# Provisioning of Opportunistic Resources at KIT

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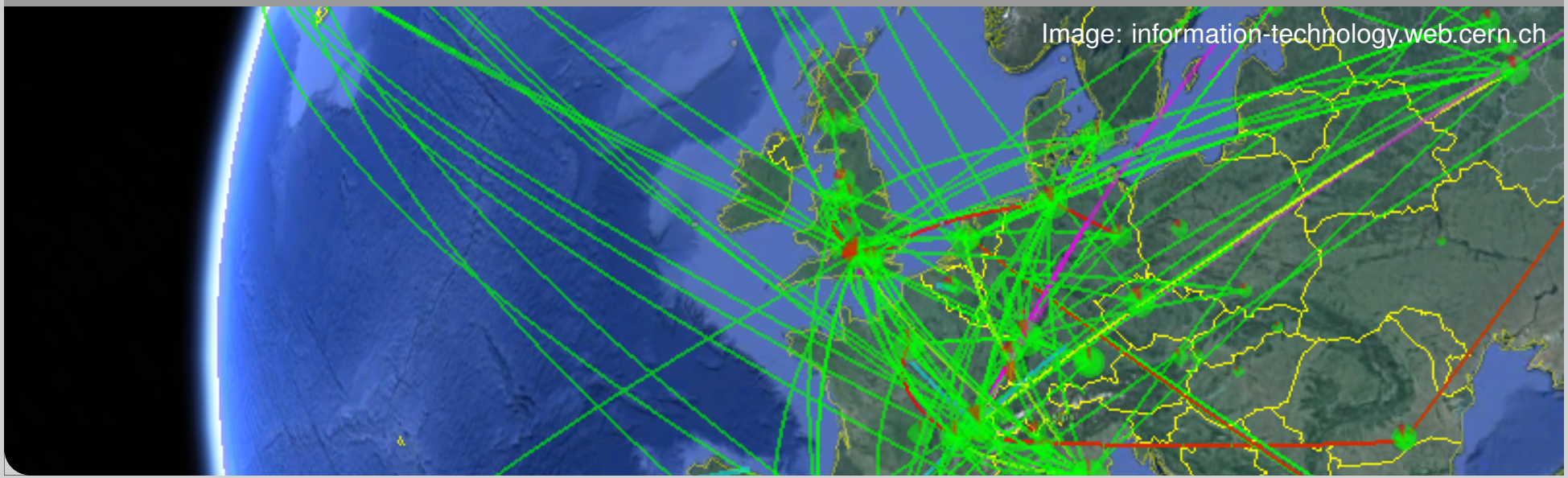
IDT-UM Collaboration Meeting, Karlsruhe – September 30, 2019

INSTITUTE OF EXPERIMENTAL PARTICLE PHYSICS (ETP), STEINBUCH CENTRE FOR COMPUTING (SCC)



# Computing Resources at ETP

- Local storage and compute resources
- Access to multiple, shared resources } Resource Scheduling
  - HPC clusters, cloud providers
- Limited network to various sites } Coordinated Caching*
- Interdisciplinary collaboration of ETP, SCC, and the WLCG Tier 1 GridKa Team

→ Comparable to situation in HEP in the future

*See contribution by René Caspart later in this session

# Opportunistic Resources

# Opportunistic Resources

**Opportunistic resource in the HEP context**

Resource, not specifically designed, but temporarily made available for HEP workflows.

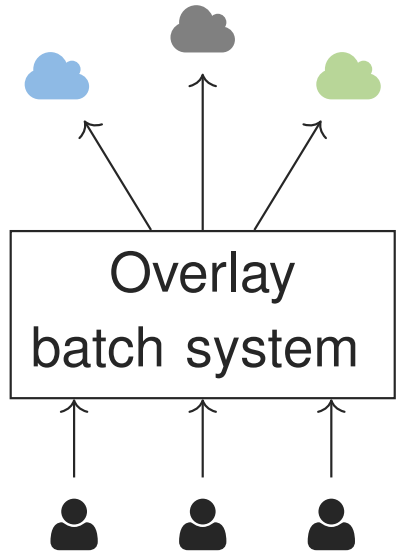
This may include

- HPC centers
- Resources at cloud providers

# Accessing Heterogeneous Resources

## Integration

- Resources are integrated into an overlay batch system
  - Transparent to the user
  - Single point of entry
  - Allows for hassle-free maintenance




## Provisioning

- Prepare resources to be able to run HEP jobs
  - OS (Centos 7, SLC6)
  - Protocols for file transfers (GridFTP, XRootD)
  - CVMFS

# Container technologies

- Containers allow for prepackaging images of exactly defined environments

**Docker**

- Widely used in industry
- Root-owned daemon for privilege escalation

**Singularity**

- Developed for HPC centers
- UIDs for privilege escalation
- User-id in container equals outside user-id

- Isolation of jobs via namespaces
- Host file system can be made available inside container
- For job scheduling: Each job can be placed in its own container

# TARDIS and COBALD

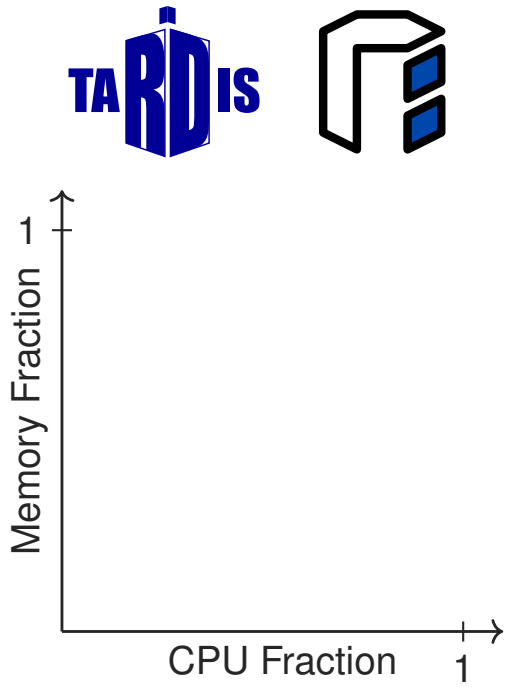
## Dynamic, Opportunistic Resource Scheduling

### TARDIS

Dynamically provisions and integrates resources into overlay batch system.

### COBALD

Assesses the fitness of resources to the current job mix with metrics *allocation* and *utilization*.



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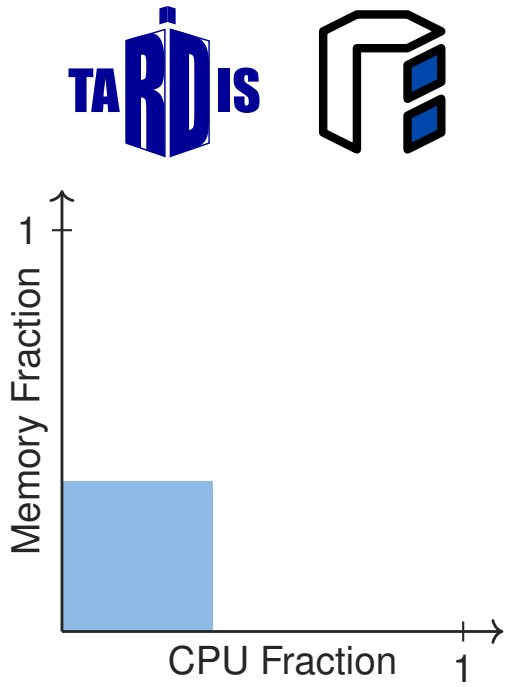

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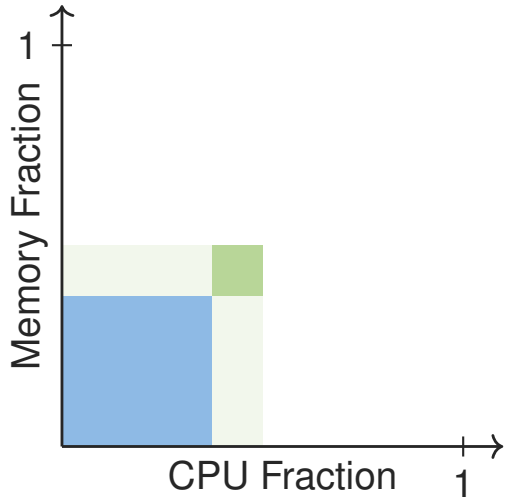

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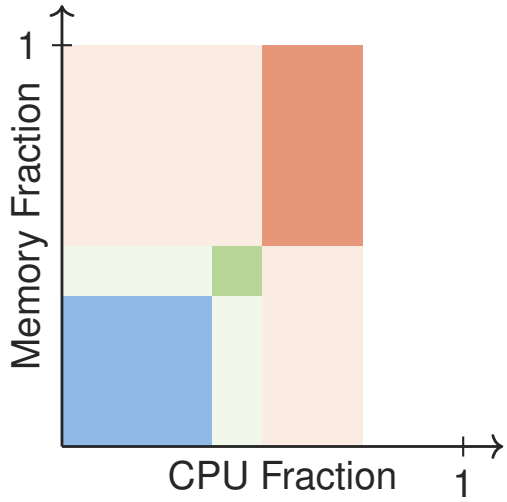

