

Investigating Job Allocation in Edge Computing Platforms

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Internet of Things, Cloud and Edge Computing

W. Shi, et al [38,39] :

- We will arrive in the post-cloud era, where there will be:
 - a large quantity of data generated by things that are immersed in our daily life, and
 - a lot of applications will also be deployed at the edge to consume these data.
- By 2019:
 - Data produced by people, machines, and things will reach 500 zettabytes, as estimated by Cisco Global Cloud Index,
 - However, the global data center IP traffic will only reach 10.4 zettabytes by that time.
 - 45% of IoT-created data will be stored, processed, analyzed, and acted upon close to, or at the edge of, the network. [38, 39]

Y. Mao, et al. [24] :

- Mobile devices tends to growth in terms of usability and processing of data, implicating the decentralization from the Cloud's presence.

Luiz Bittencourt, et al. [9] :

- As a combination of
 - Run small, localized applications at the edge
 - High-capacity from the cloud,
 - Support heterogeneous requirements
 - Resources from the edge of the network and from the Cloud.

Internet of Things, Cloud and Edge Computing

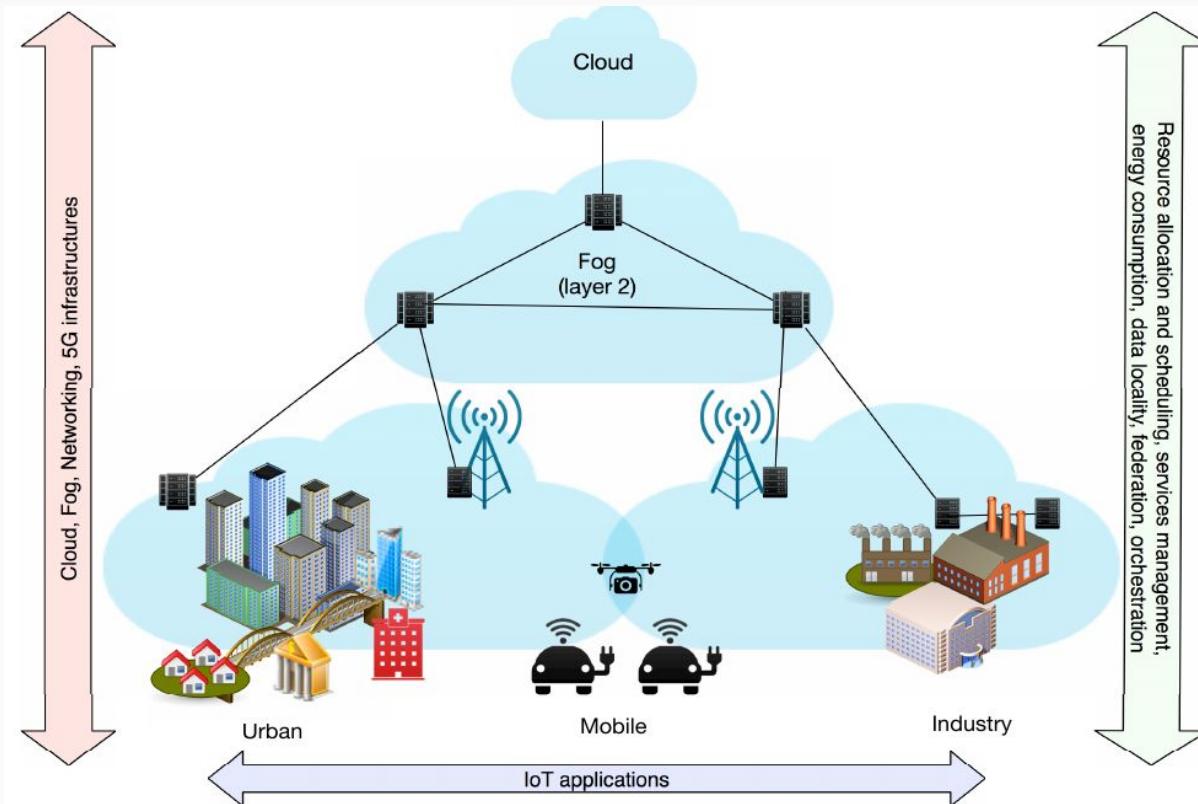


Figure: Illustrative overview, within the IoT-Fog-Cloud infrastructure [1]

Use case: Qarnot Computing

The Company

Incorporated in 2010, provides a disruptive solution able to turn IT waste heat into a viable heating solution for buildings.

With a distributed infrastructure in housing buildings, offices and warehouses across several geographical areas in France and Europe, in each situation valorizing the waste heat produced by IT computations to heat air and water for the building.

The whole platform is composed of about:

- 1,000 computing devices hosting
- 3,000 diskless machines.

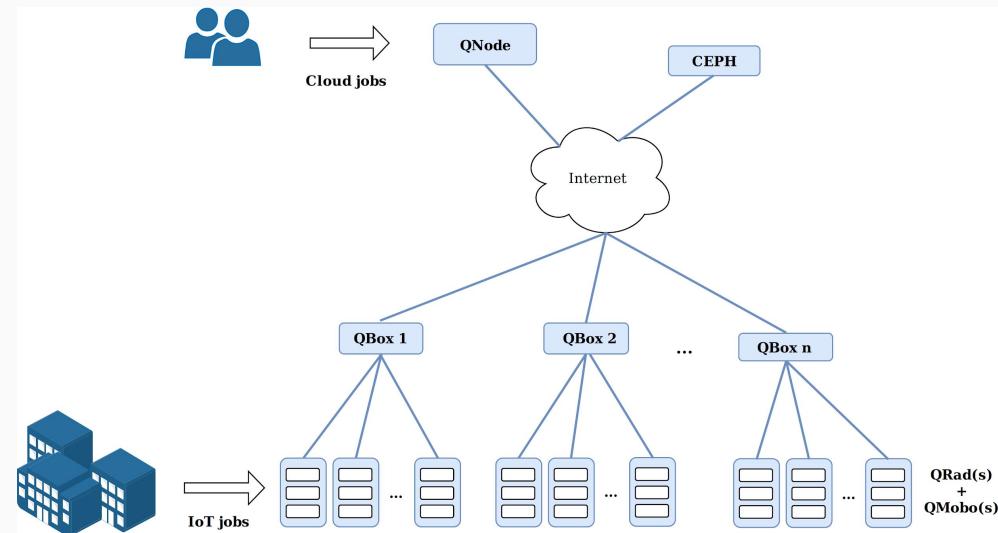


Figure: <https://www.qarnot.com/>

Use case: Qarnot Computing



Infrastructure: QWare



Job Allocation

How to manage jobs and resources, in order to fit the jobs among the resources in the best way.

- S. M. Parikh [31] points that the management of flexible resources allocation is a problem emerged in the context of Cloud/ Edge Computing, due to heterogeneity in hardware capabilities, workload estimation and a variety of services, also as the maximization of the profit for cloud providers and the minimization of cost for cloud consumers.
- Huang et.al [21] affirm that to make appropriate decisions when allocating hardware resources to the tasks and dispatching the computing tasks to resource pool has become the main issue in cloud computing.
- According to Hameed Hussain et.al [22] the resource management mechanism determines the efficiency of the used resources and guarantees the Quality of Service (QoS) provided to the users.

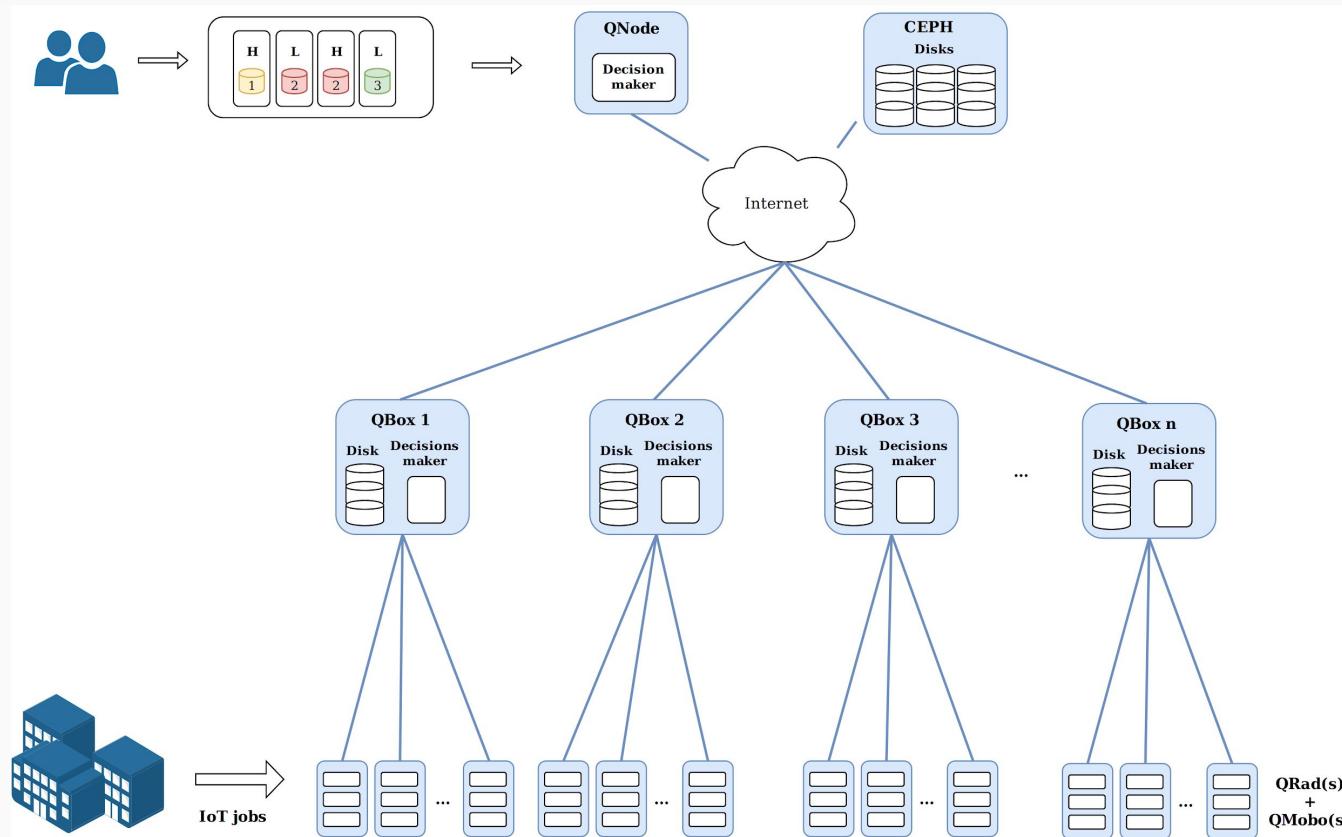
Policies implemented and compared:

- Standard (current Qarnot policy)
- Locality Based
- Full Replicate
- 3 Replicate
- 10 Replicate

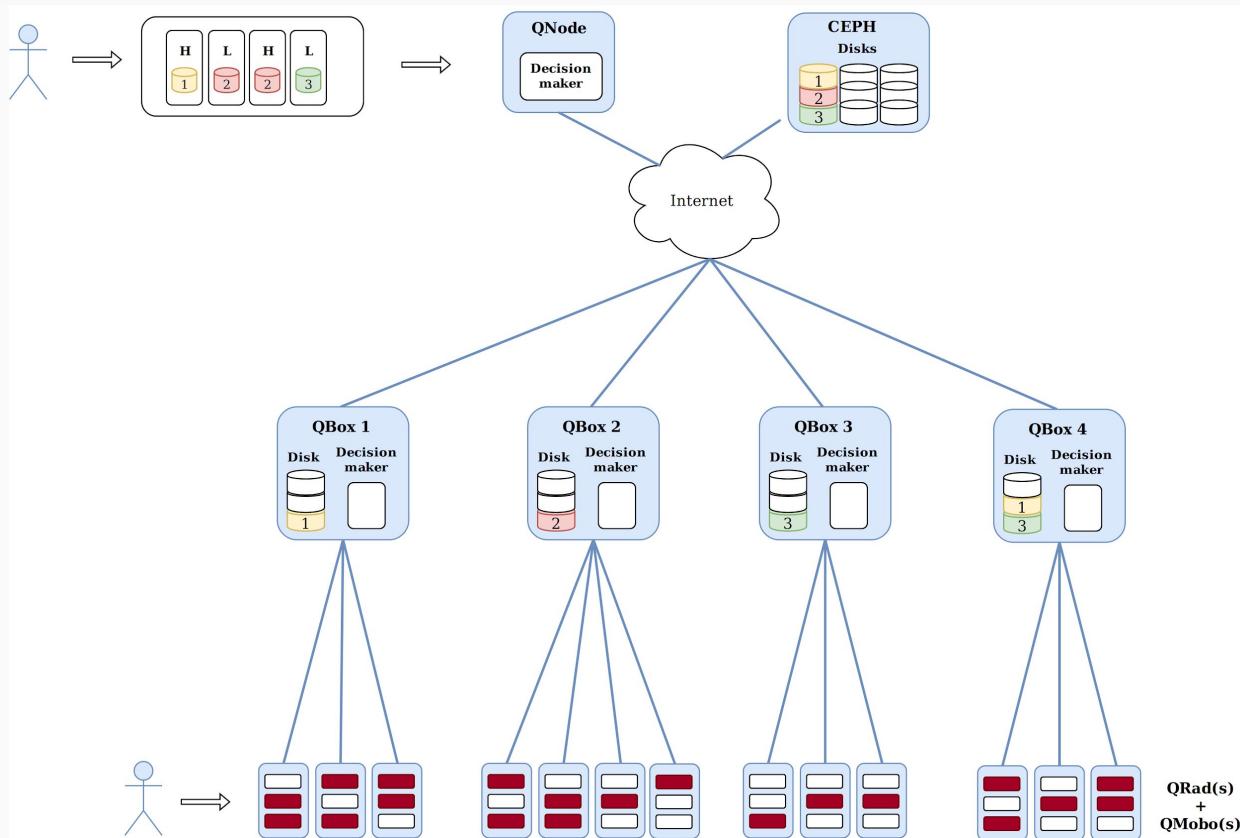
Job's detail:

