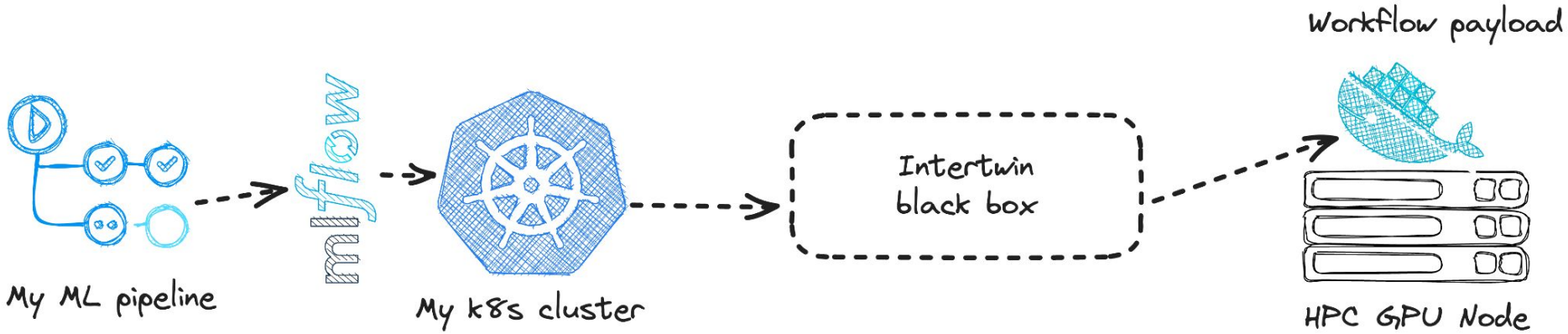
- Offloading managed automatically by frameworks capable of speaking K8s:
  - I have my pipeline (mlflow, snakemake, kubeflow, argo workflows etc…) I want to declaratively indicate to the fwk that that step must be executed on a special and remote node



An inspiring use-case: INFN AF analysis offload

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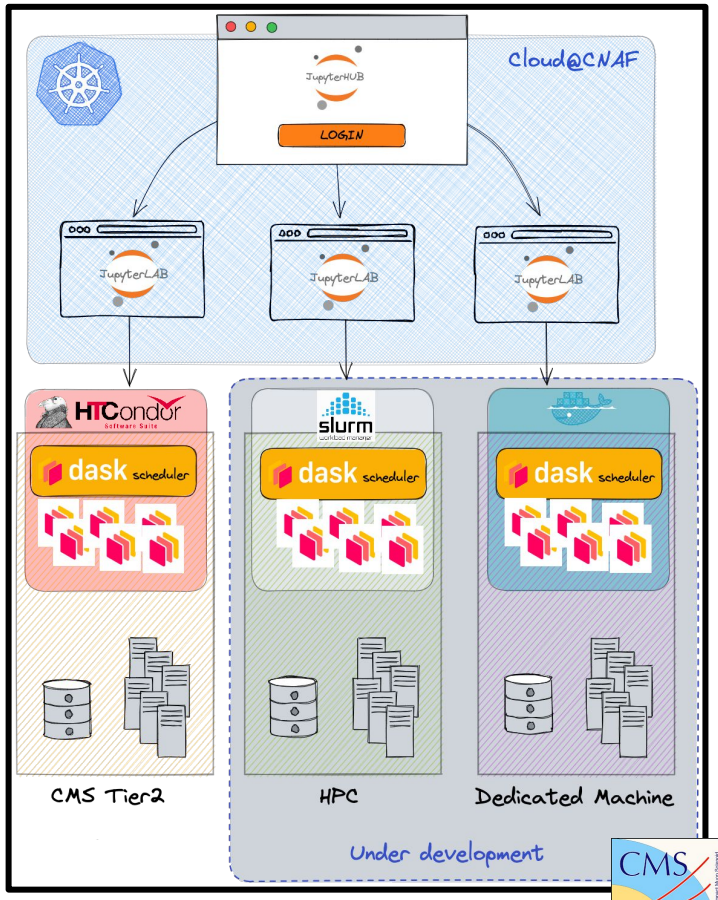
- **INFN Analysis Facility offload on Italian Tier2 sites**:
  - Deployment of Dask clusters on remote resources via RemoteHTCondor (Dask-jobqueue plugin)
  - "Pilot" wn jobs on Italian Tier2 production HTCondor queues via Interlink + HTCondor sidecar
  - Dedicated slot on all sites to contribute for a "seed" of resources available for AF user DASK cluster bootstraping
  - Scaling of the static quota based on active users
  - Additional workers will follow normal batch submission
  - Making this dynamically adapting based on the user "pressure"

What users see

What the offloading hides to the user



Flagship AI ...

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- **Easy GPU access**:
  - seamless access to HPC centers
  - ML training triggered via workflow automation, e.g. ML pipelining tools (Kubeflow, MLflow, ...)
  - many GPUs at once == more/faster hyperparameter optimization