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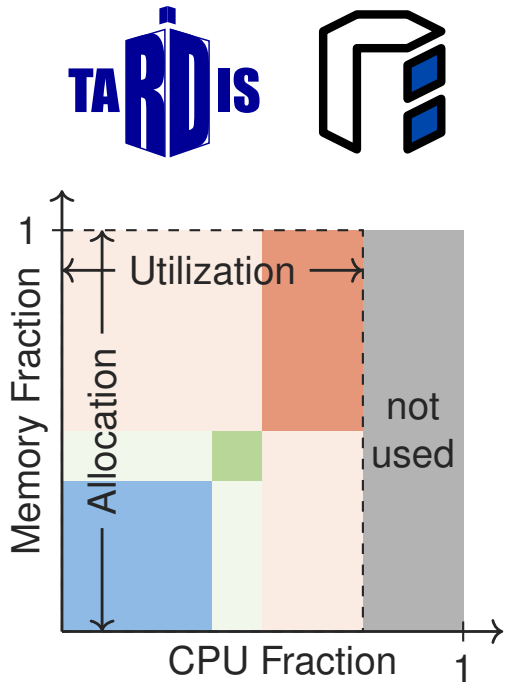

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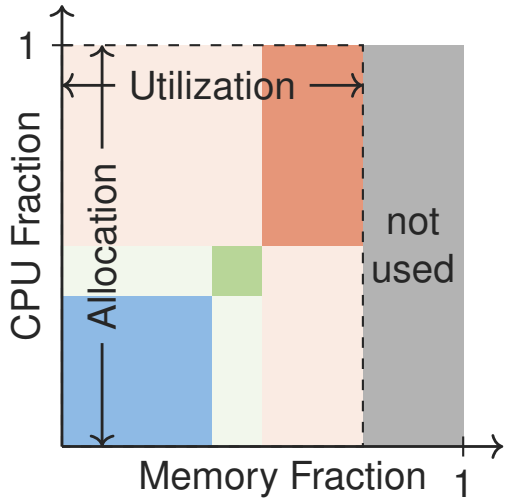

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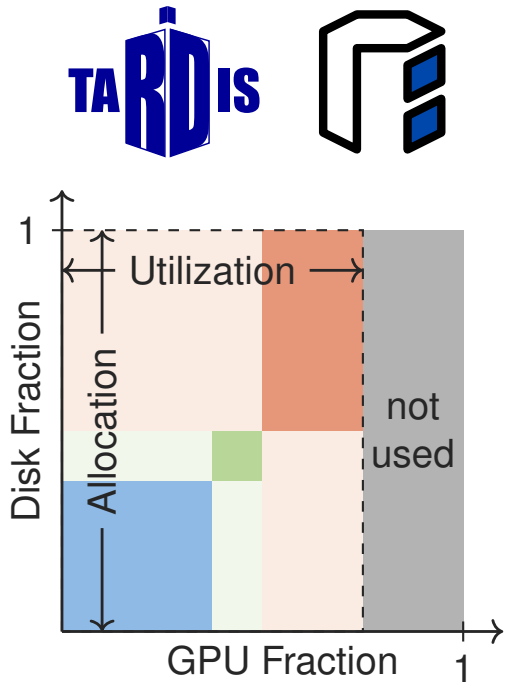
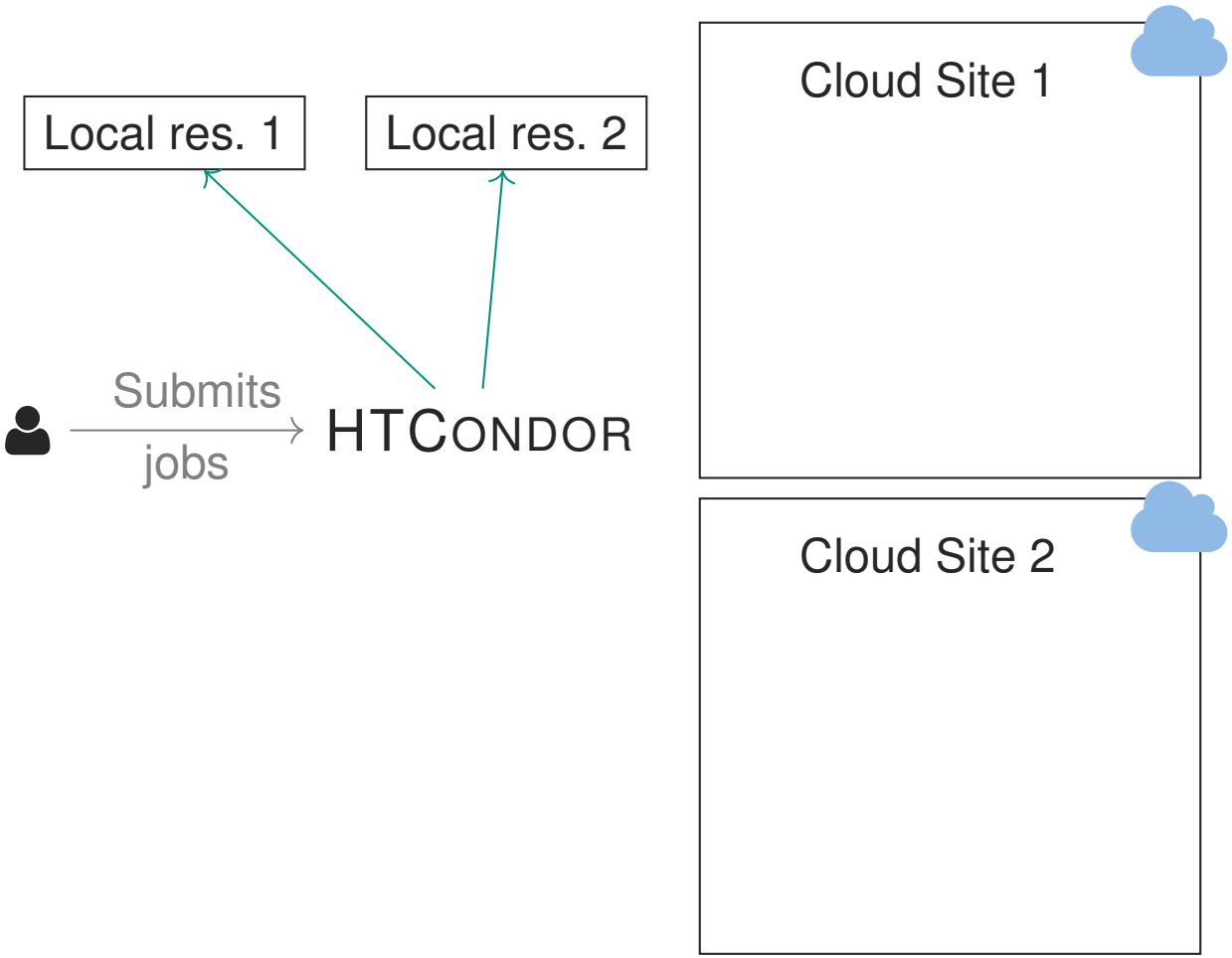