- Priorities: Background, Low, High
- Data sets dependencies

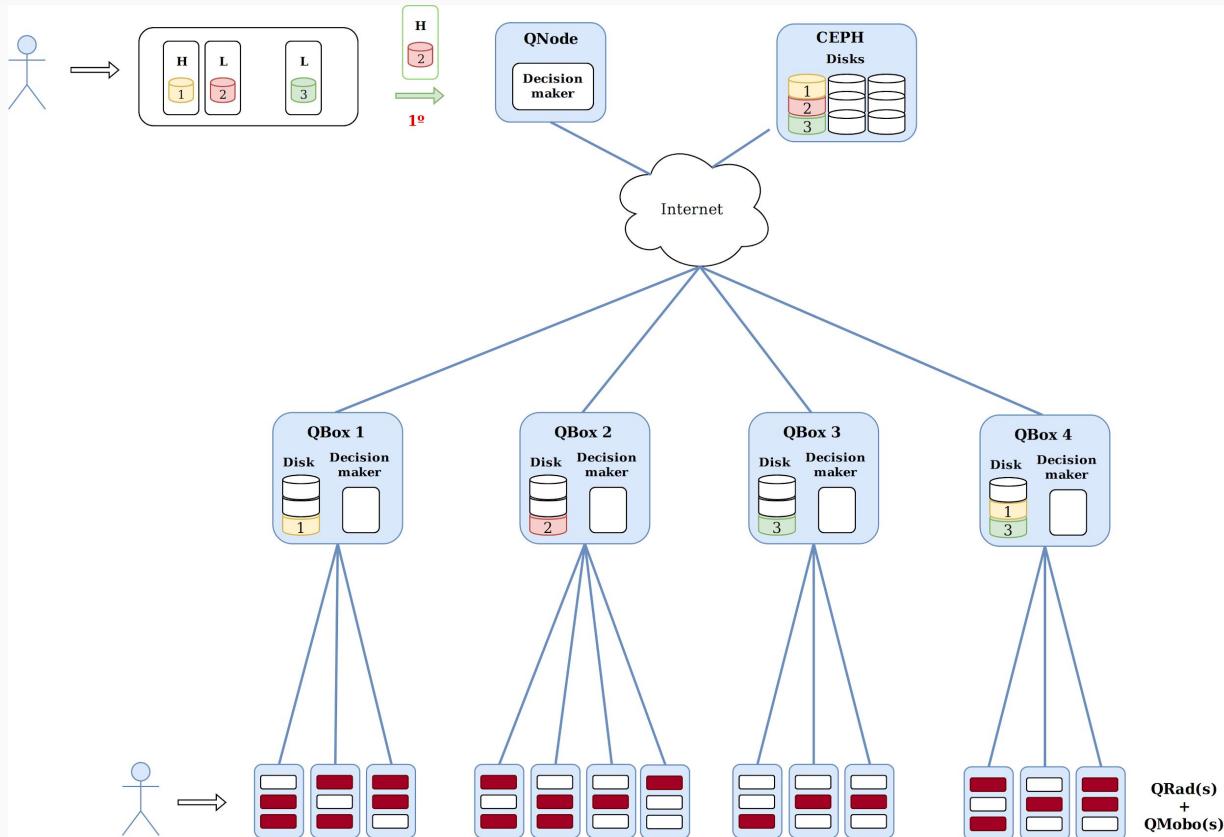
Qarnot Infrastructure



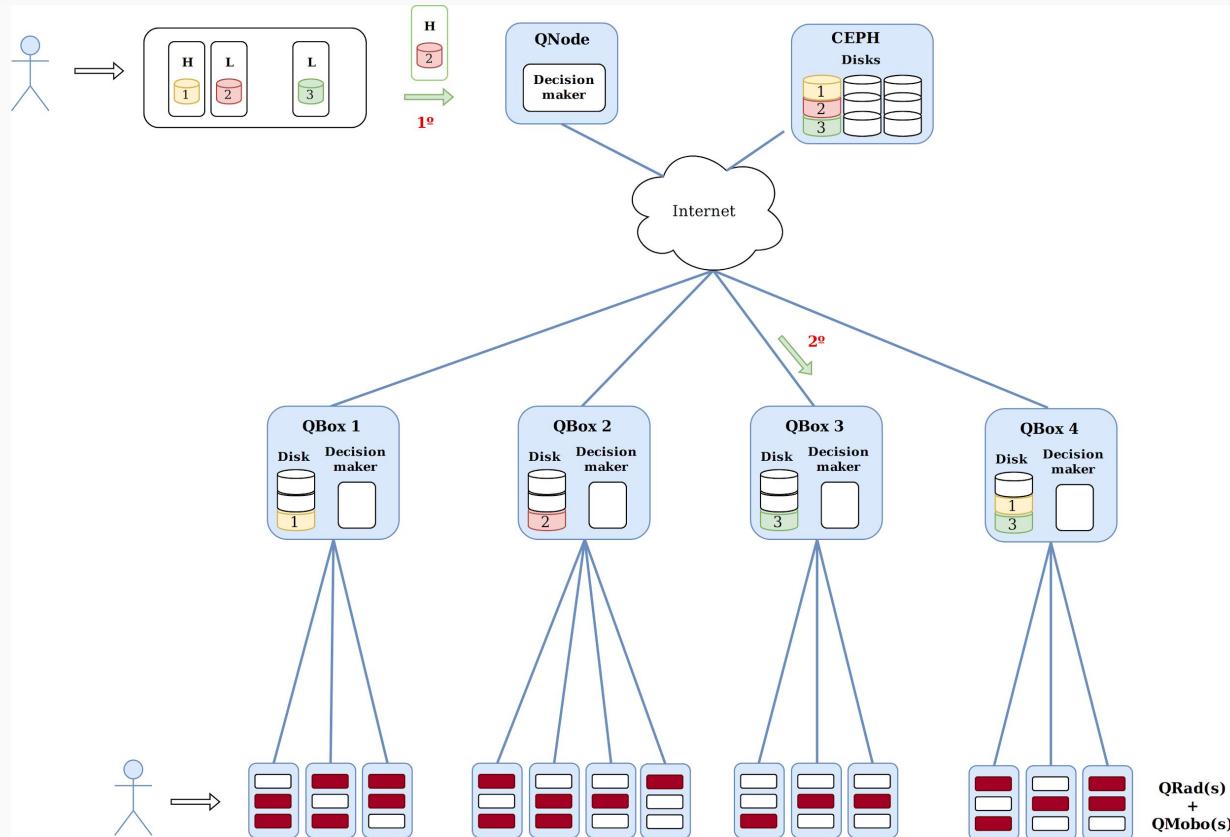
Job Allocation Policies - Standard



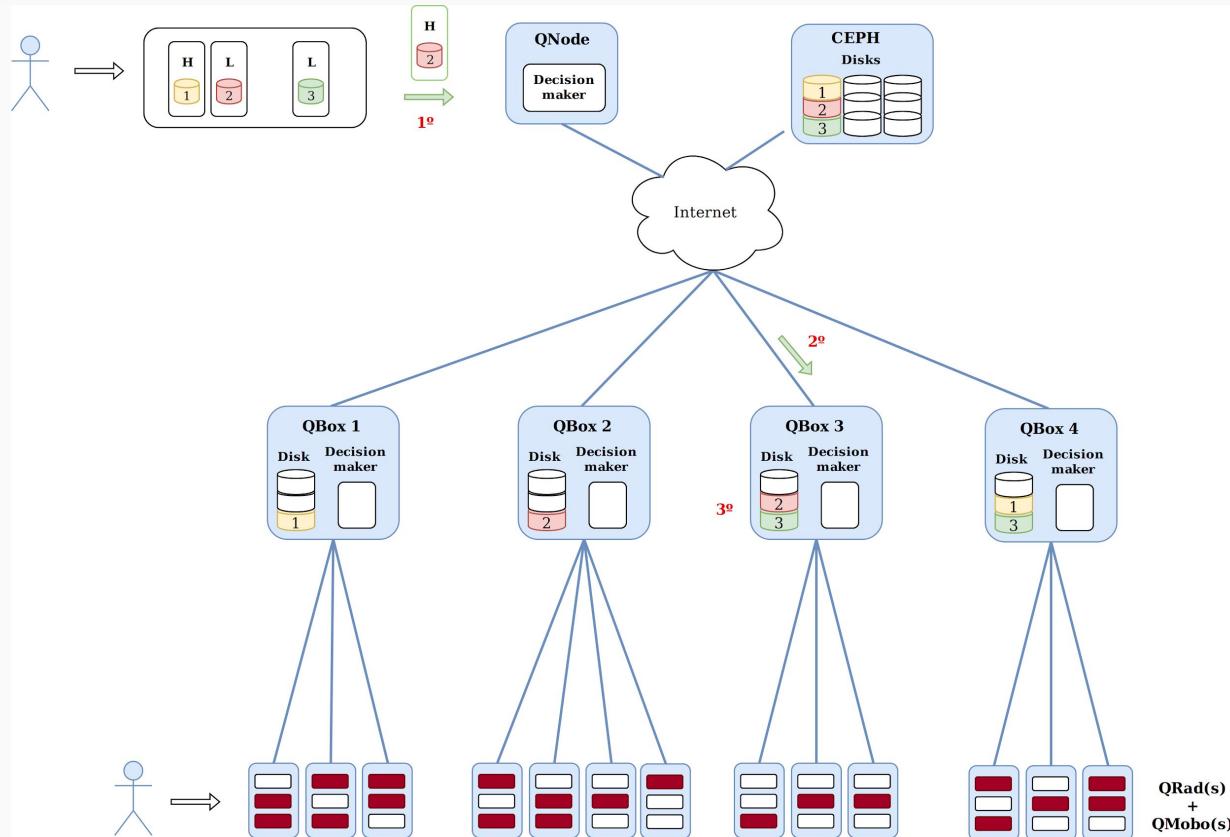
Job Allocation Policies - Standard



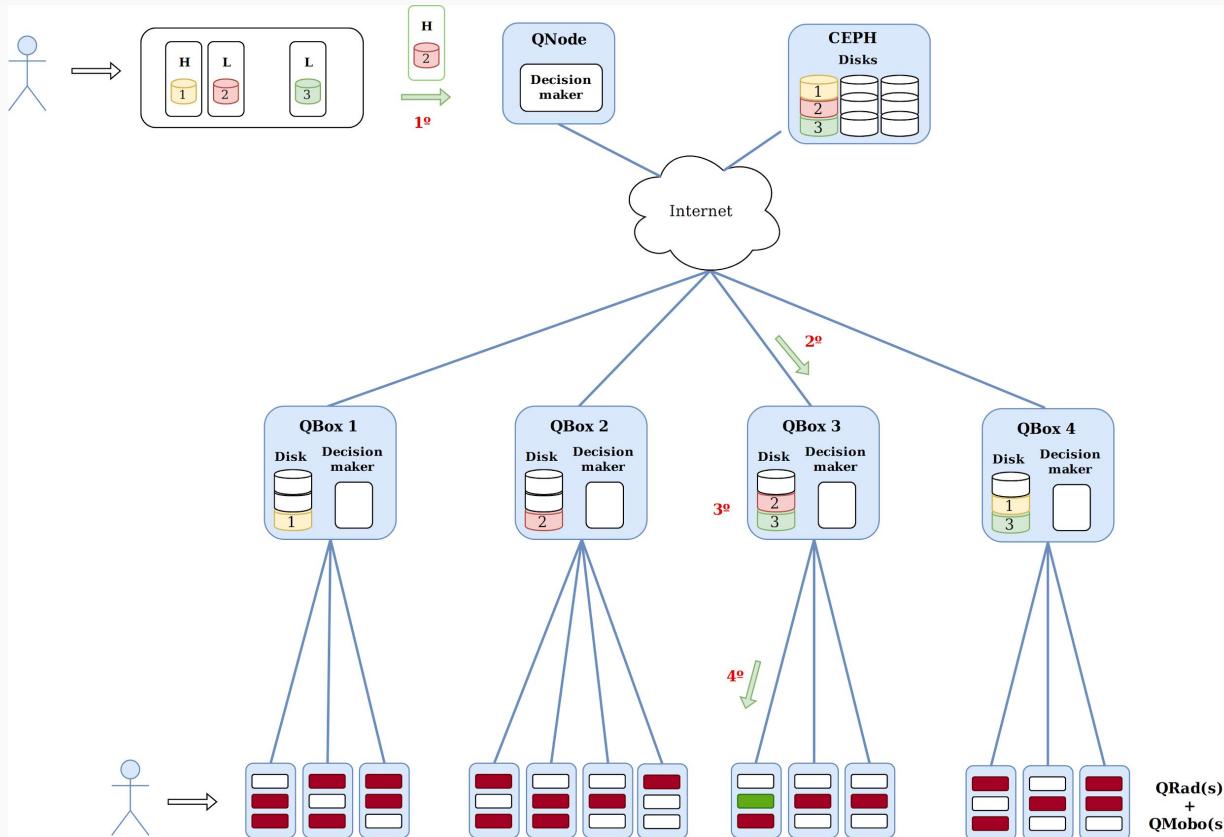
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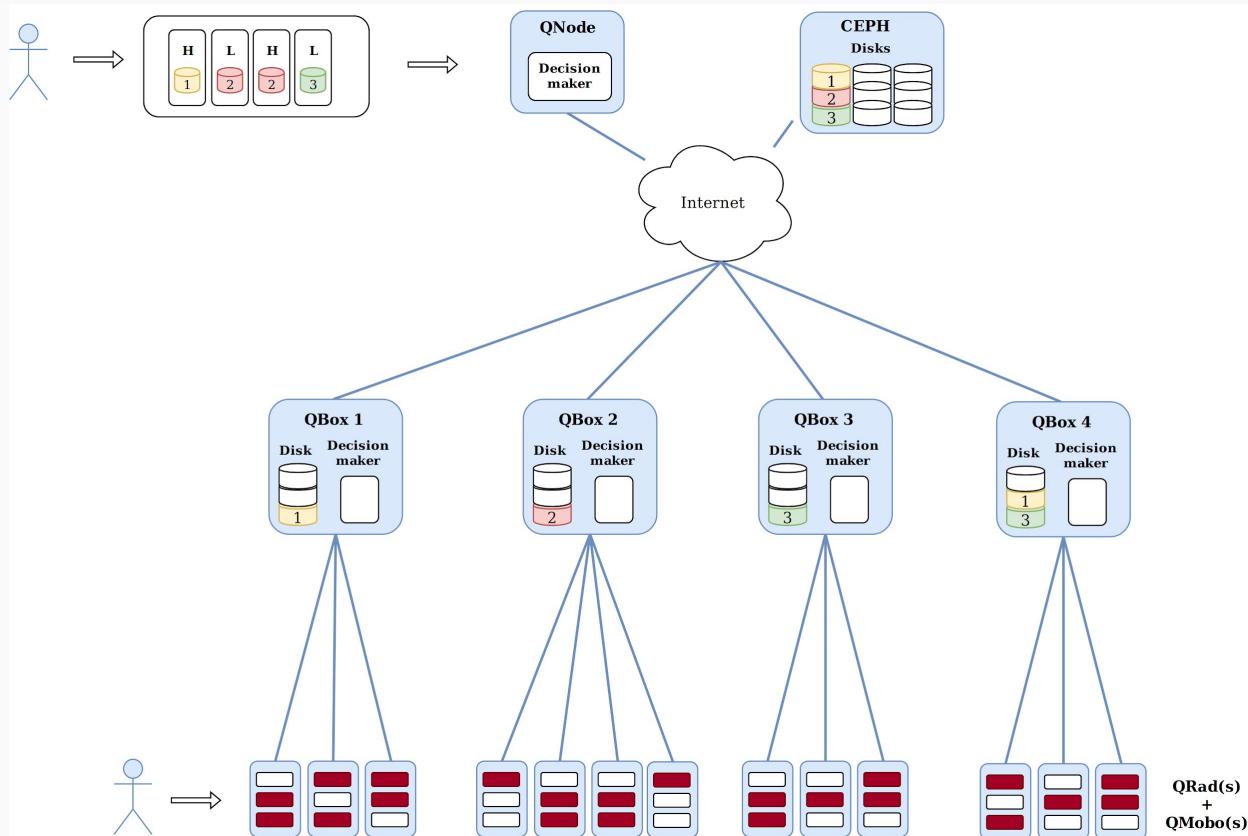
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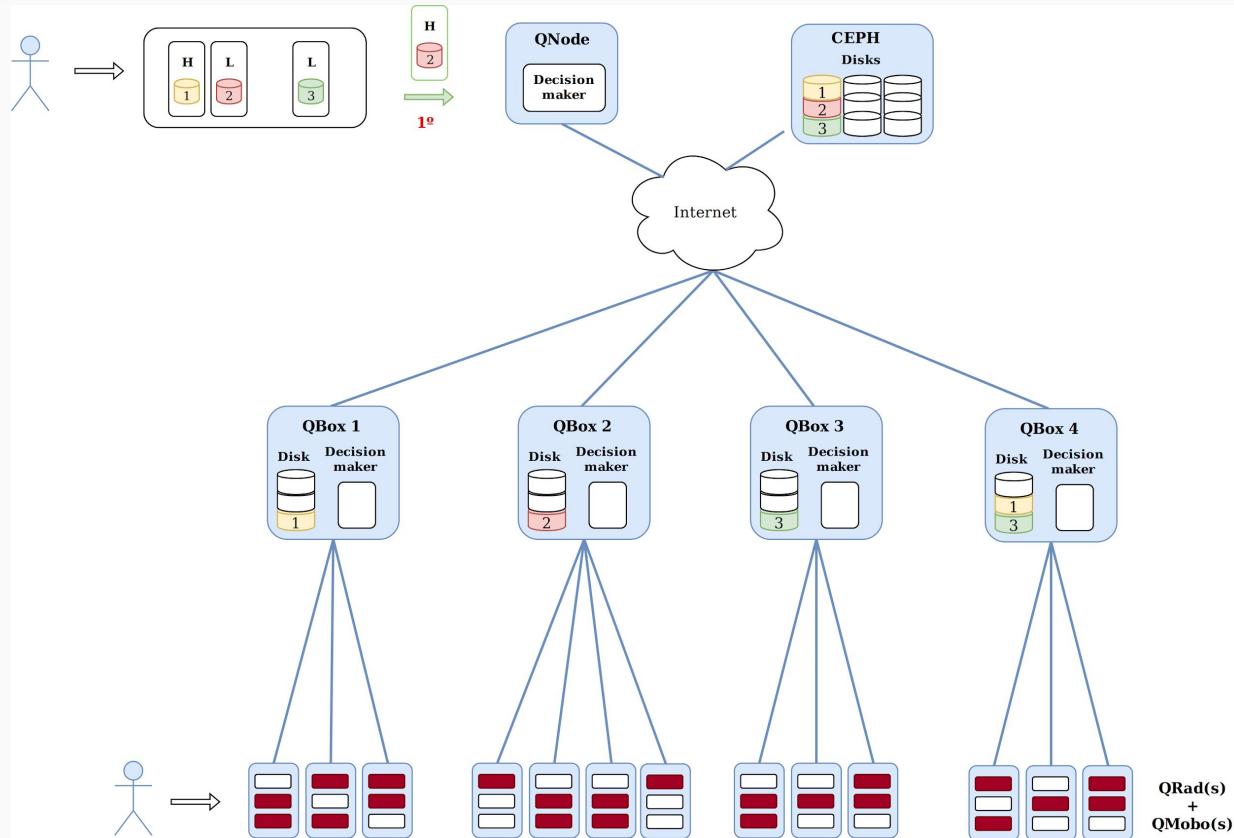
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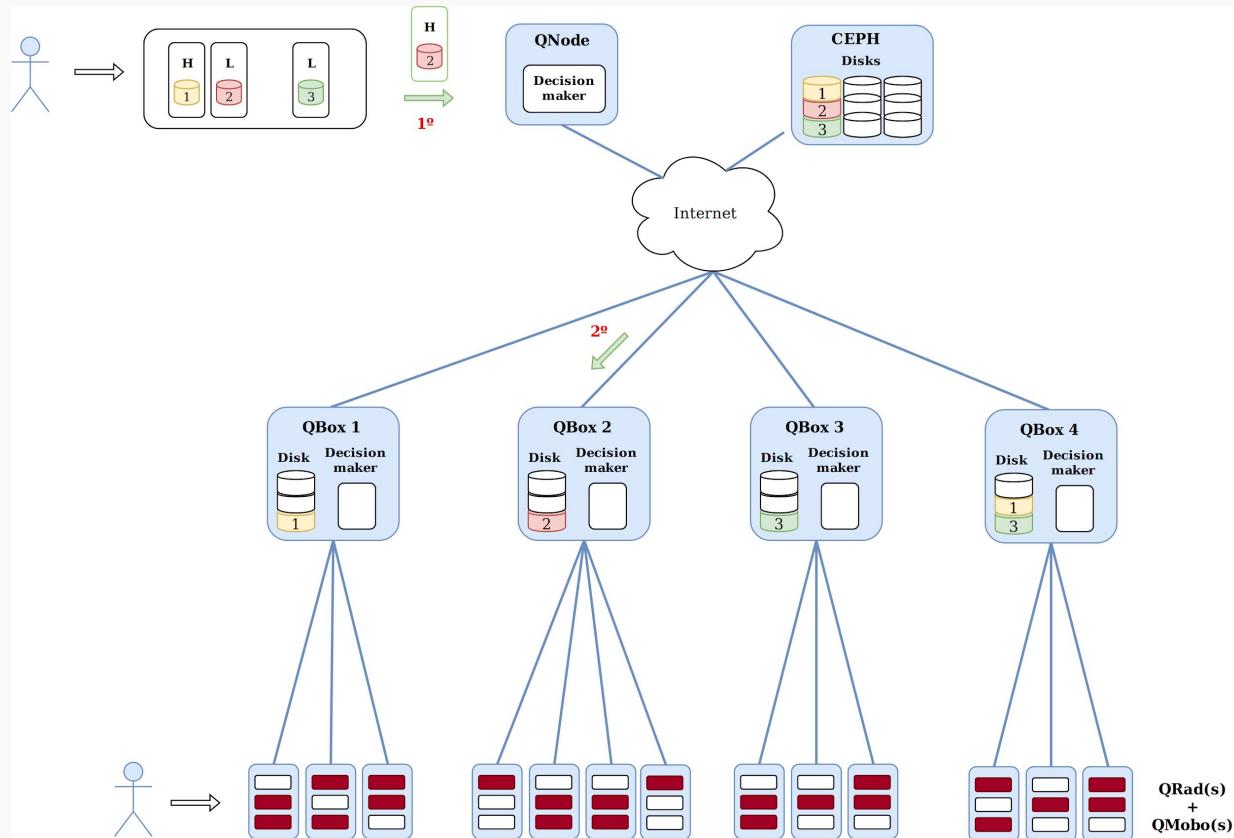
Job Allocation Policies - Locality Based