# Opportunistic Resources at ETP

- Resources are dynamically allocated on available cloud providers



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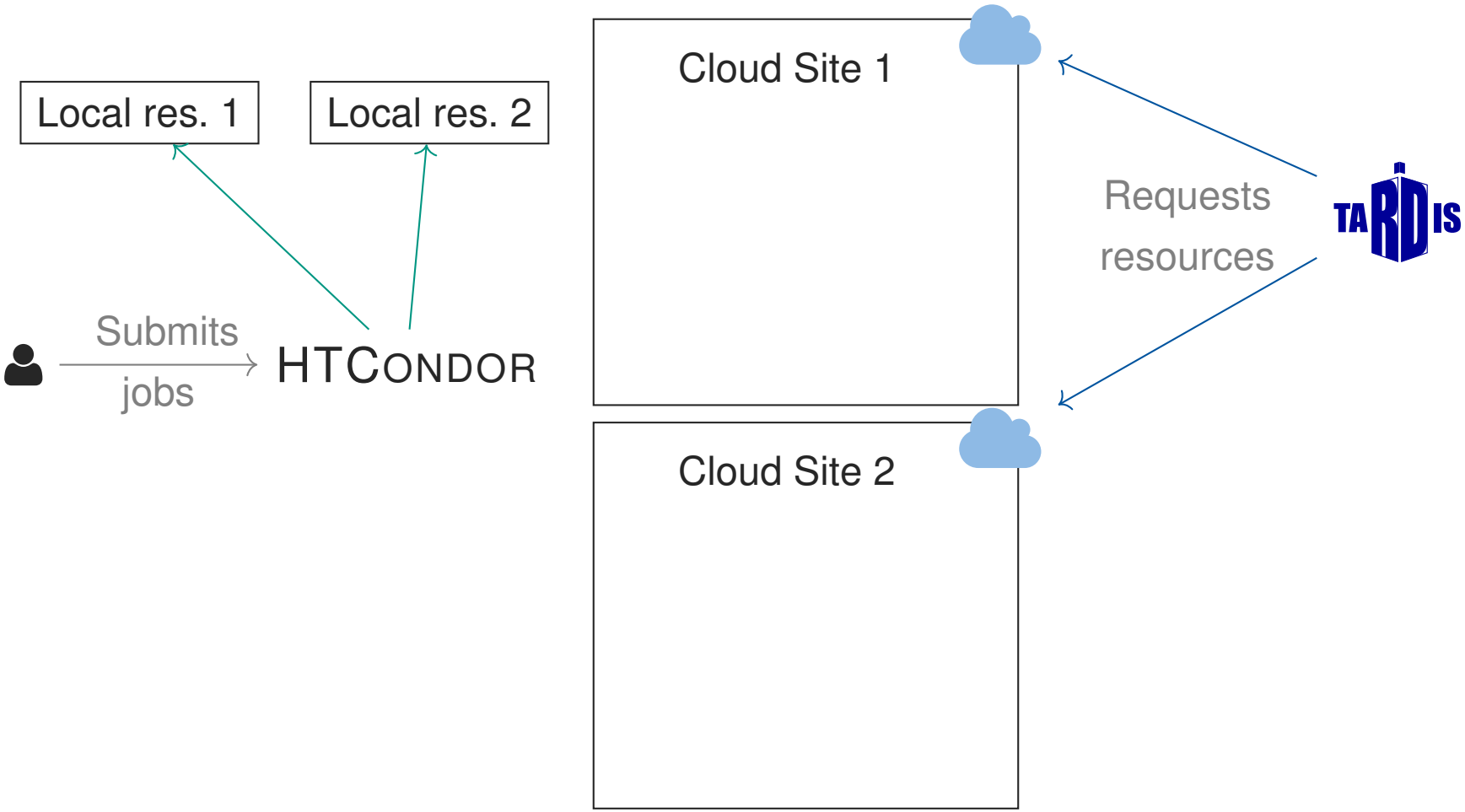

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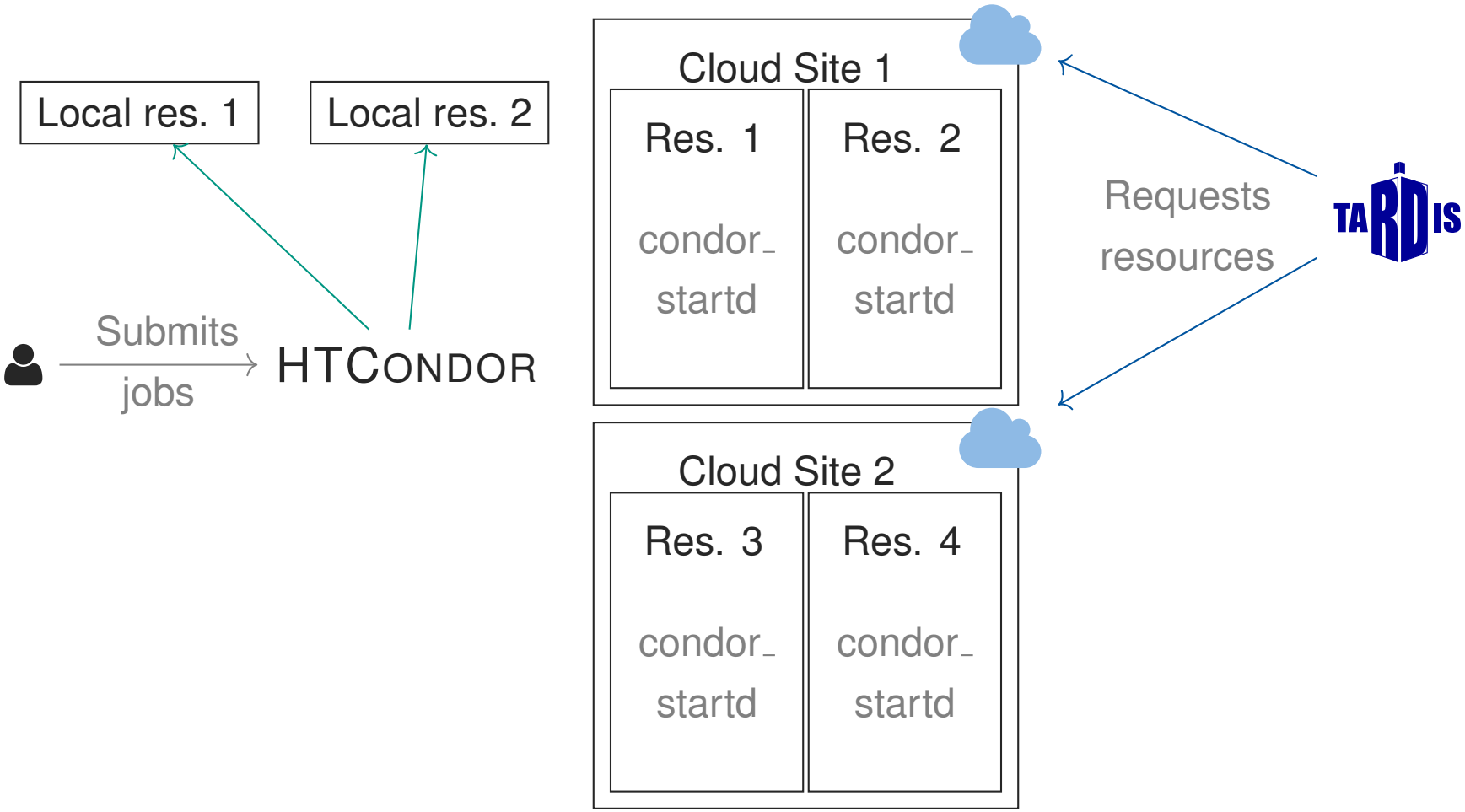

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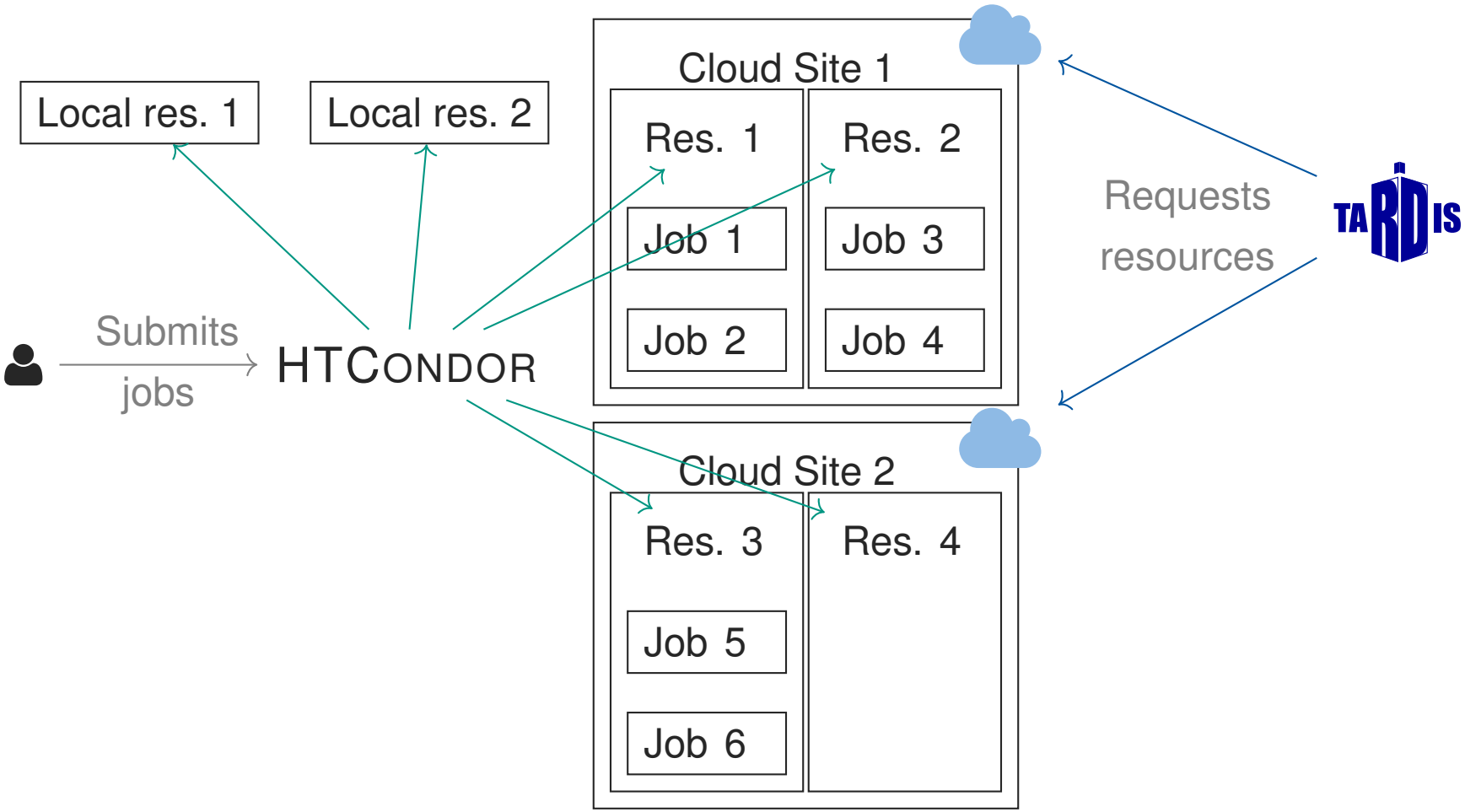

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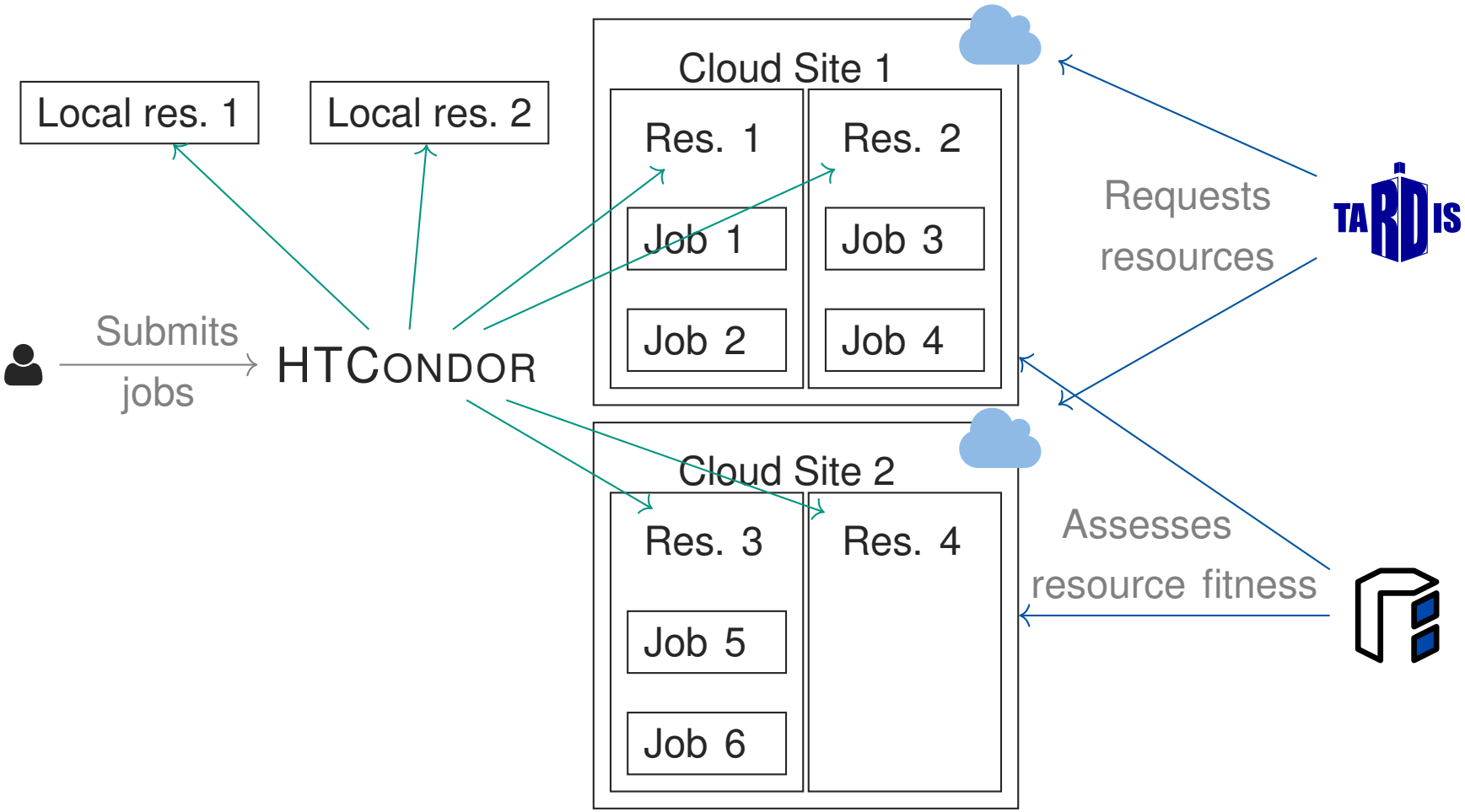

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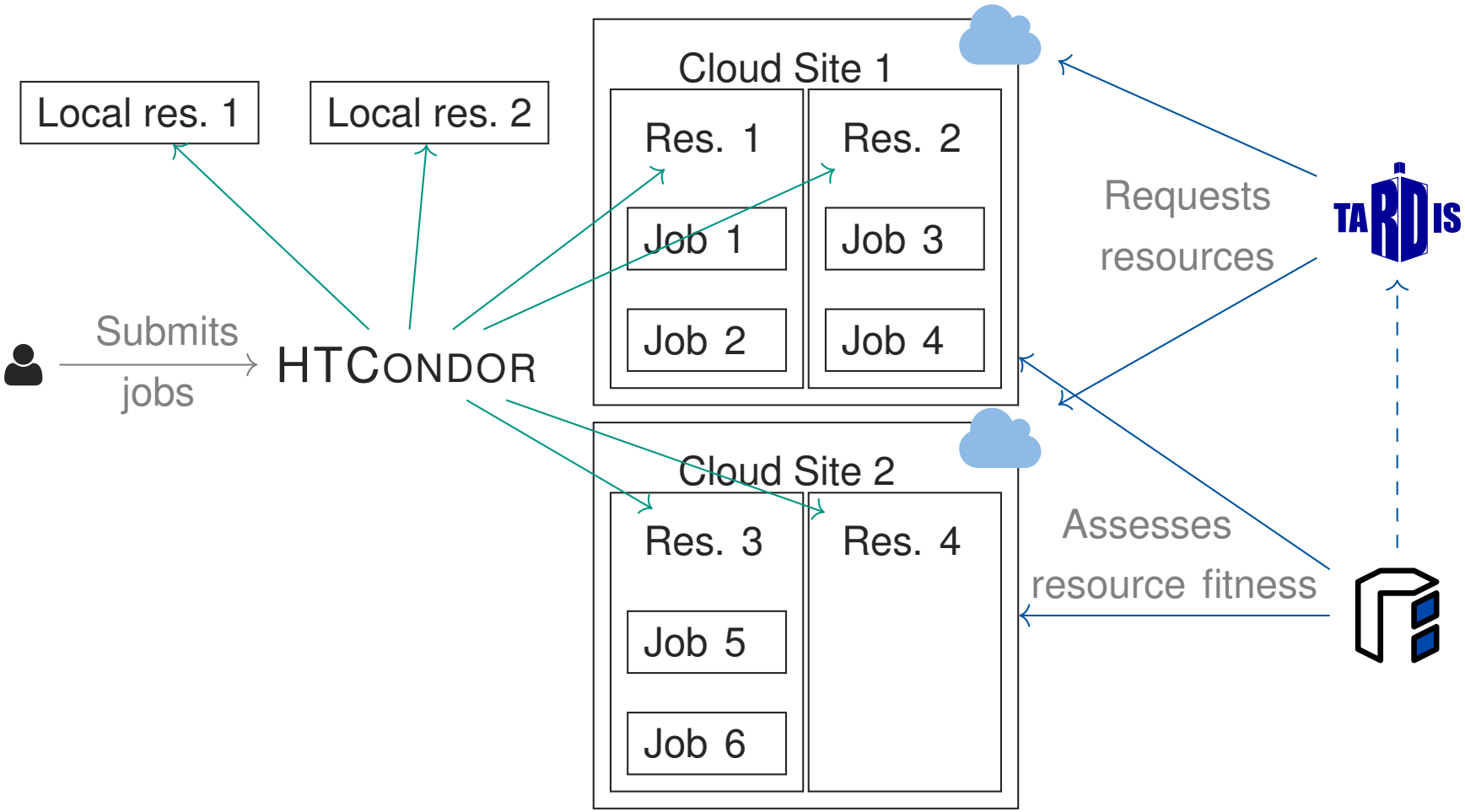