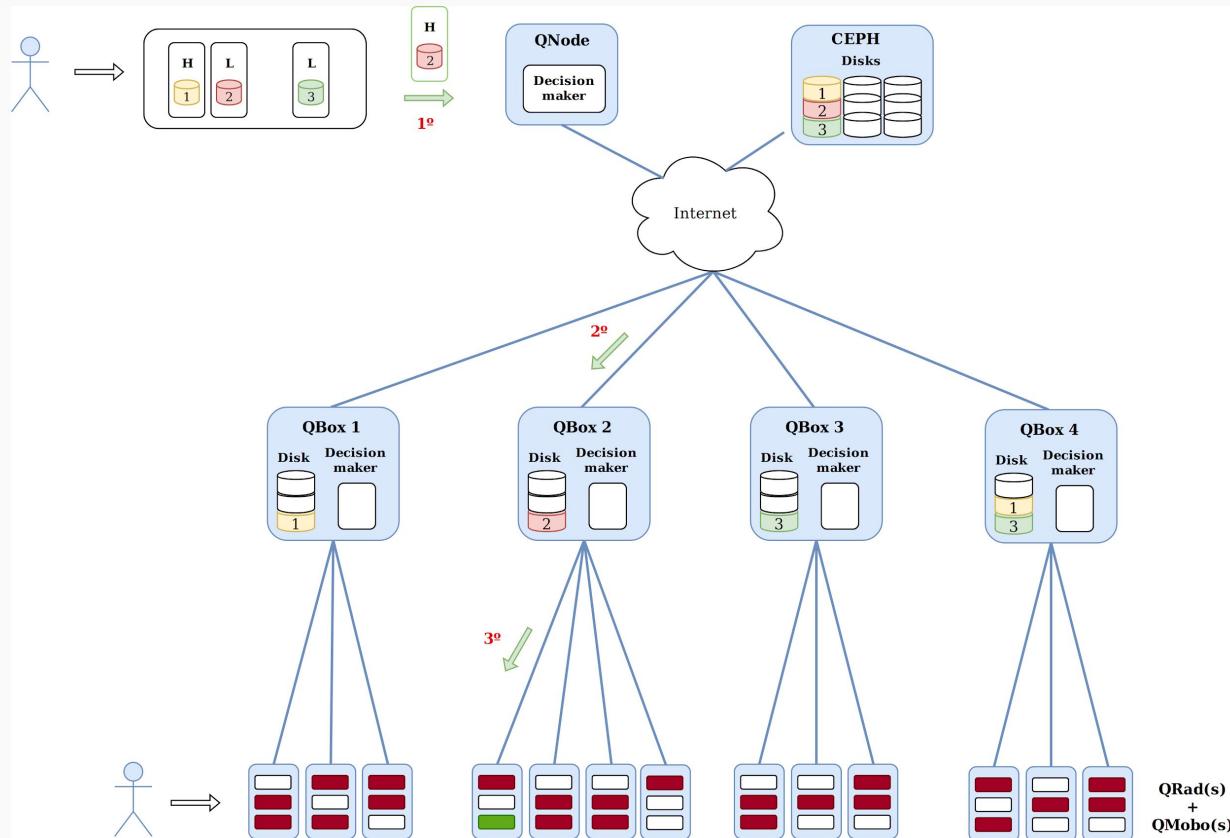
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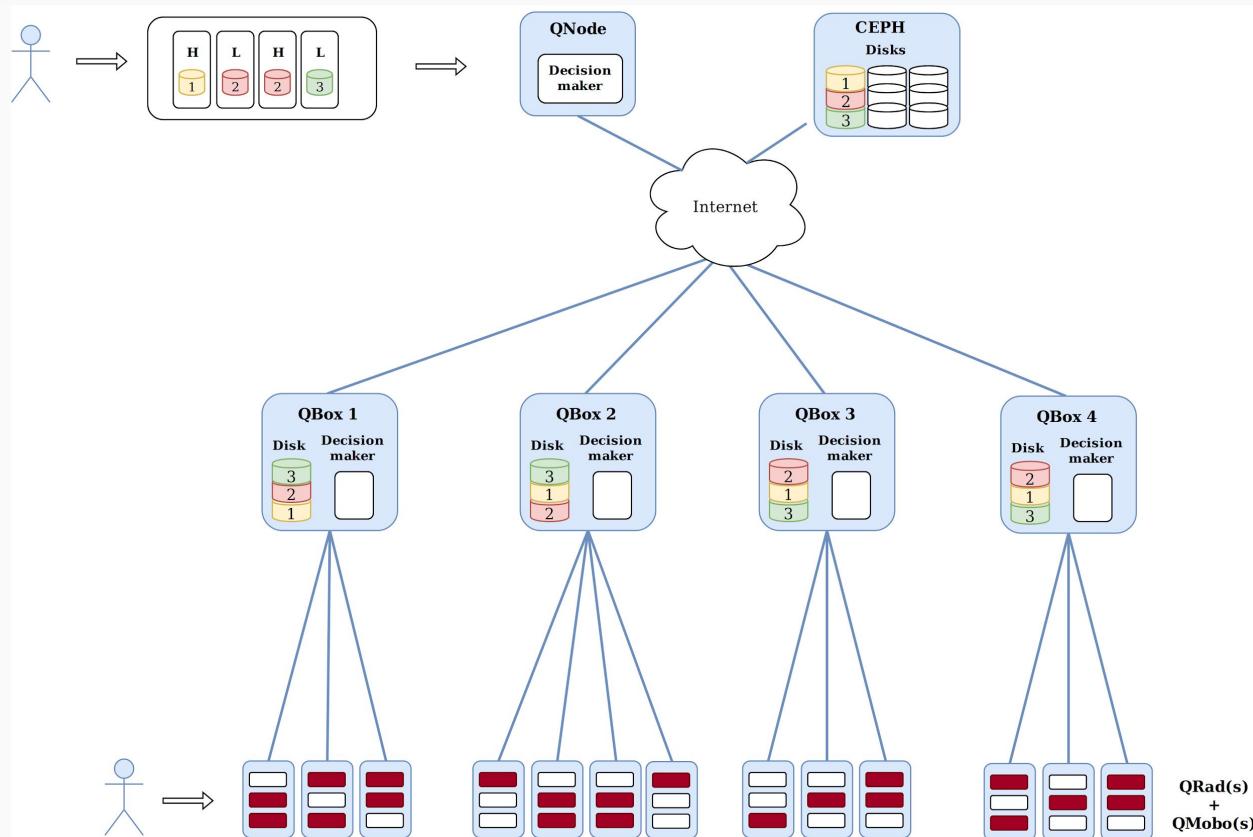
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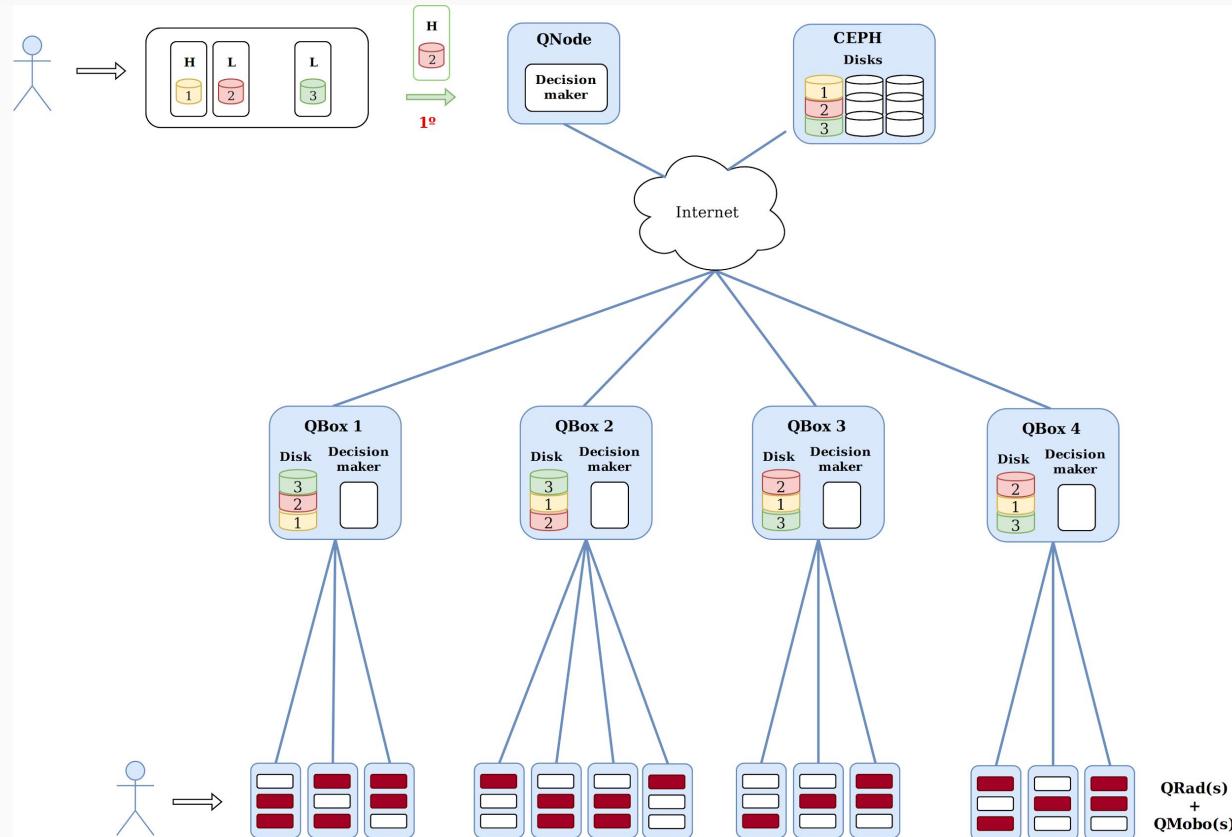
Job Allocation Policies - Locality Based



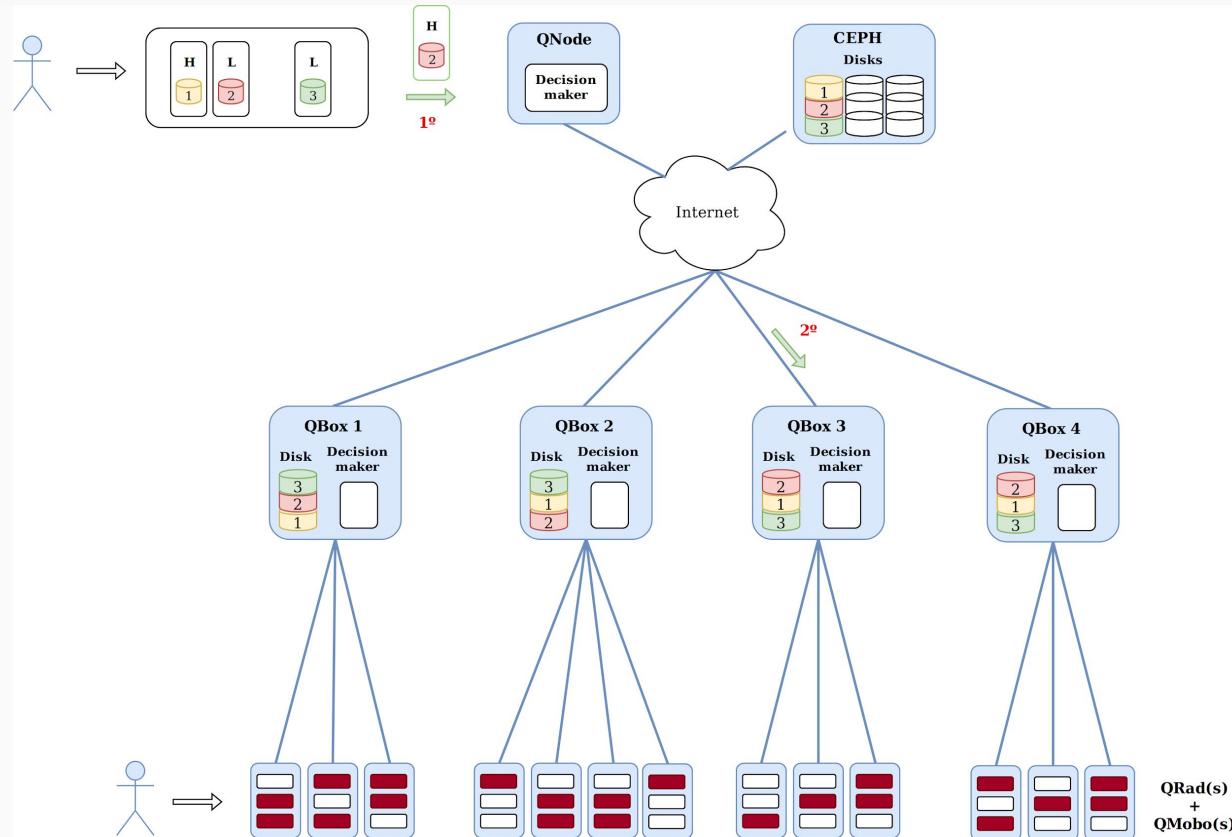
Job Allocation Policies - Full Replicate