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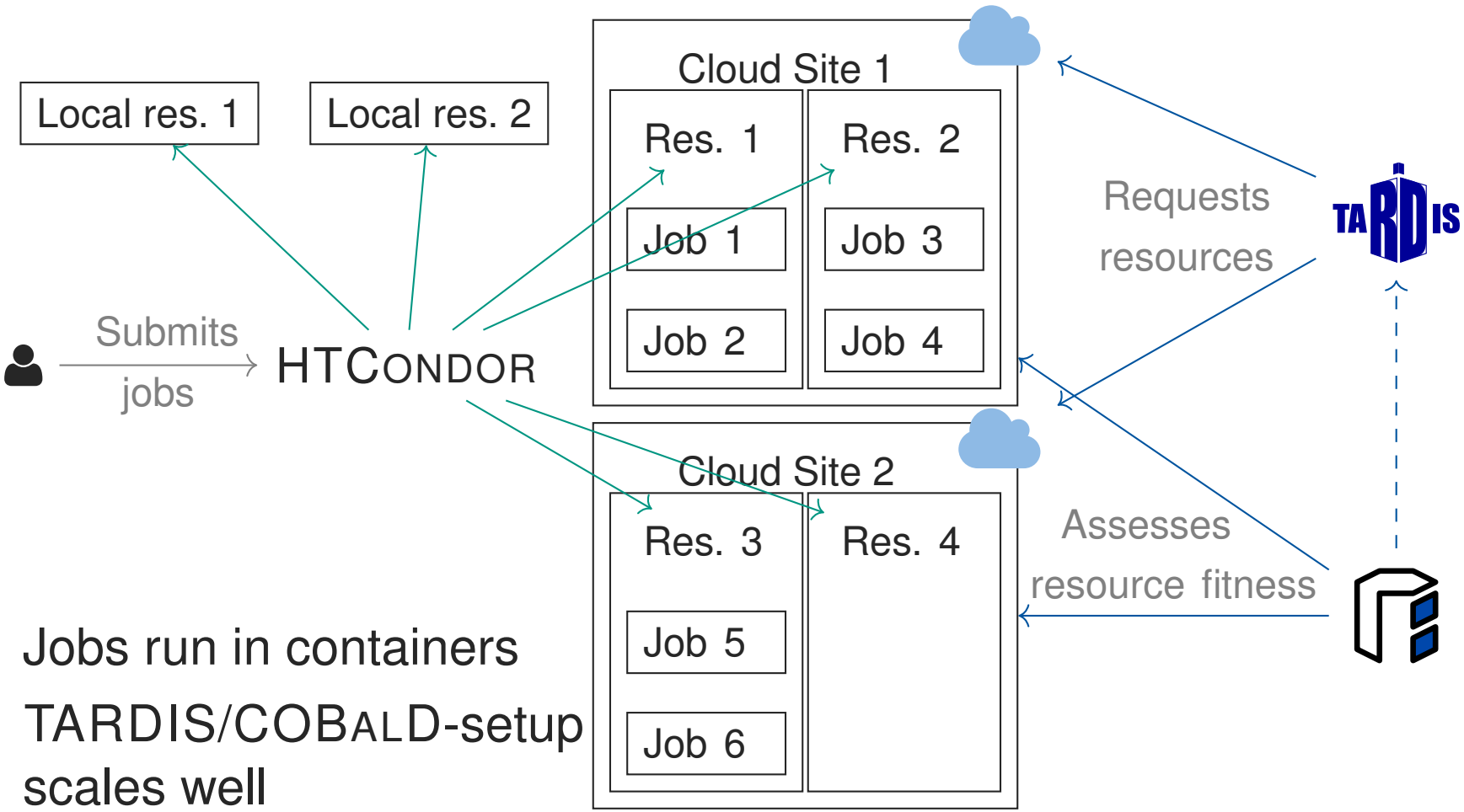
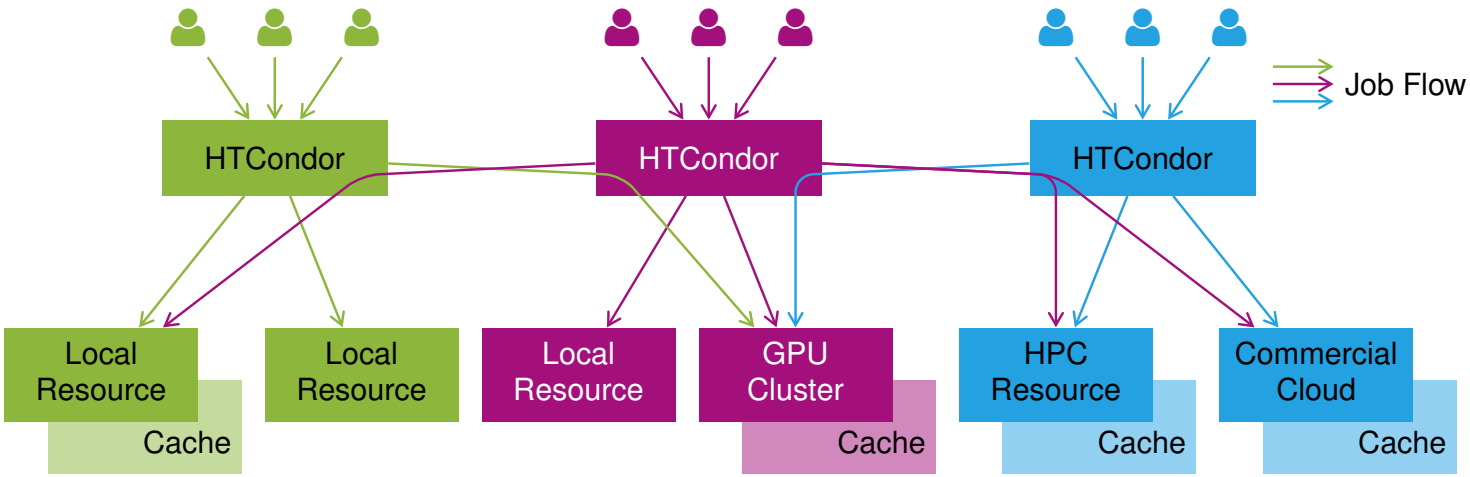



- Jobs run in containers
- TARDIS/COBALD-setup scales well

# Flocking

- Flocking is an internal HTCondor-mechanism for connecting HTCondor-resource pools
- Jobs are eligible for flocking if no match is found in local pool
- Less operational overhead than pilot-concept
- Would allow for connecting German resources (comparable to OSG)



# A Timeline of Opportunistic Resources at ETP

- Years of experience with opportunistic resources at ETP/SCC
- Experience taught us: Predicting decisions made by the batch system is hard
  $\Rightarrow$ react rather than predict
- Develop scalable, modular system for technologies to come

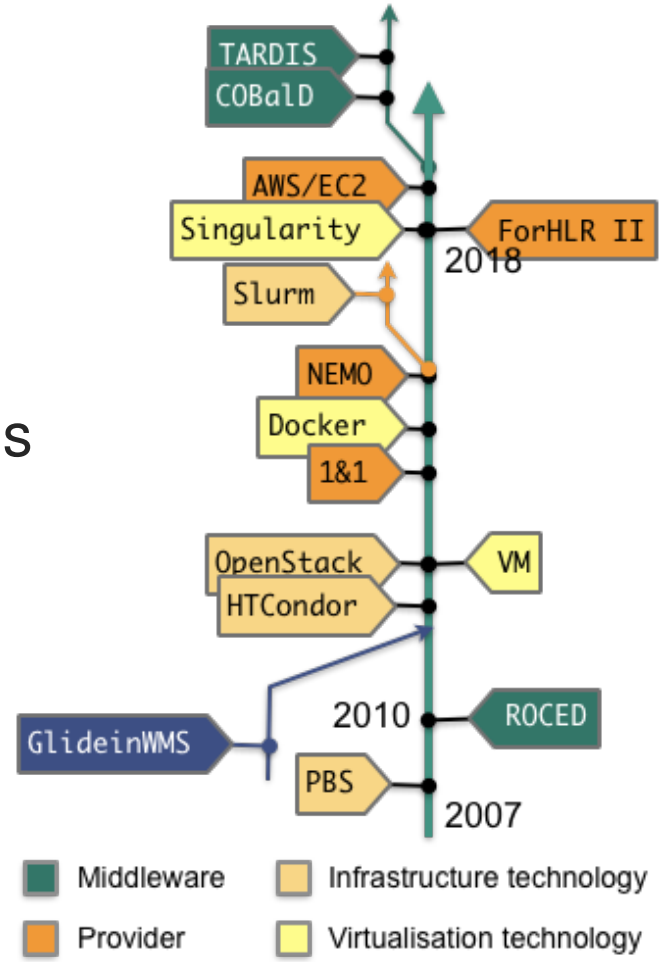



Figure by Eileen Kühn

# Current Setup

# TOPAS Cluster

**T**hroughput **Op**timized **A**nalysis **S**ystem

- Designed for 1PB/d throughput
- Located at GridKa, joined operation by ETP and GridKa
- Runs independent HTCONDOR instance

## Computing Operations

- ETP HTCONDOR flocks jobs to TOPAS
- TARDIS backfills for Tier1 extension
  - ALICE, ATLAS, Belle2, and LHCb jobs are run completely transparent to the experiments via extra entry point