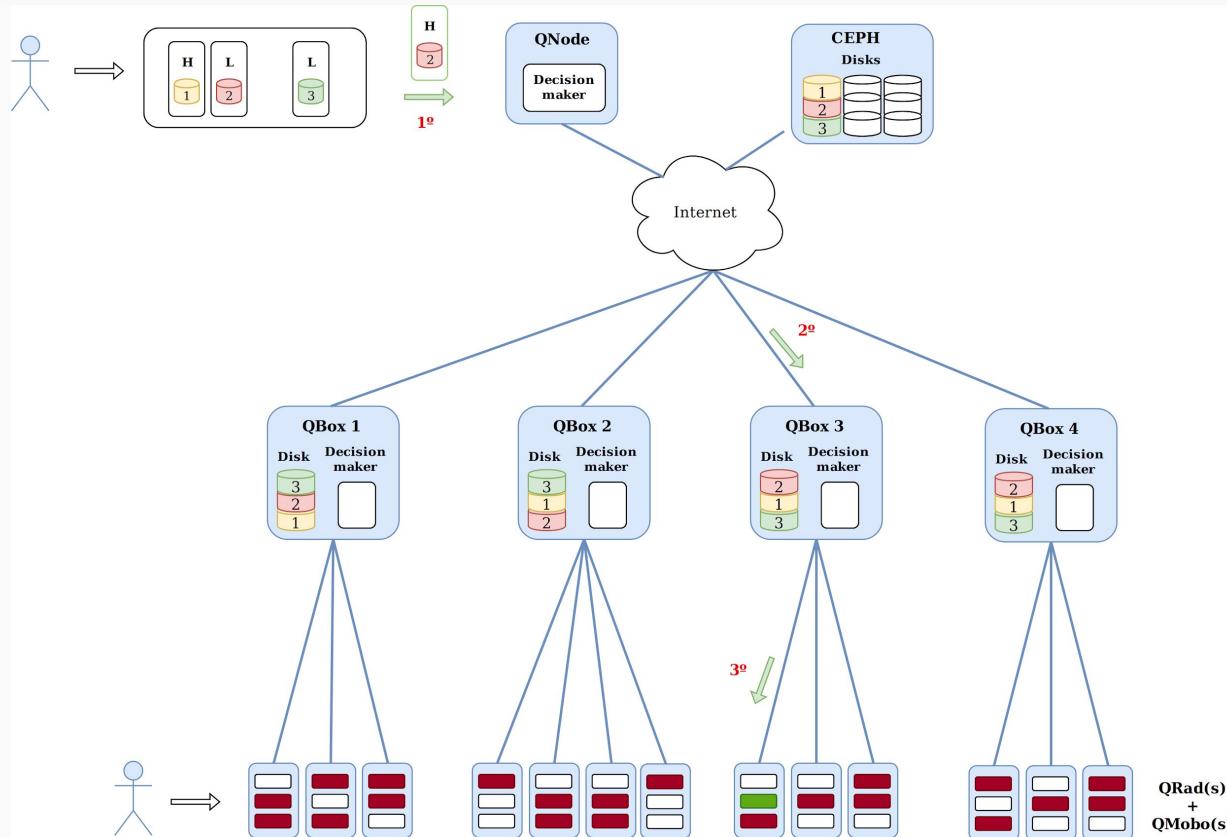
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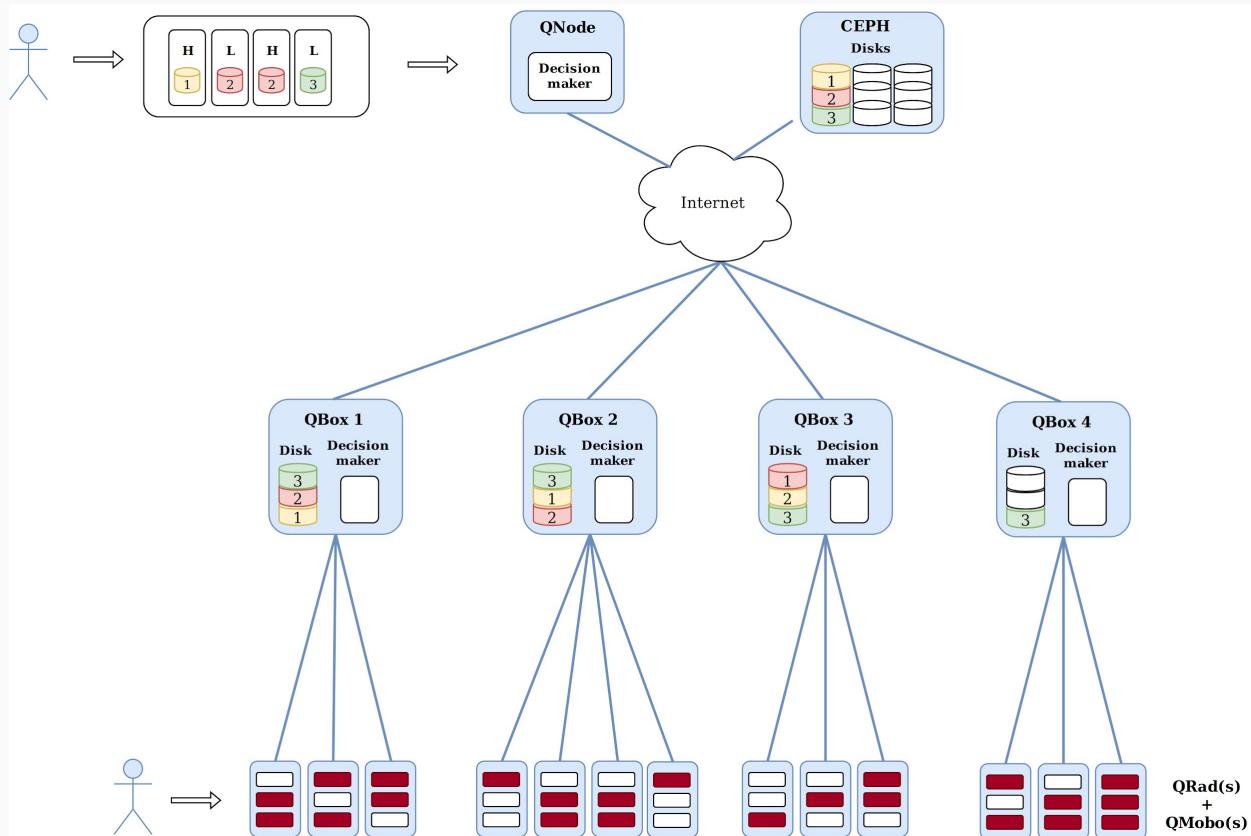
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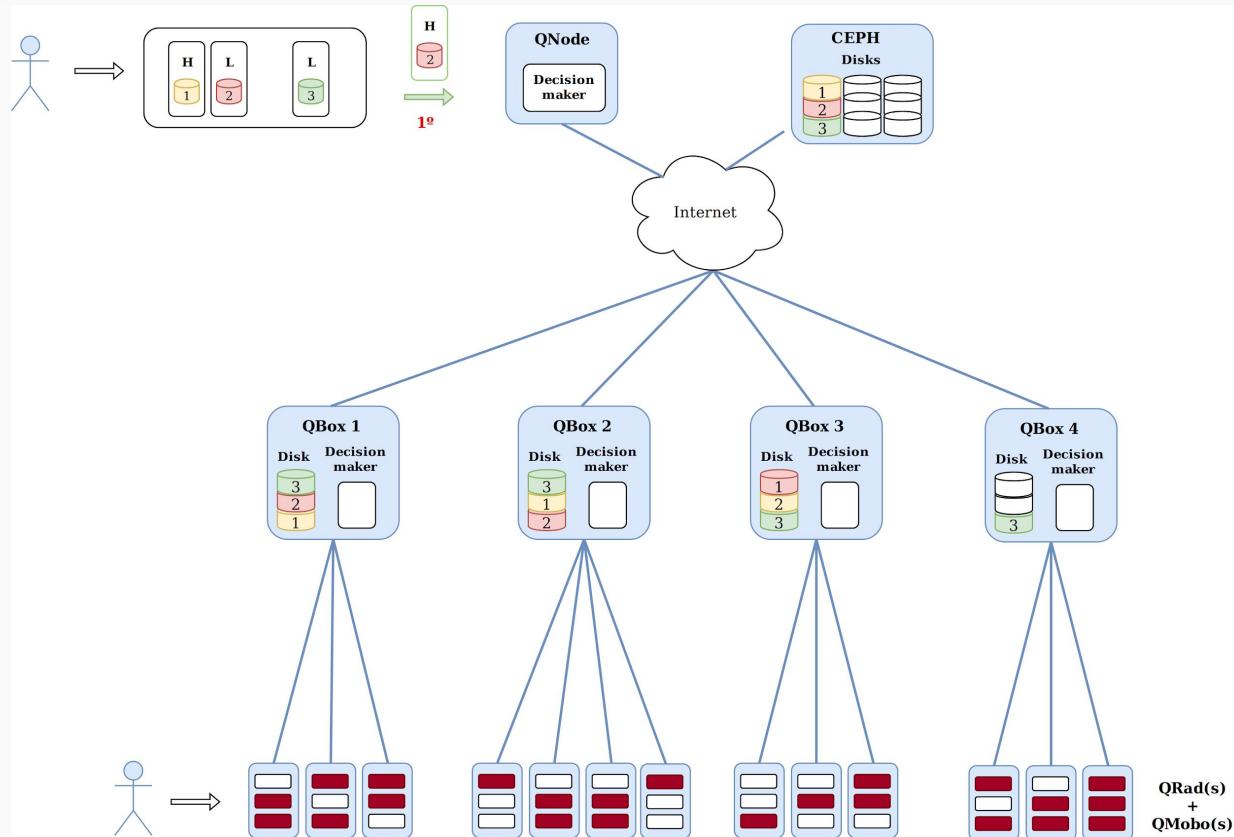
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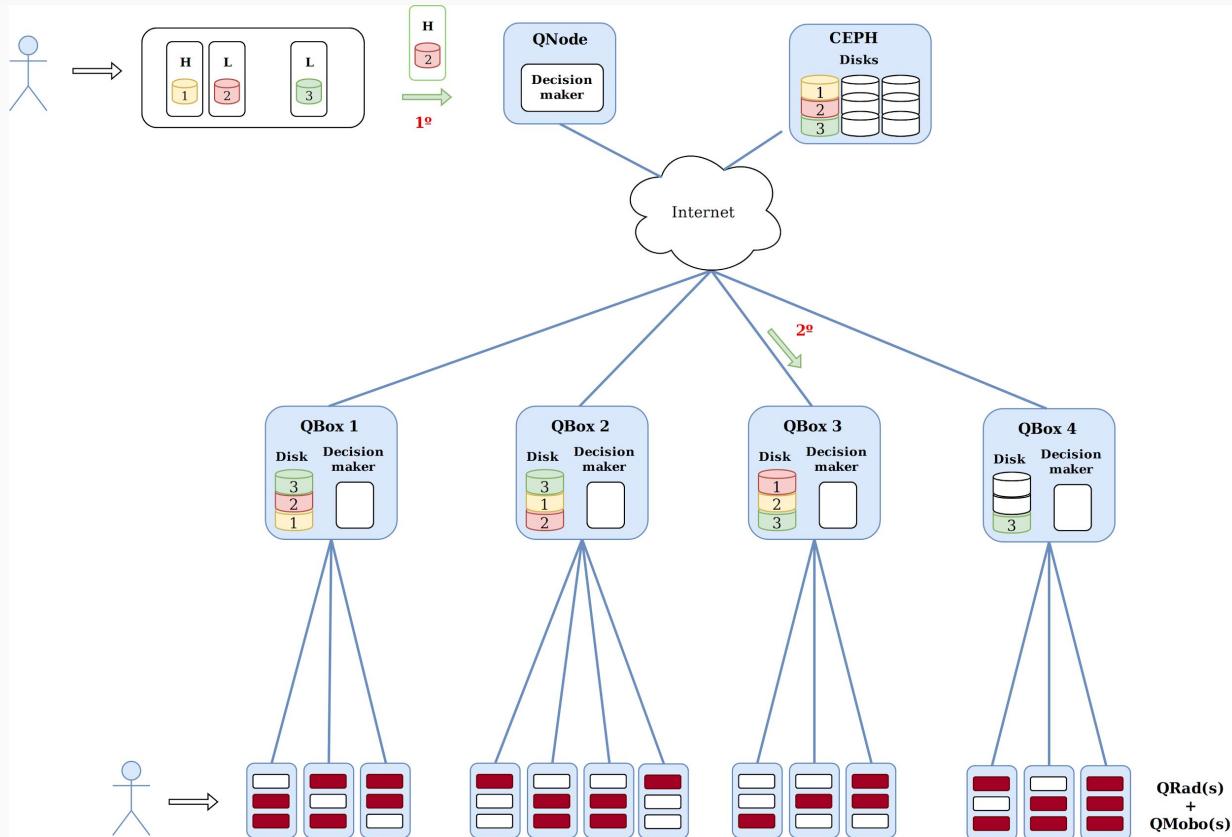
Job Allocation Policies - 3/10 Replicate



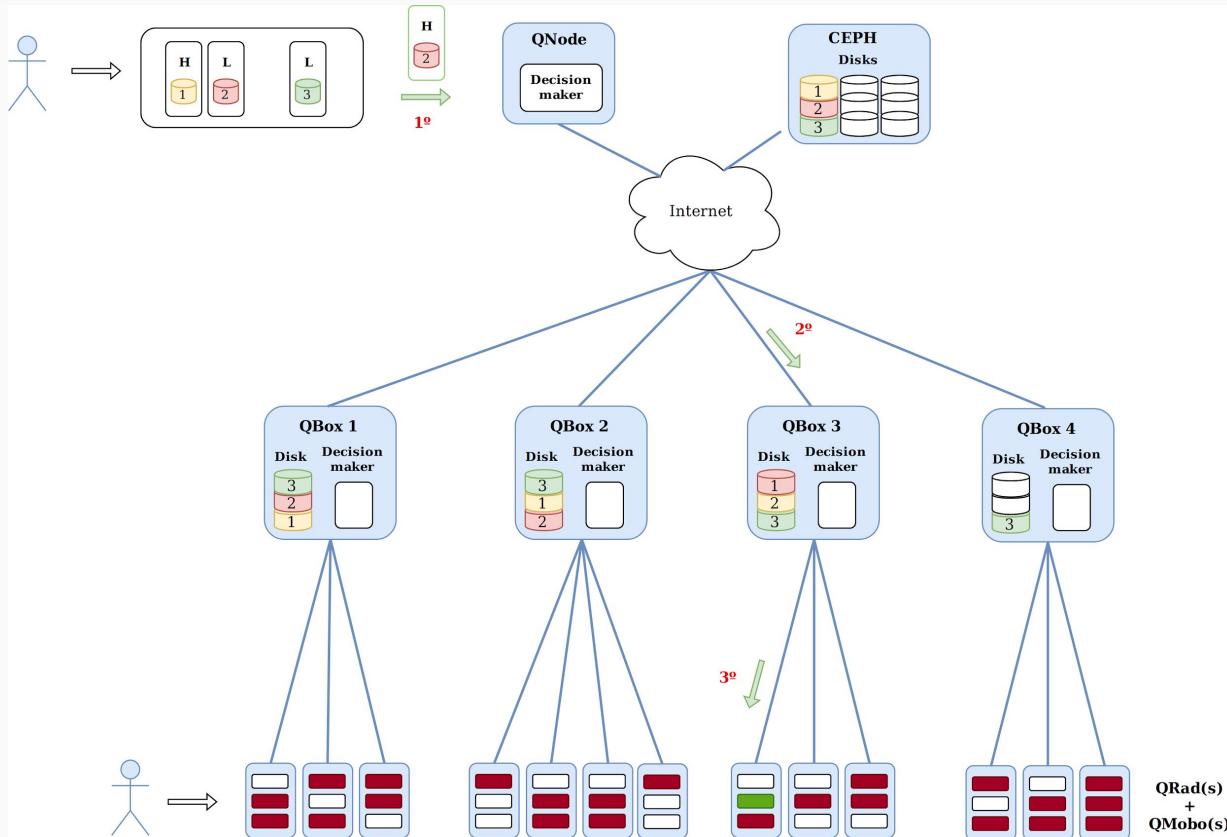
Job Allocation Policies - 3/10 Replicate



Job Allocation Policies - 3/10 Replicate



Job Allocation Policies - 3/10 Replicate



Simulated environment:

- **Simgrid (Platform)**: a scientific instrument to study the behavior of large scale distributed systems such as Grids, Clouds, HPC or P2P systems, Simgrid [12].
-
- **Batsim (Infrastructure)**: a dedicated simulator toolkit to help researchers investigate HPC scheduling strategies have been developed, Batsim [15].
- **PyBatsim (Decision maker)**:

Platform Simulators: **Simgrid**

Platform simulator with realistic network and computation models.