# Current Situation at ETP

## FORHLR2

- BaWü Resource
- 25 000 cores, 97 TB memory (backfilling)
- Singularity on RHEL7

## TOPAS

- Located at GridKa
- $\sim$ 600 cores, 2.6 TB memory
- 1 PB cache
- Docker on RHEL7

## BWFORCLUSTER NEMO

- BaWü Resource
- 19 000 cores, 118 TB memory (shared)
- 20 TB cache
- Docker in VMs

## Local Resources

static

- Linux desktops, worker nodes
- 600 cores, 2 TB memory
- Docker on Ubuntu 16/18 and CentOS7

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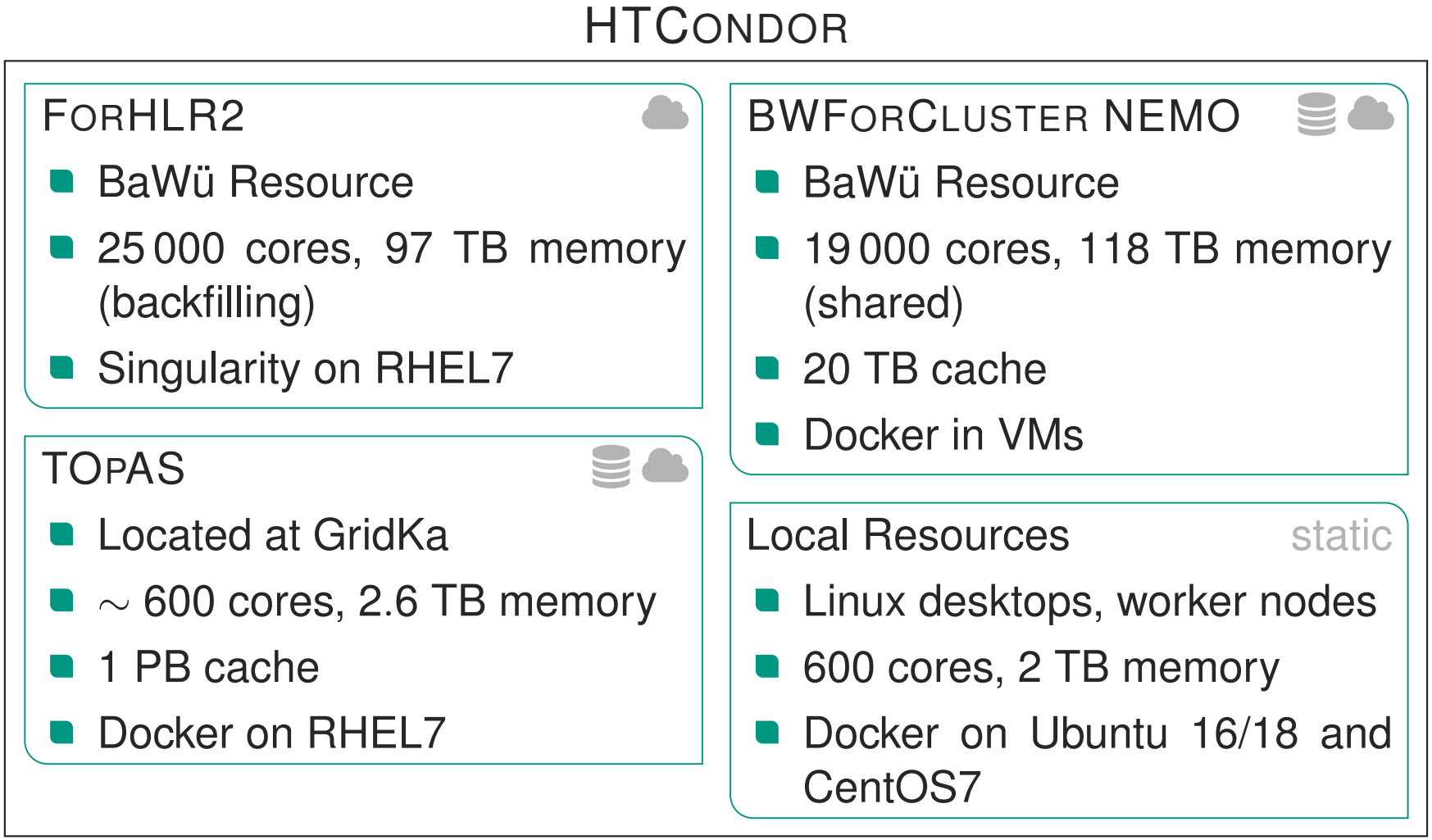

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HTCondor

ForHLR2

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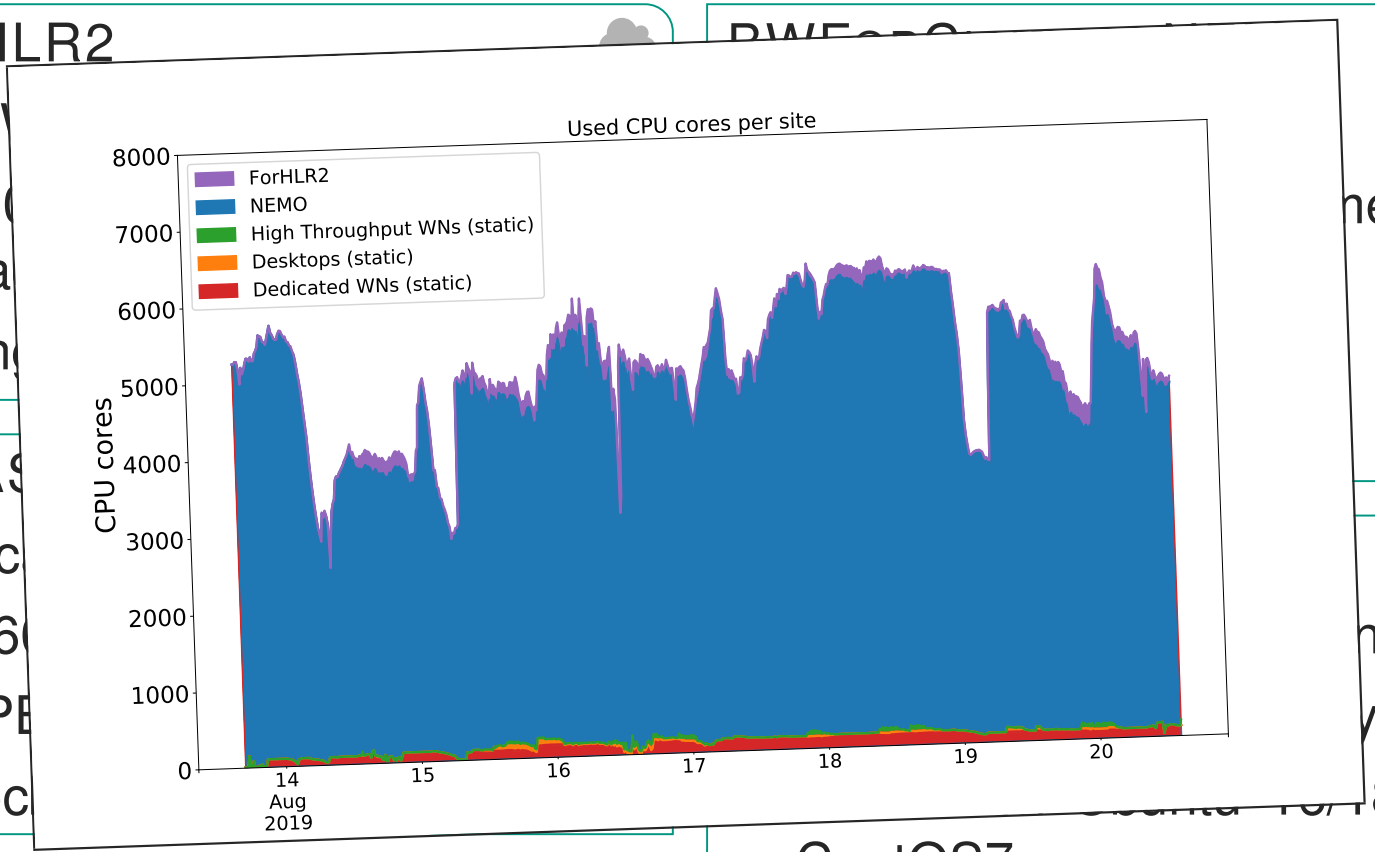
- 25 (ba
- Sin