Used to simulate the Qarnot platform:

- CPUs in QMobs
- QBox disks and CEPH
- Network links between CEPH and QBox disks

Plugin for temperature support (QRad and ambient air) w.r.t. power consumption.

Platform Simulators: **Batsim**

Infrastructure simulator for jobs and I/O scheduling, built on top of SimGrid.

Completes SimGrid's simulation with:

- The submission of tasks
- The submission of external events (e.g., target/outside temperature change)
- The communication with the decision making process

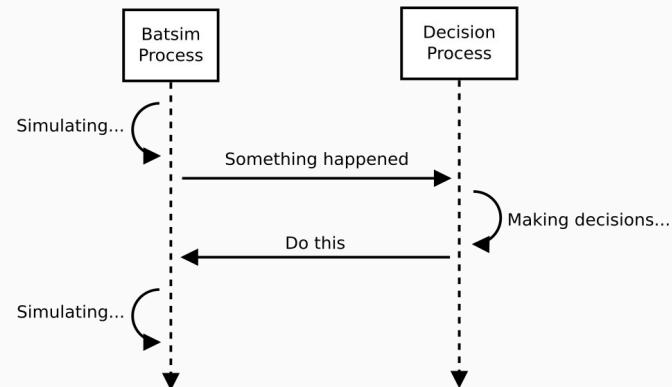
Platform Simulators: PyBatsim

Decision making process.

Talks with the Batsim process via a socket

Manages:

- The dispatch of tasks/instances (QNode scheduler)
- The placement of instances (QBox scheduler)
- The different storages and data movements (Storage Controller)
- The heating needs (Frequency Regulator)



Platform Simulators: Qarnot extractor

Generates from the InfluxDB logs a set of files given as input for a simulation:

- The platform description
- The list of instances
- The list of external events
- The list of datasets

Extracts other data to be compared with the simulation outputs:

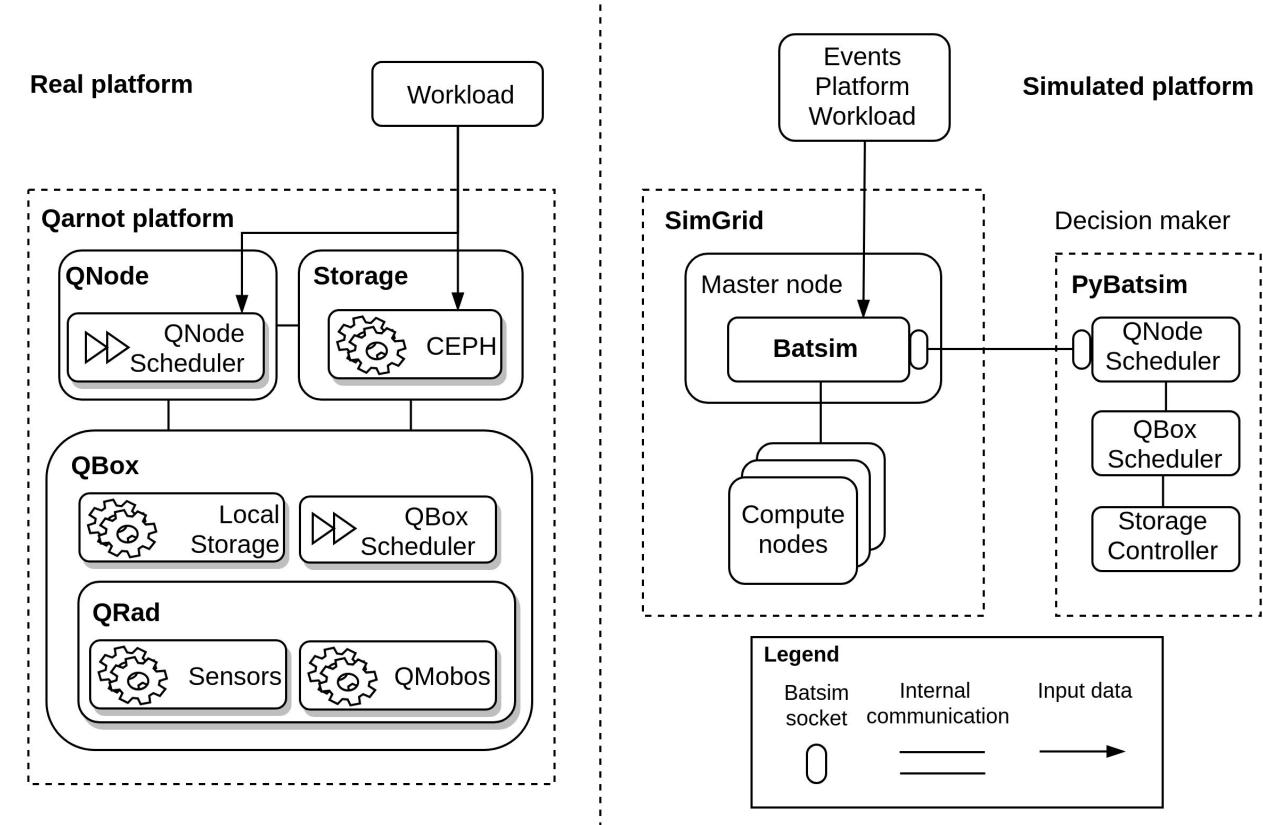
- Logs of ambient temperature
- Logs of instances placements (not implemented yet)

Platform Simulators: Limitations

- No cluster tasks
- No booting time of QMobos before starting instances
- No real values of power/speed of CPUs
- Empty initial state of the platform
- No external event “QMobo X becomes (un)available” (do we want that?)

Qarnot Extractor:

- Workloads
- Data sets
- Events
- Platform



Experiments

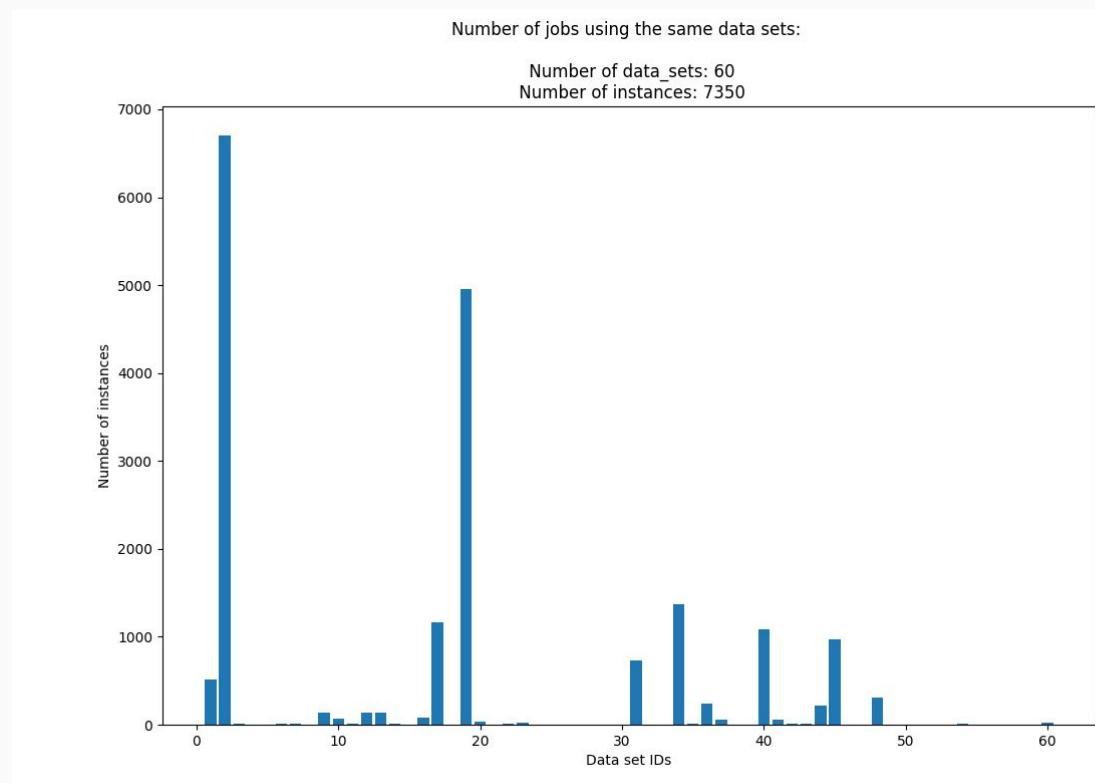
Assumptions:

- Workloads-size : 1 day, 3 days, 1 week and 3 weeks

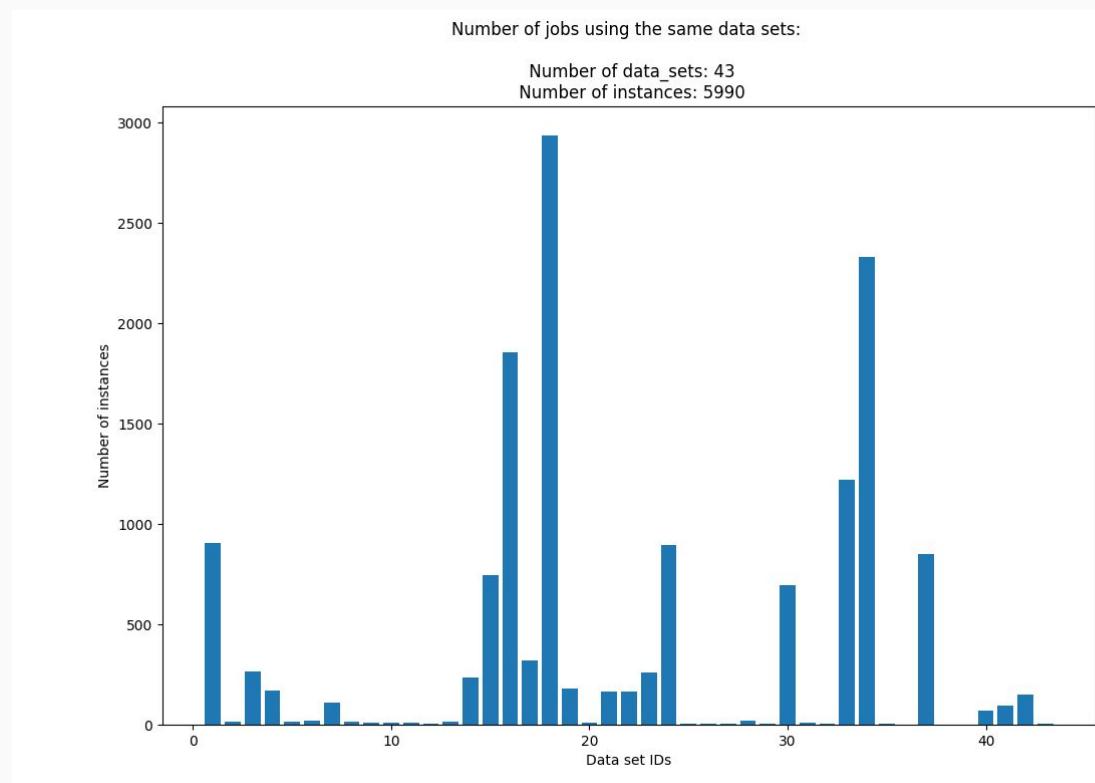
Analyses of results

- Jobs' processing time
- Data set dependencies
- Job allocation metrics
 - Number of data transfers
 - Total data transferred (GB)
 - Bounded Slowdown

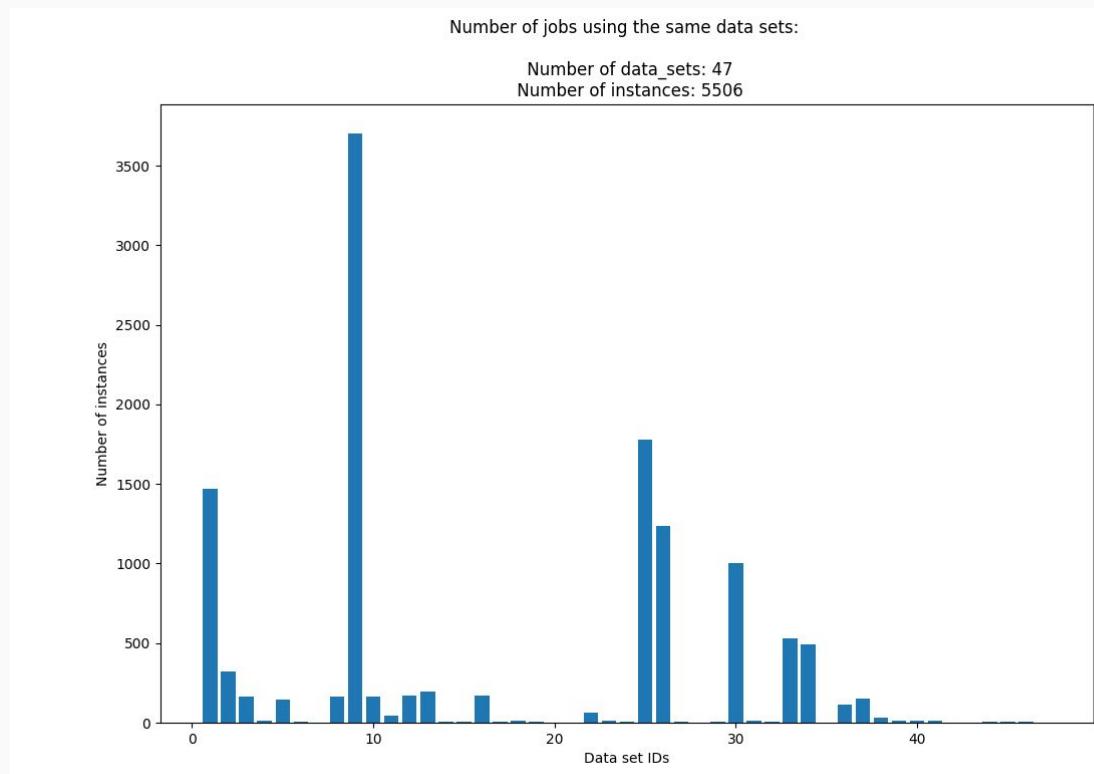
Analyses of Results: Data Sets Dependencies



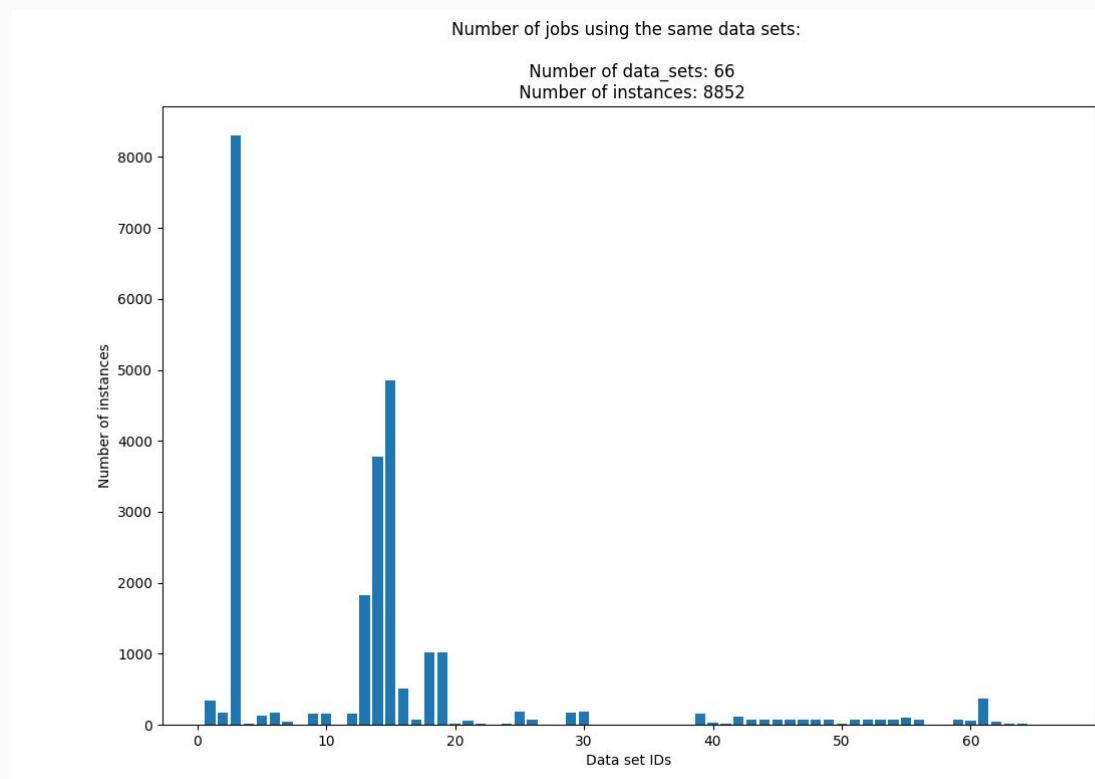
Analyses of Results: Data Sets Dependencies