TOpA

- Loc
- ~ 6
- 1 PB
- Doc




memory

static

nodes

18 and

CentOS7

# TARDIS and COBALD at GridKa

- entry point: `pps-arc-1-kit`
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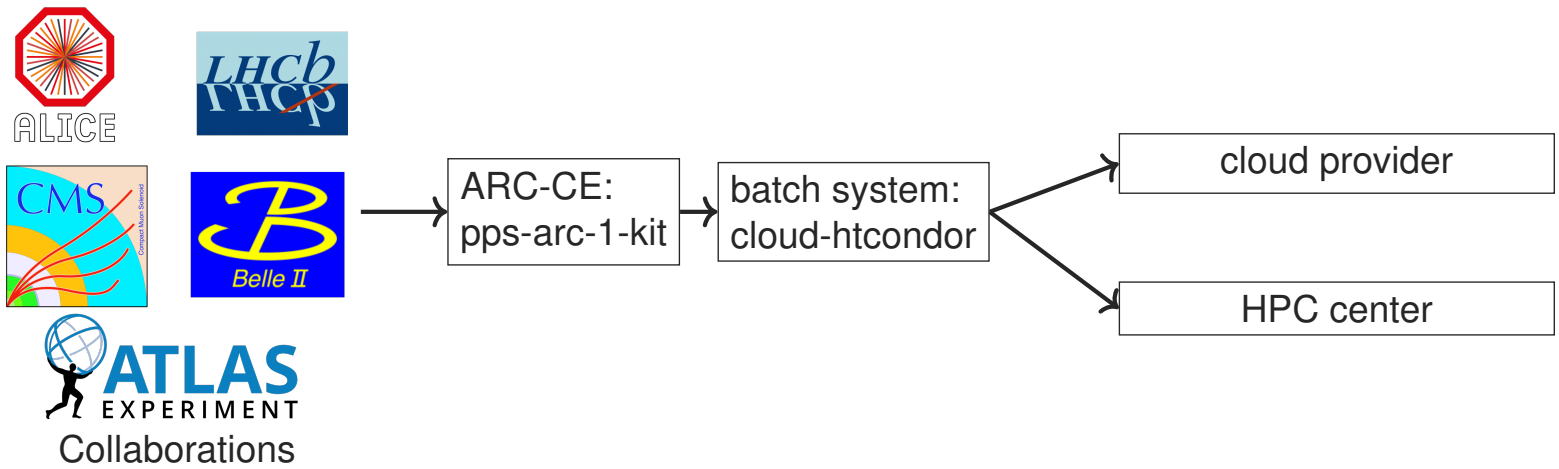


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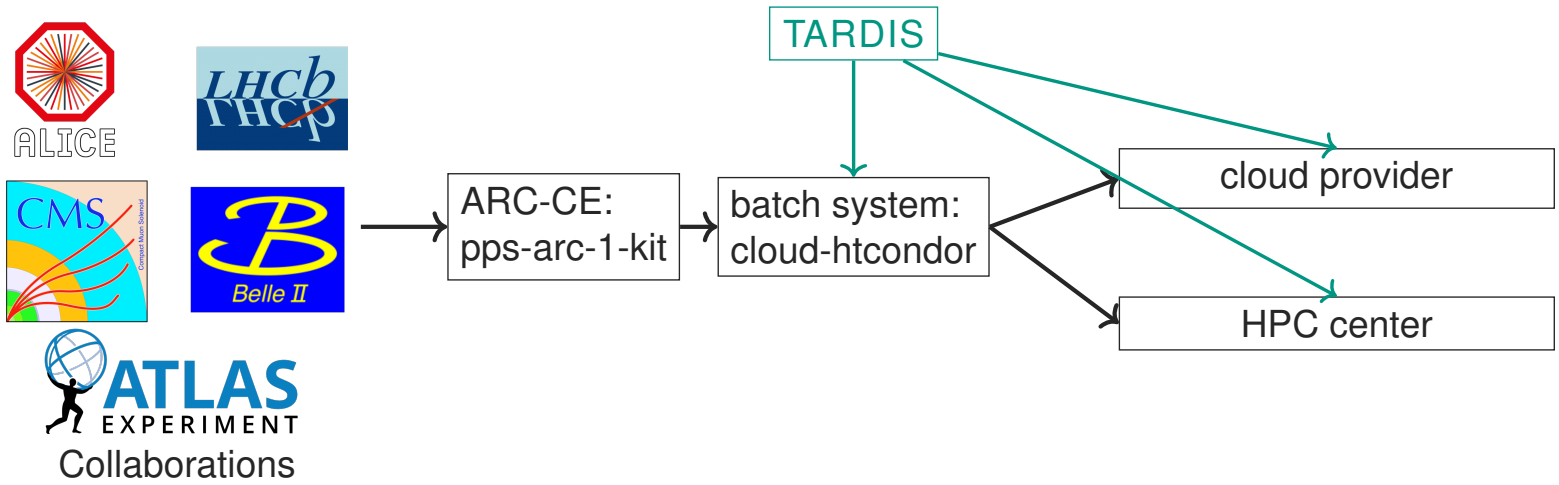


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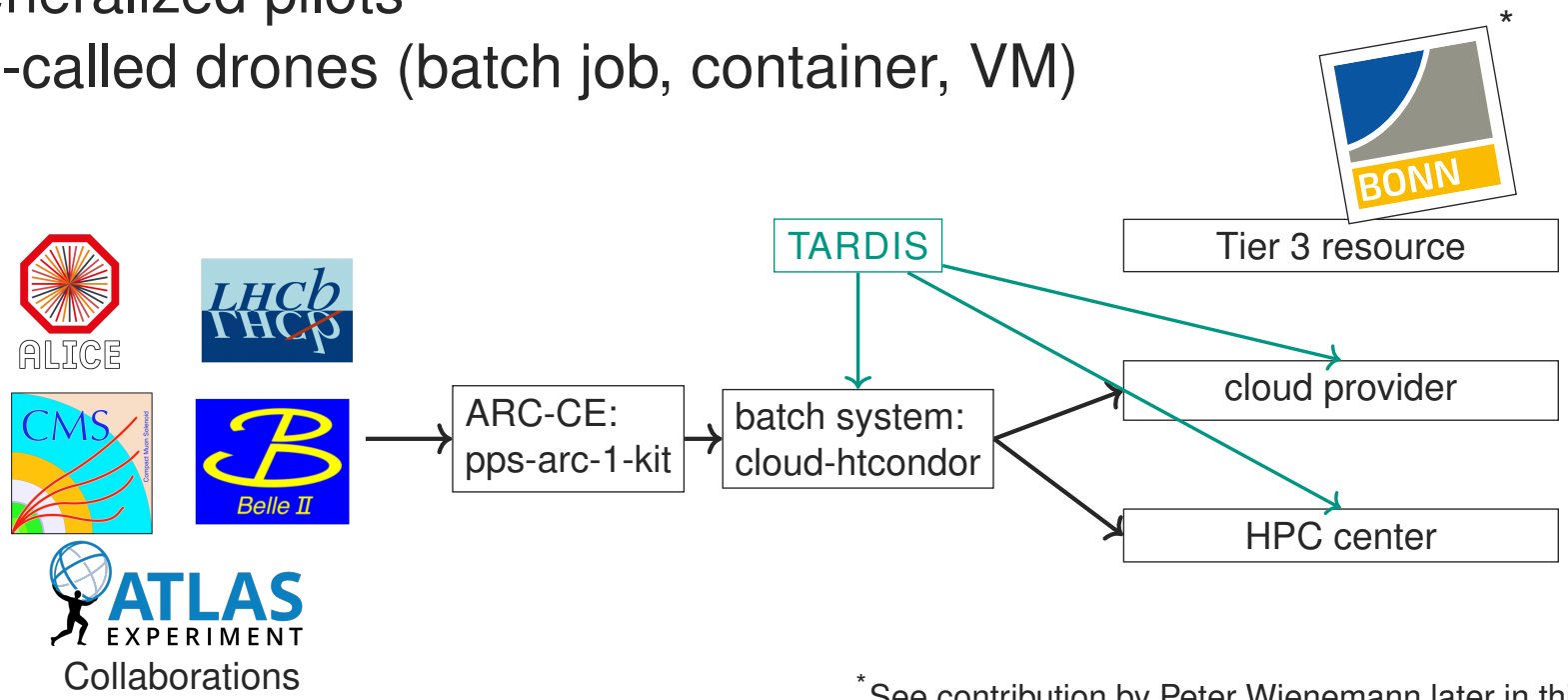