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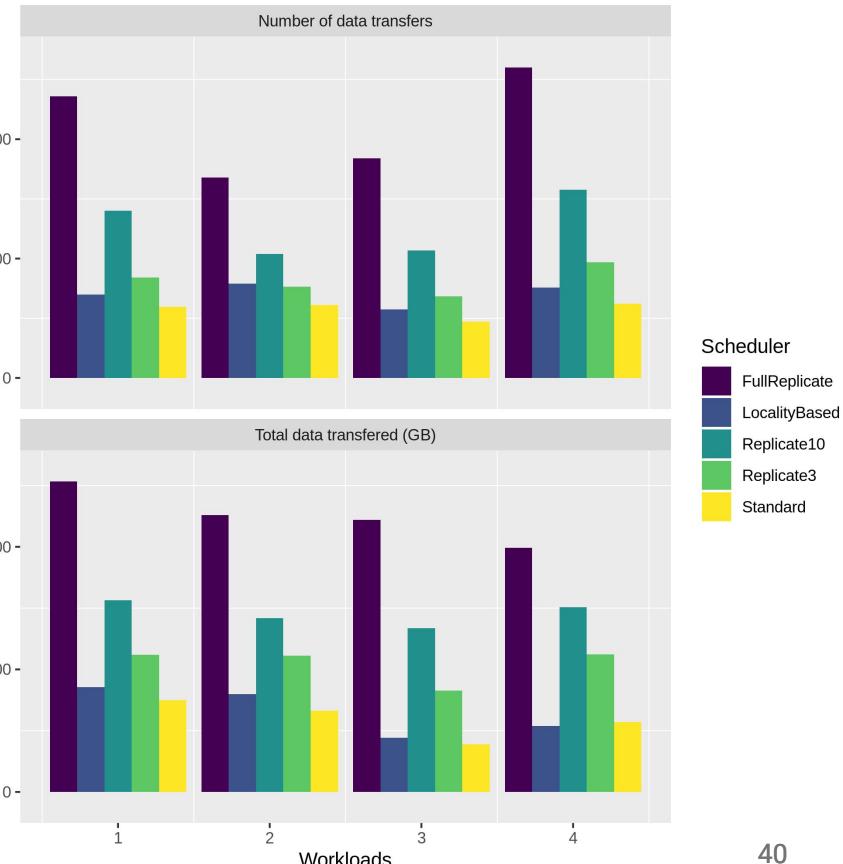
Analyses of Results: Data Sets Dependencies



Analyses of Results: Data Transfer

Workload:

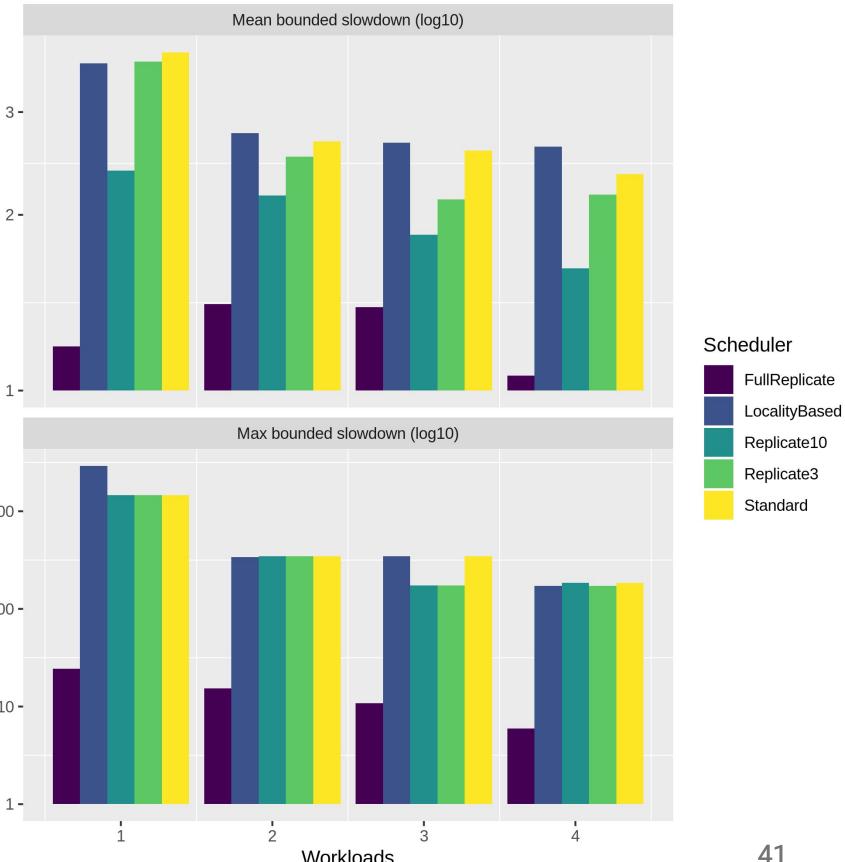
1 week (1-7 of march) :
~600 QRads
~12,000 jobs



Analyses of Results: Bounded Slowdown

Workload:

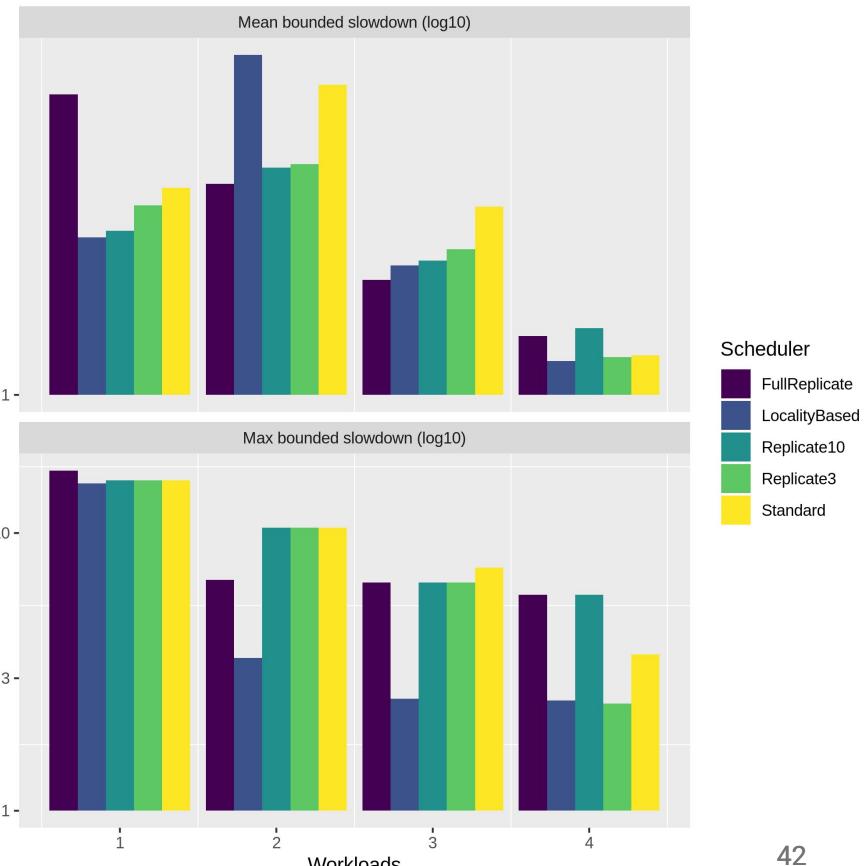
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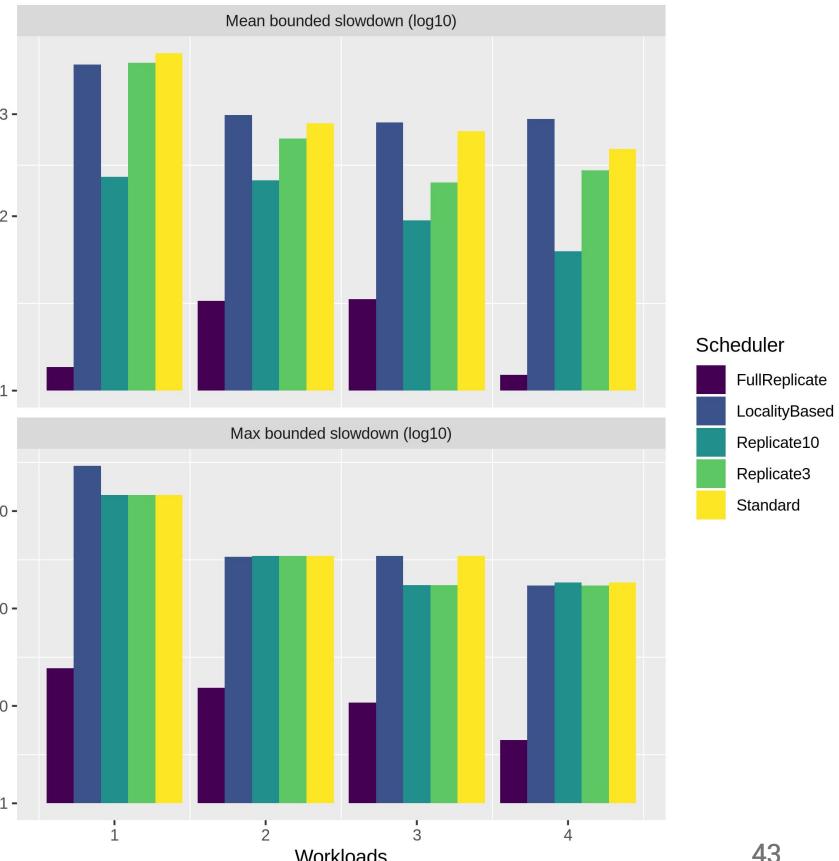
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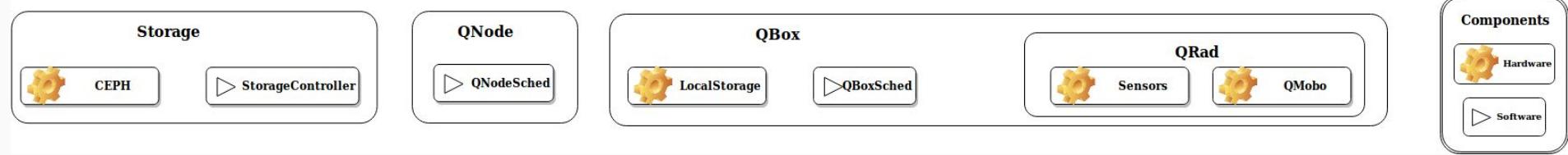