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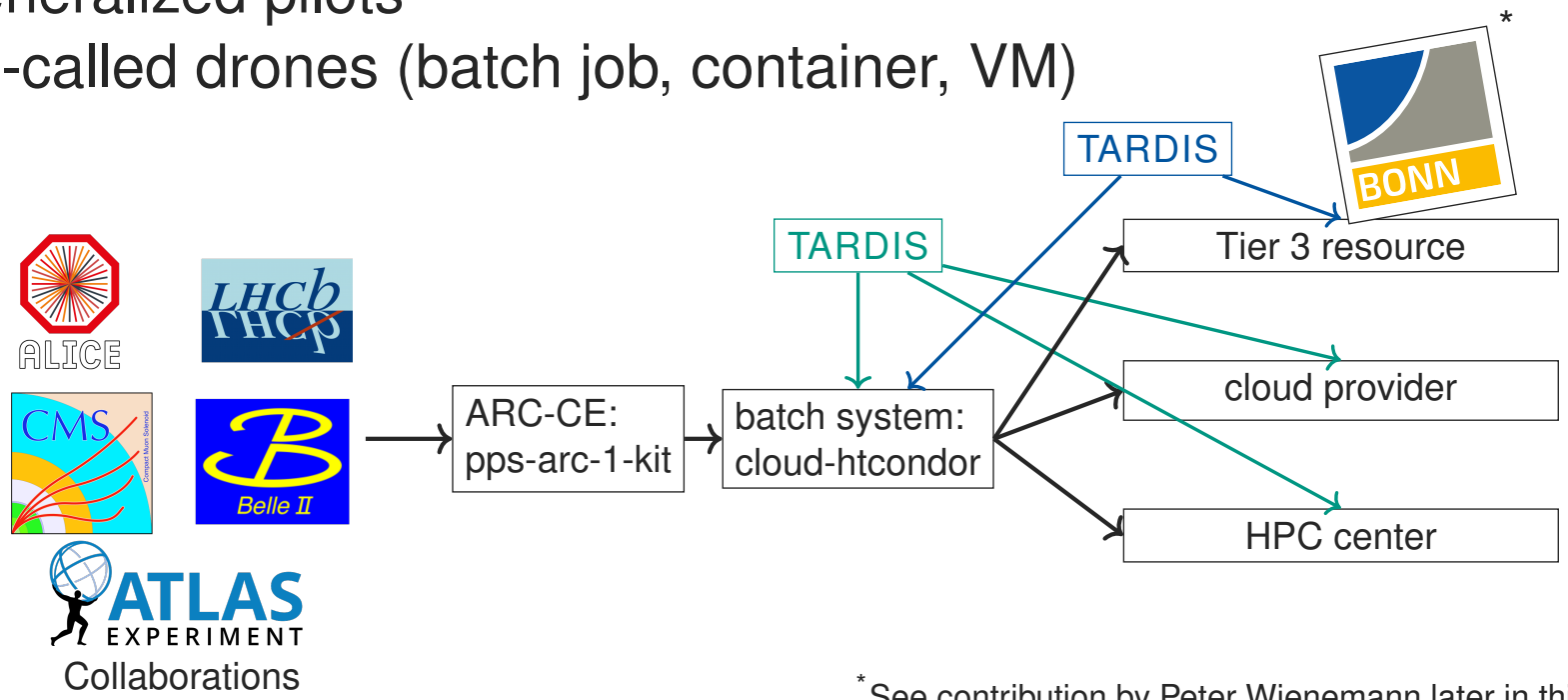


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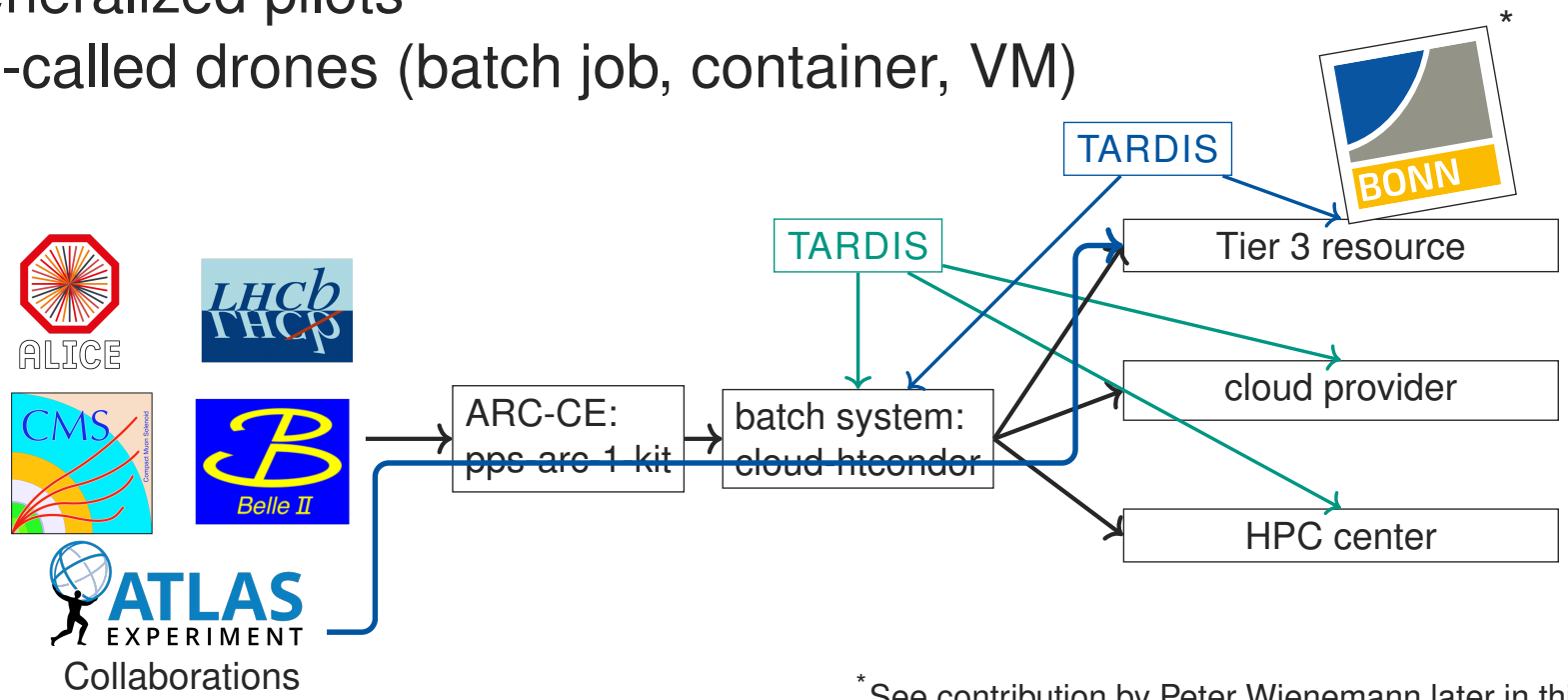


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# Placing ETP in the IDT-UM Context

## Area A

| | |
|---|---|
| **A1) Werkzeuge zur Einbindung**<br>• Scheduling von Cloud-Jobs<br>• Container-Technologien<br>• Checkpointing<br>• Zugang zu Experiment-Datenbanken | **A2) Effiziente Nutzung**<br>• Transiente Datencaches<br>• Transparenter Zugriff auf verteilte Daten |
| **A3) Workflow-Steuerung**<br>• Identifikation und Steuerung<br>• In-Pilot Job-Monitoring<br>• Accounting<br>• Optimierung durch Data-Mining | |

https://indico.desy.de/indico/event/21264/contribution/26/0/material/slides

# Placing ETP in the IDT-UM Context

## Area B

| | |
|---|---|
| **B1) Tests der Technologiekomponenten**<br>Implementierung und Tests auf verschiedenen Plattformen von<br>• Speicher- und Cachinglösungen und<br>• virtualisierter Dienste (Datenbanken, Monitoring, Accounting). | **B2) Job- und Ressourcenmanagement**<br>Jobverteilung und Überwachung in der Umgebung heterogener Computingressourcen unter Einbeziehung von Containervirtualisierung.<br>  |
| **B3) Virtualisierung von Nutzerjobs**<br>• Erfassung der Anforderungen,<br>• Bestimmung und Erzeugung der Laufzeitumgebung,<br>• Erstellung des Containers und von Metadaten und<br>• Checkpointing von Containervirtualisierung. | **B4) Kombinierte Tests**<br>Testen von Gesamtsystemen (Speicher, Dienste, Ressourcemanagement) auf verschiedenen Plattformen in Bezug auf<br>• Installations- und Wartungsaufwand,<br>• Performance,<br>• Skalierbarkeit und<br>• Robustheit. |

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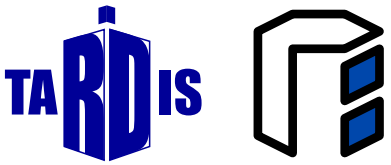
# Summary




- TARDIS and COBALD allow for dynamic integration of opportunistic resources
- Developed in close collaboration of ETP and SCC at KIT for production system

## Outlook

- Federation of national computing resources with single point of entry
- Single national submission infrastructure
- Nation-wide distribution of jobs on specific resources is done locally

# References

- TARDIS: `https://github.com/MatterMiners/tardis`

  DOI 10.5281/zenodo.3257718

- COBALD: `https://github.com/MatterMiners/cobald`

  DOI 10.5281/zenodo.1887873

# Appendix

# TARDIS and COBALD: Scalability

## Scalability

- decision based on managed resource information
- horizontal scaling of resources
  - up to 400 drones at ETP
  - 1152 drones for whole ForHLR II
  - ∼20000 drones for whole CMS WLCG computing
- one COBalD/TARDIS instance per provider (multi agent system)
- current operation mode is one COBalD/TARDIS instance per resource provider