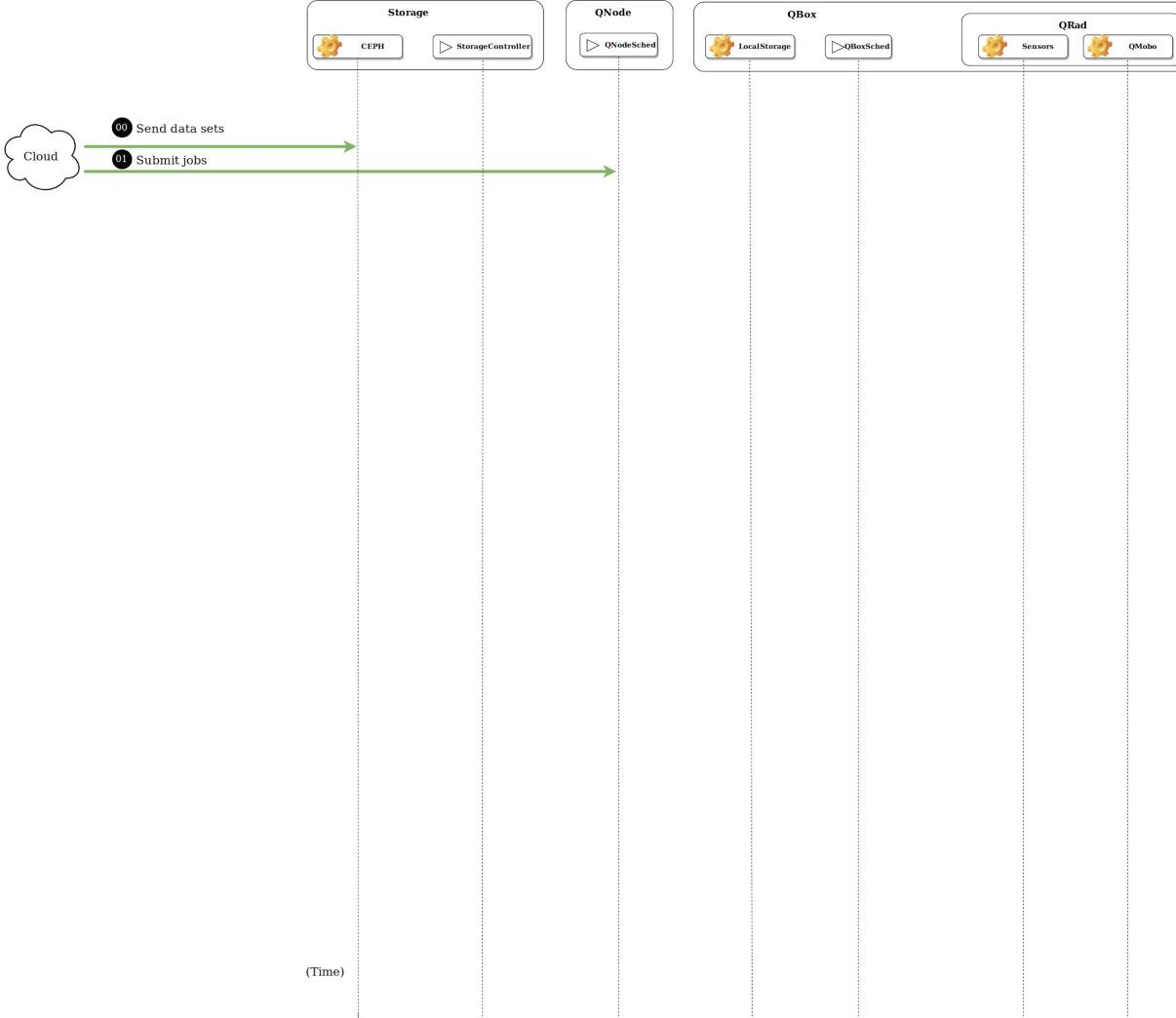
Conclusion and Further Remarks

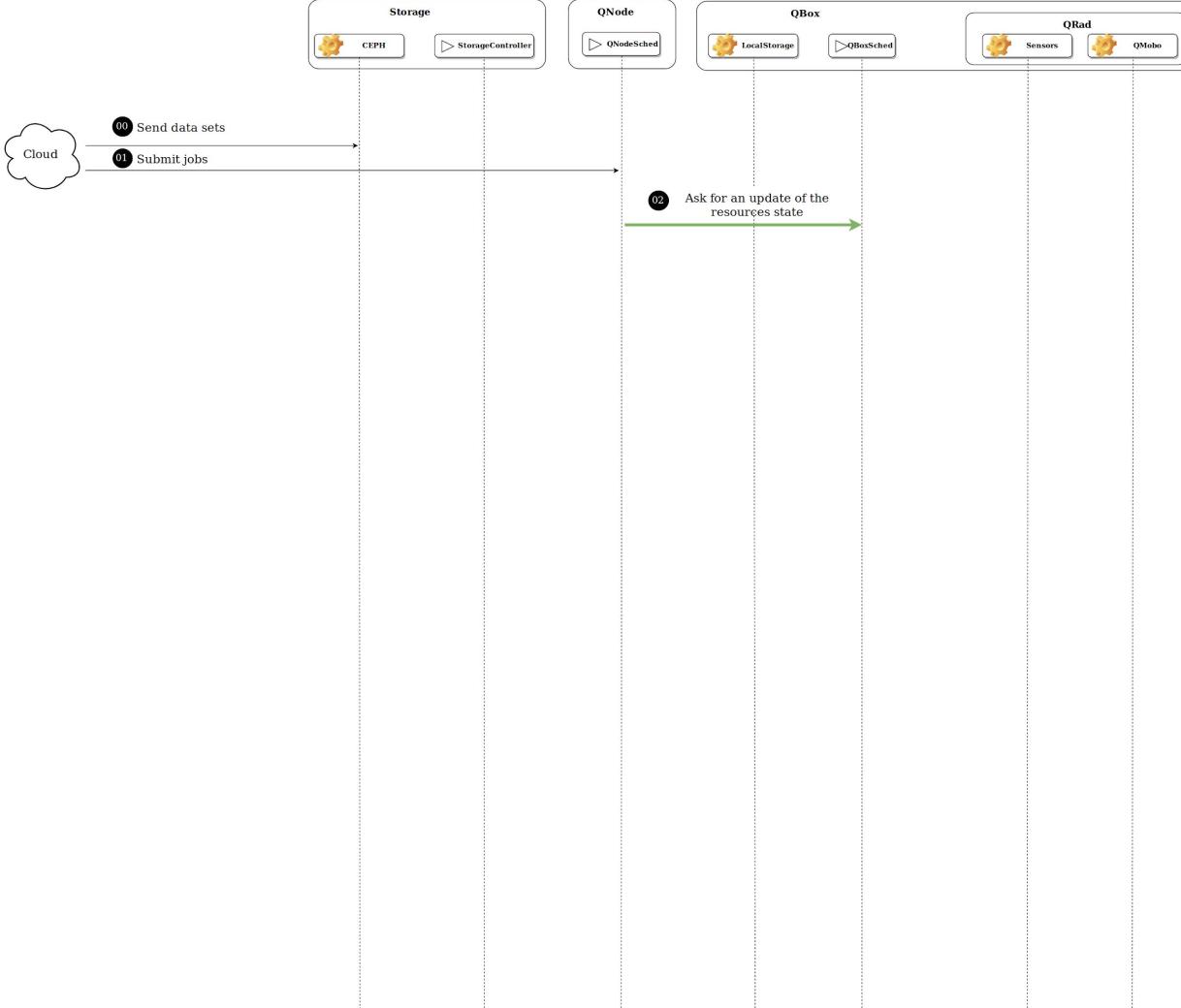
Bibliography

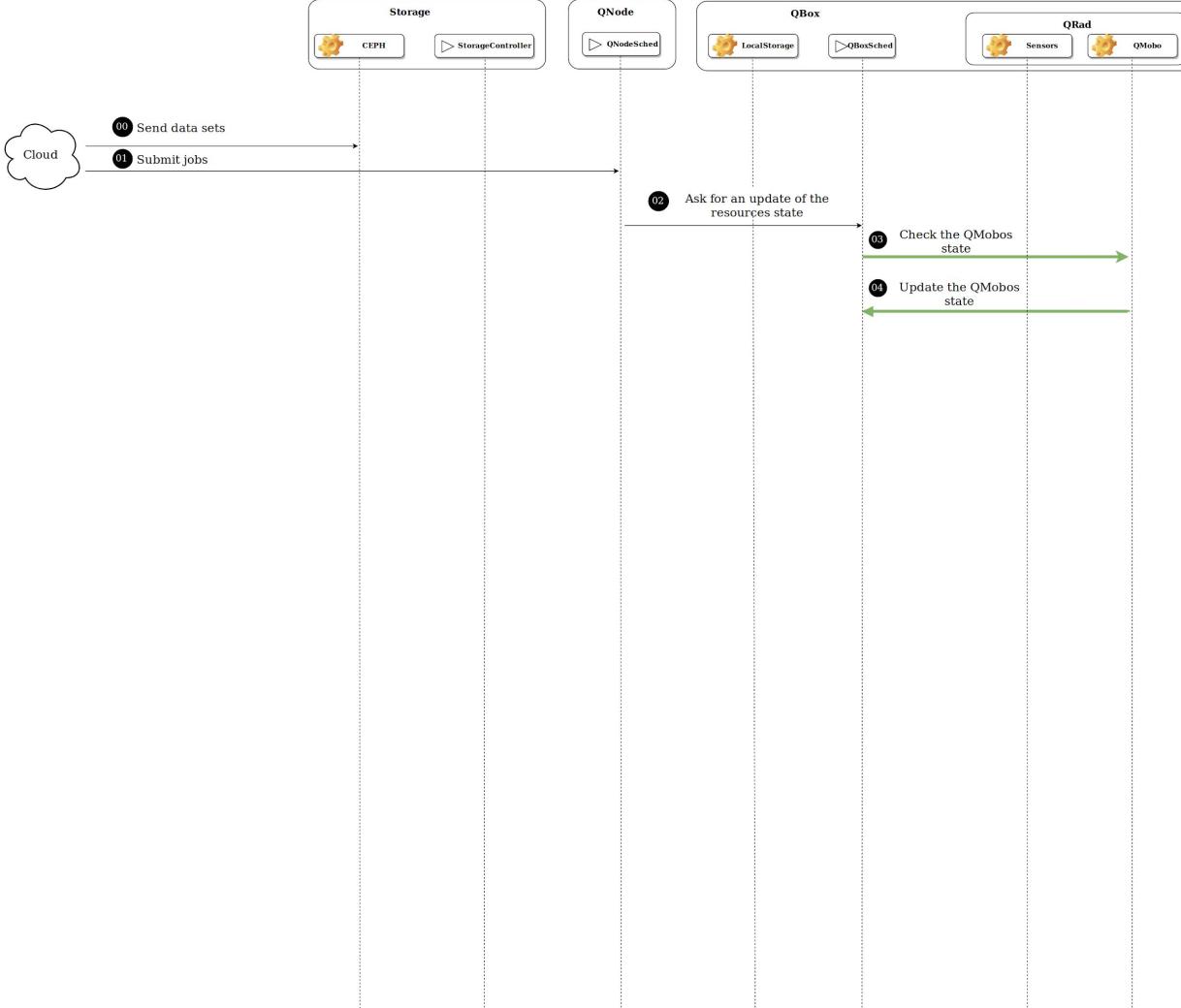
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- [39] W. Shi and S. Dustdar. The promise of edge computing. *Computer*, 49(5):78–81, May 2016.
- [9] Luiz Bittencourt, Roger Immich, Rizos Sakellariou, Nelson Fonseca, Edmundo Madeira, Marilia Curado, Leandro Villas, Luiz DaSilva, Craig Lee, and Omer Rana. The internet of things, fog and cloud continuum: Integration and challenges. *Internet of Things*, 3-4:134 – 155, 2018.
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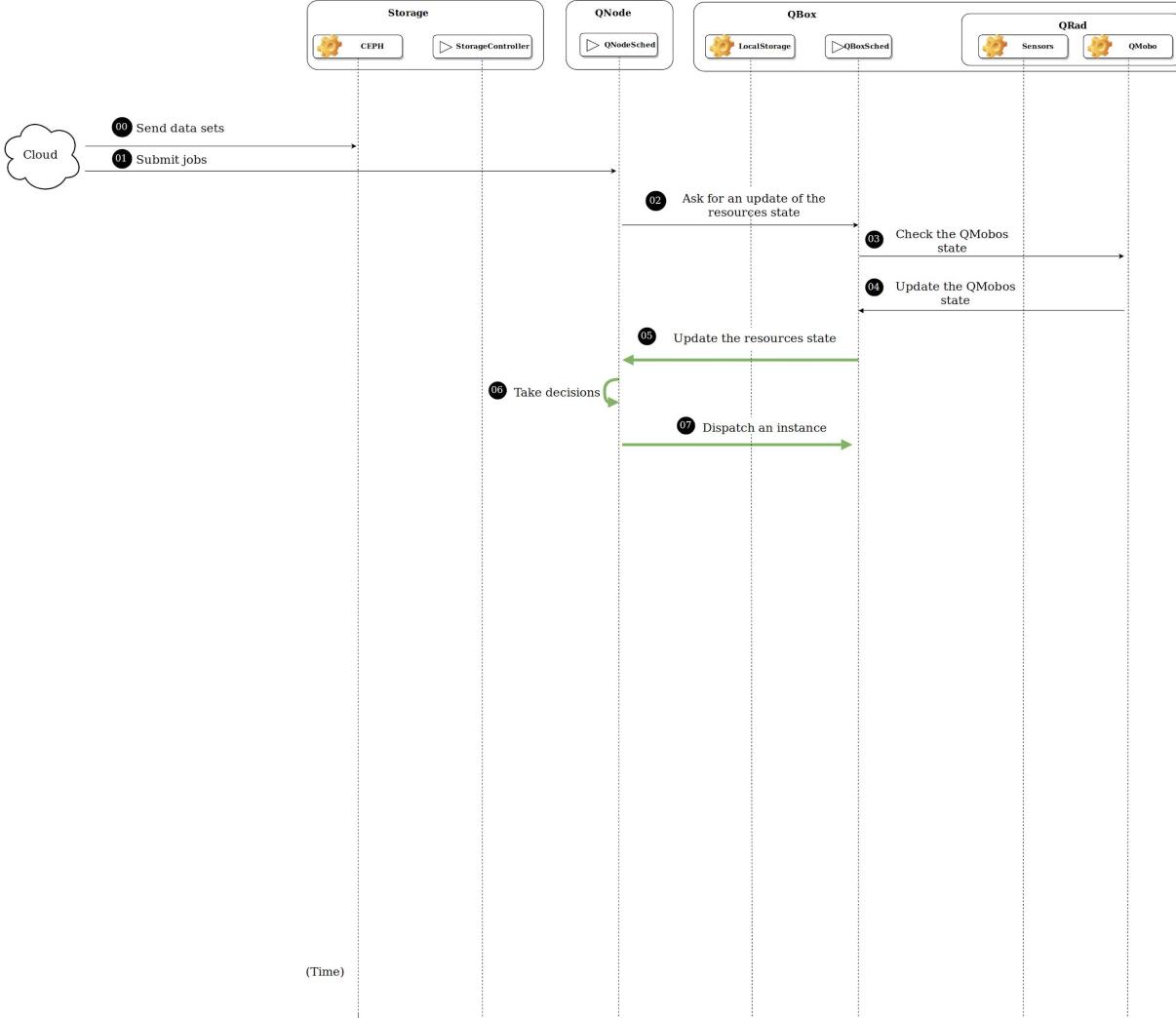
The real platform

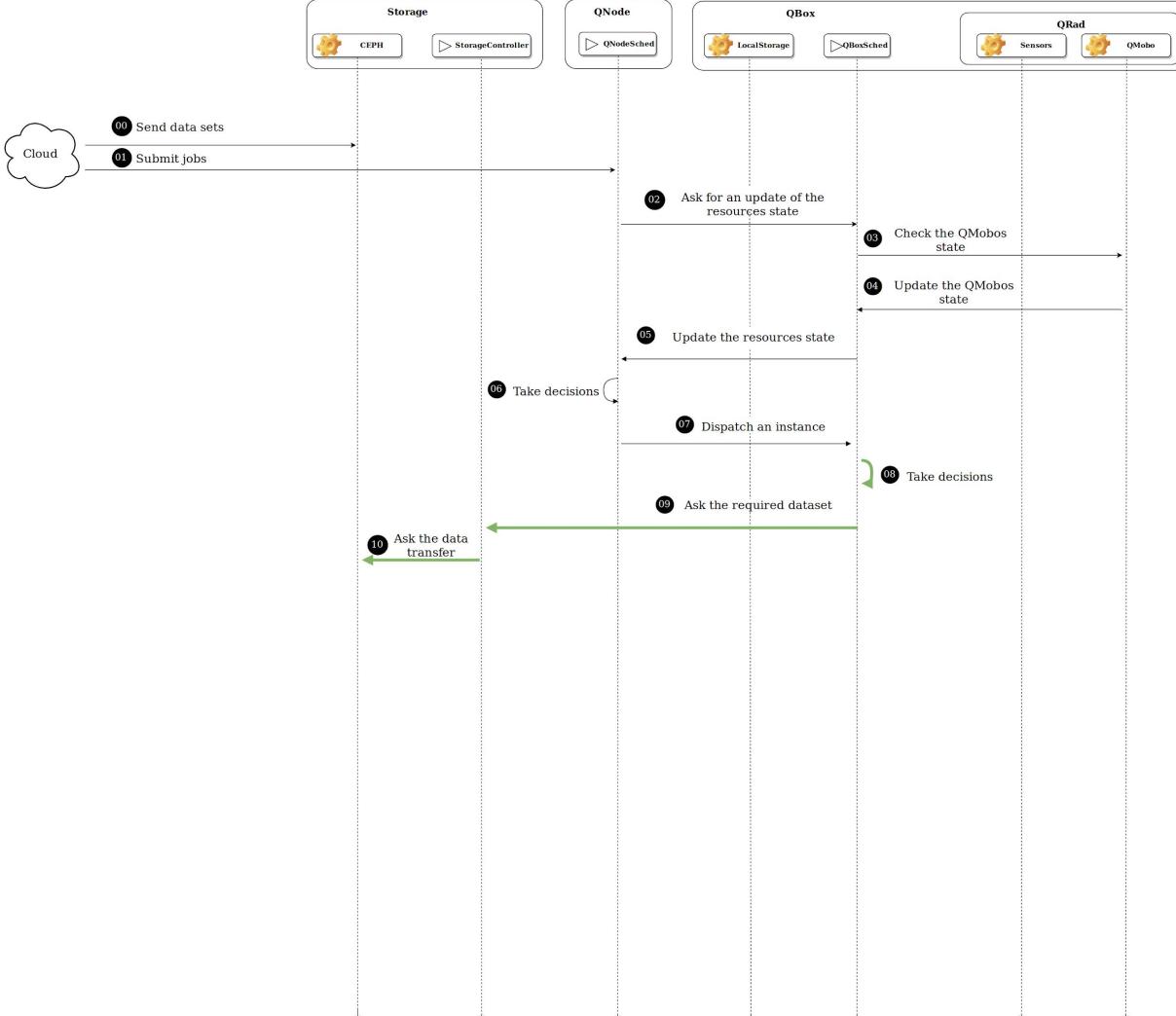


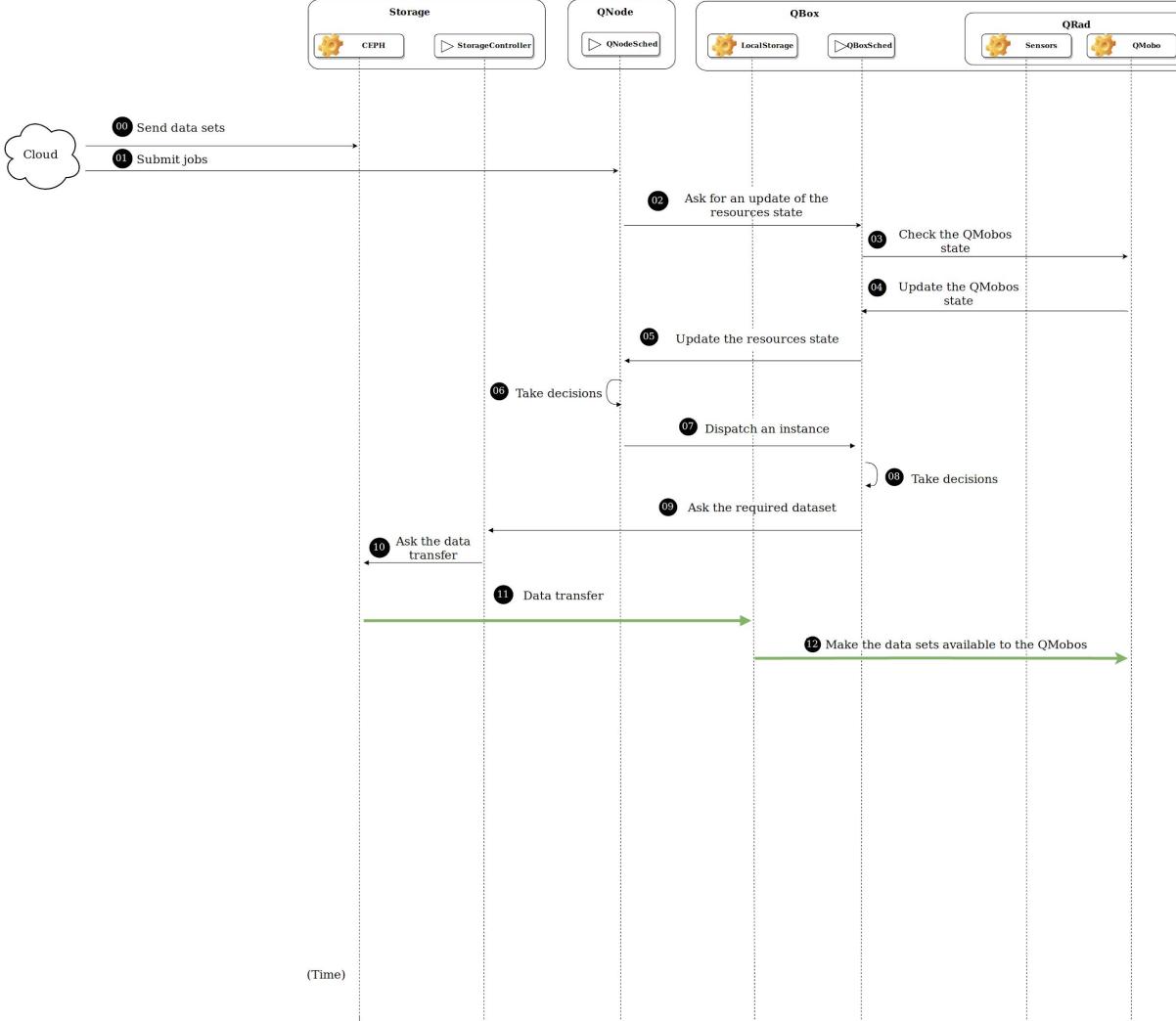


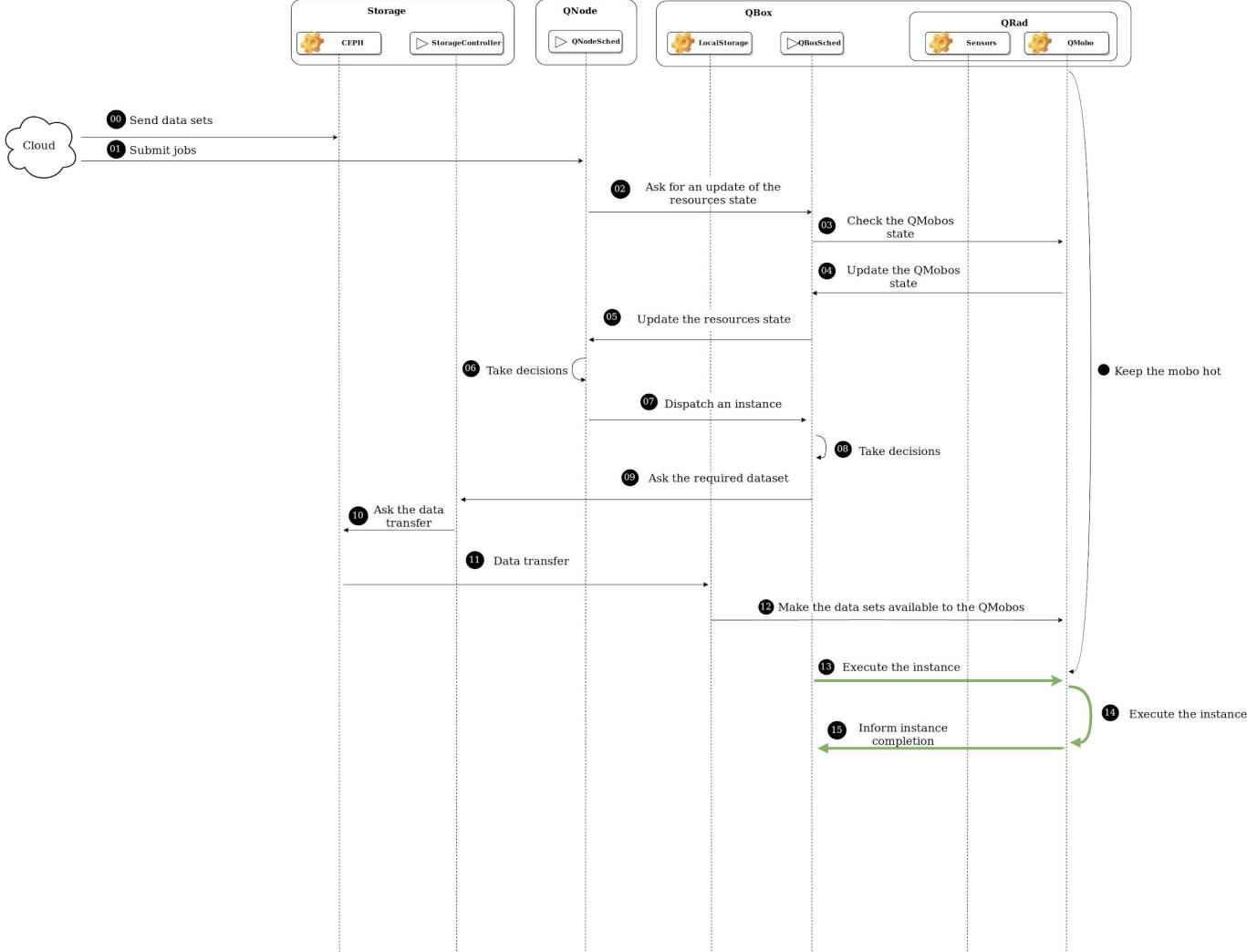


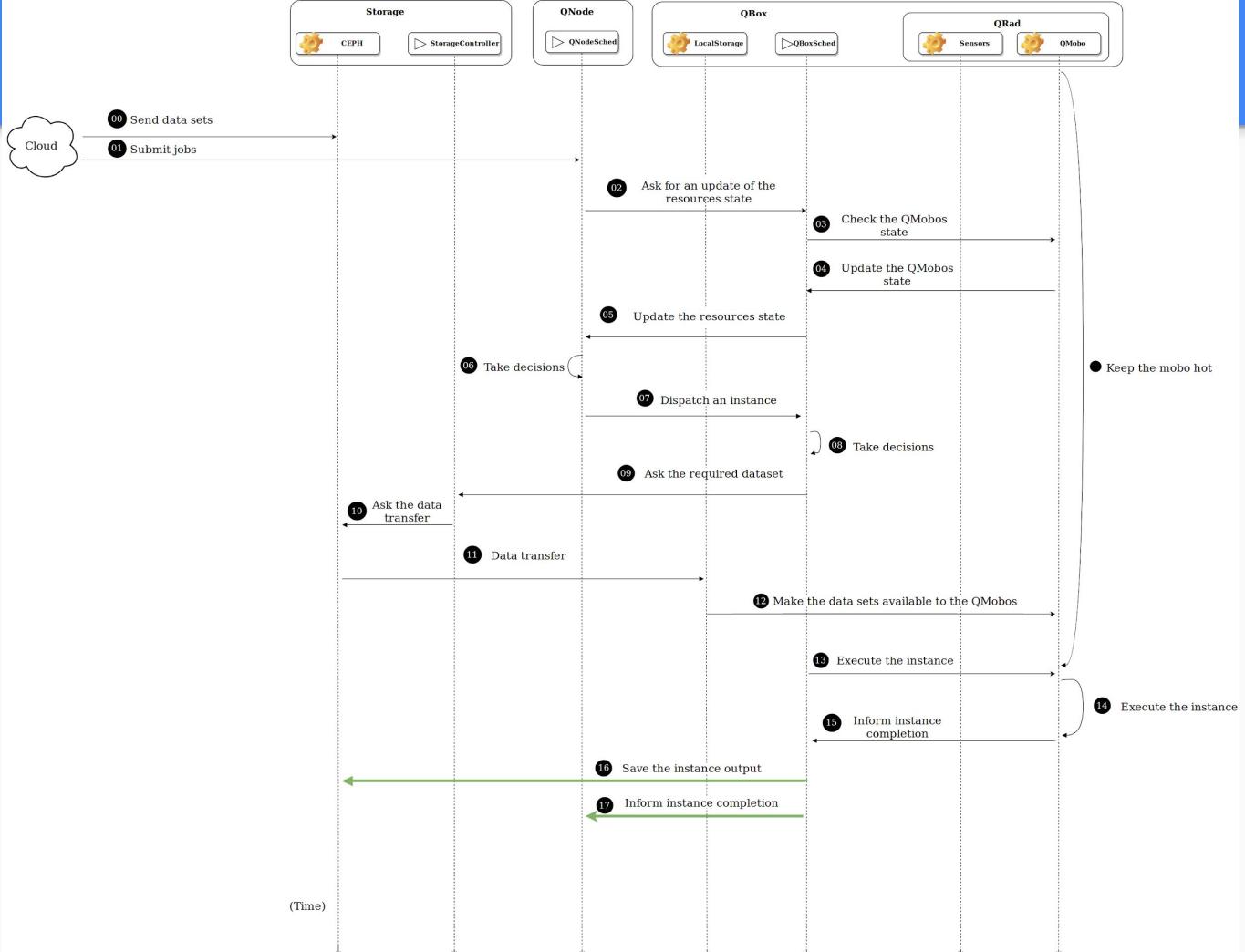


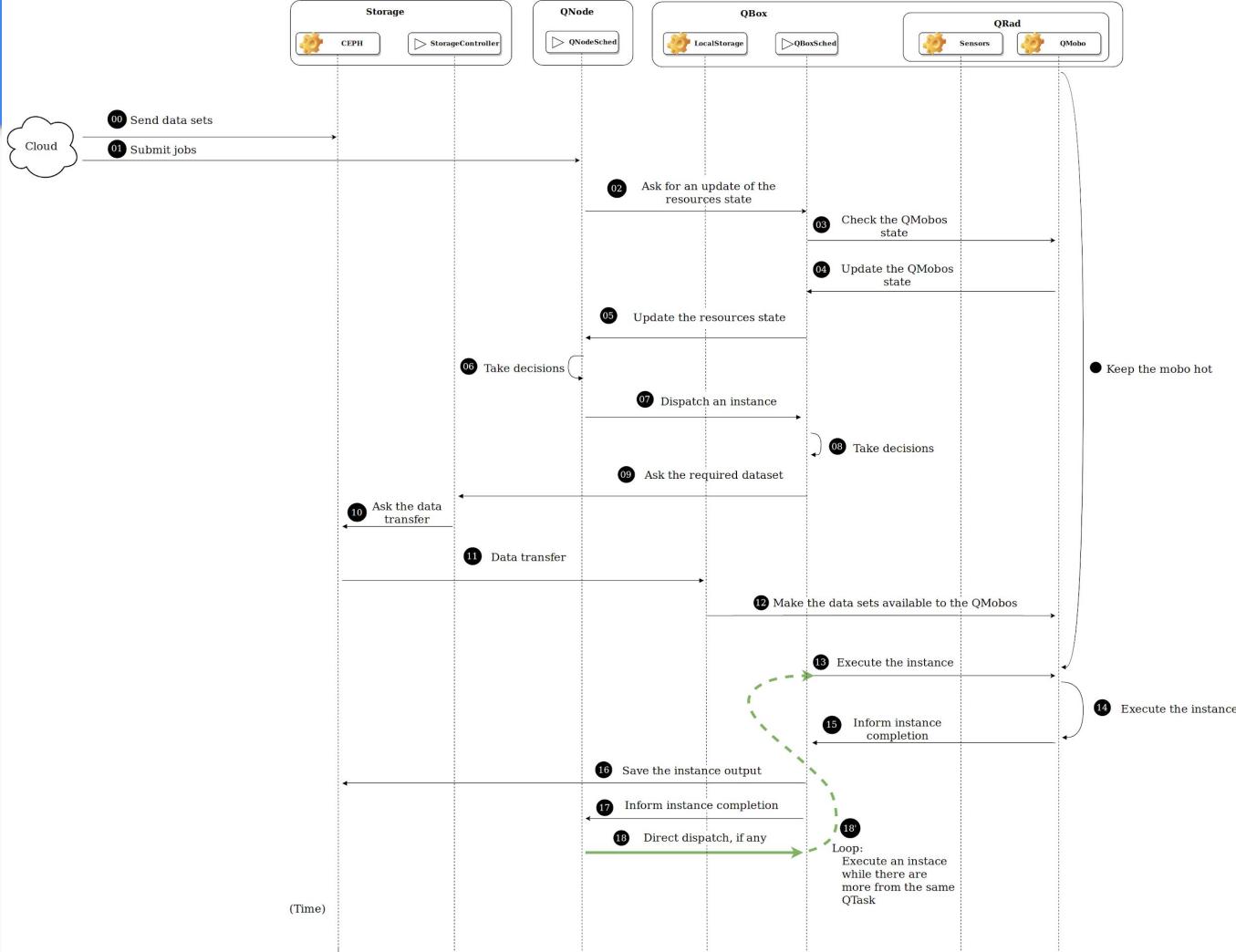


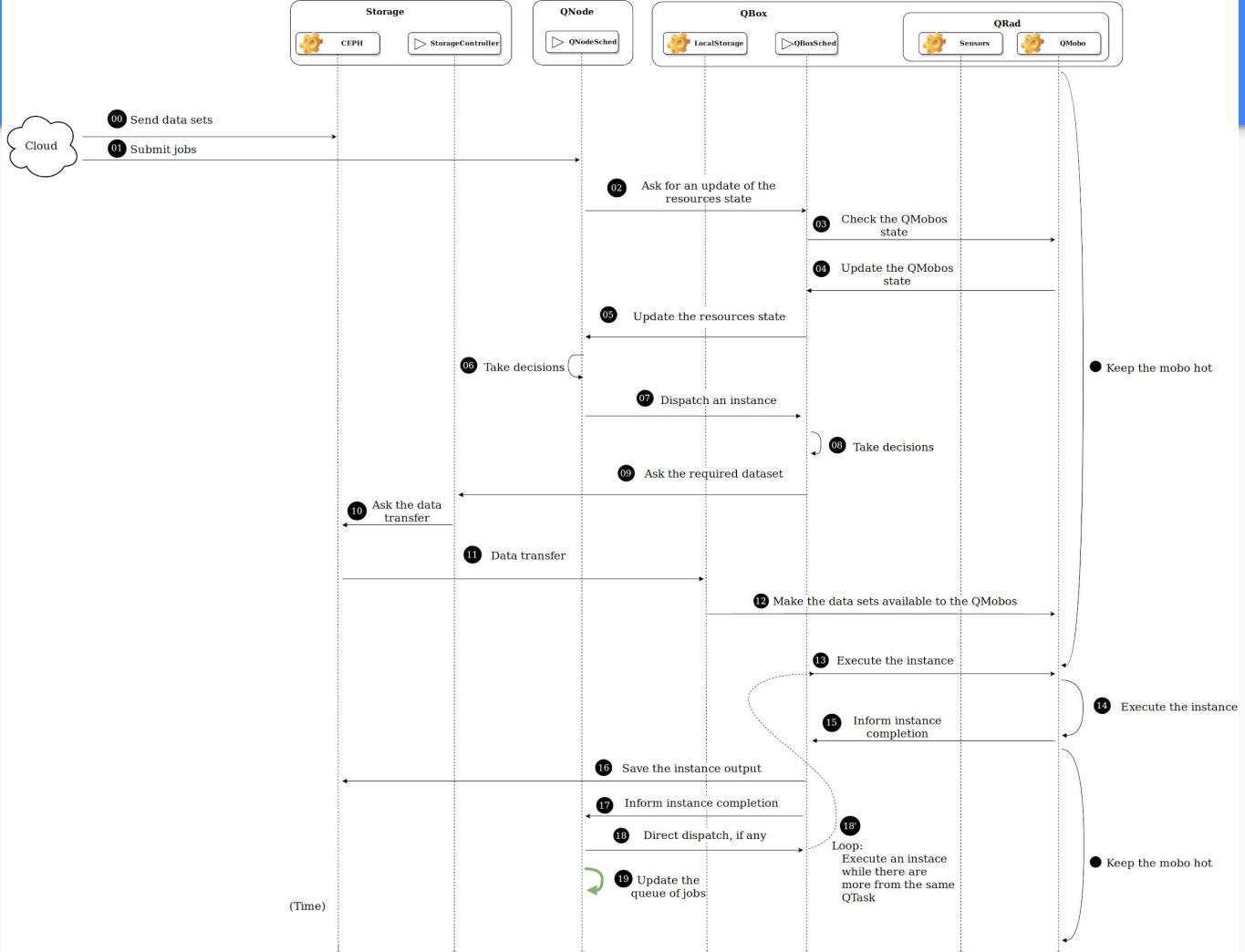






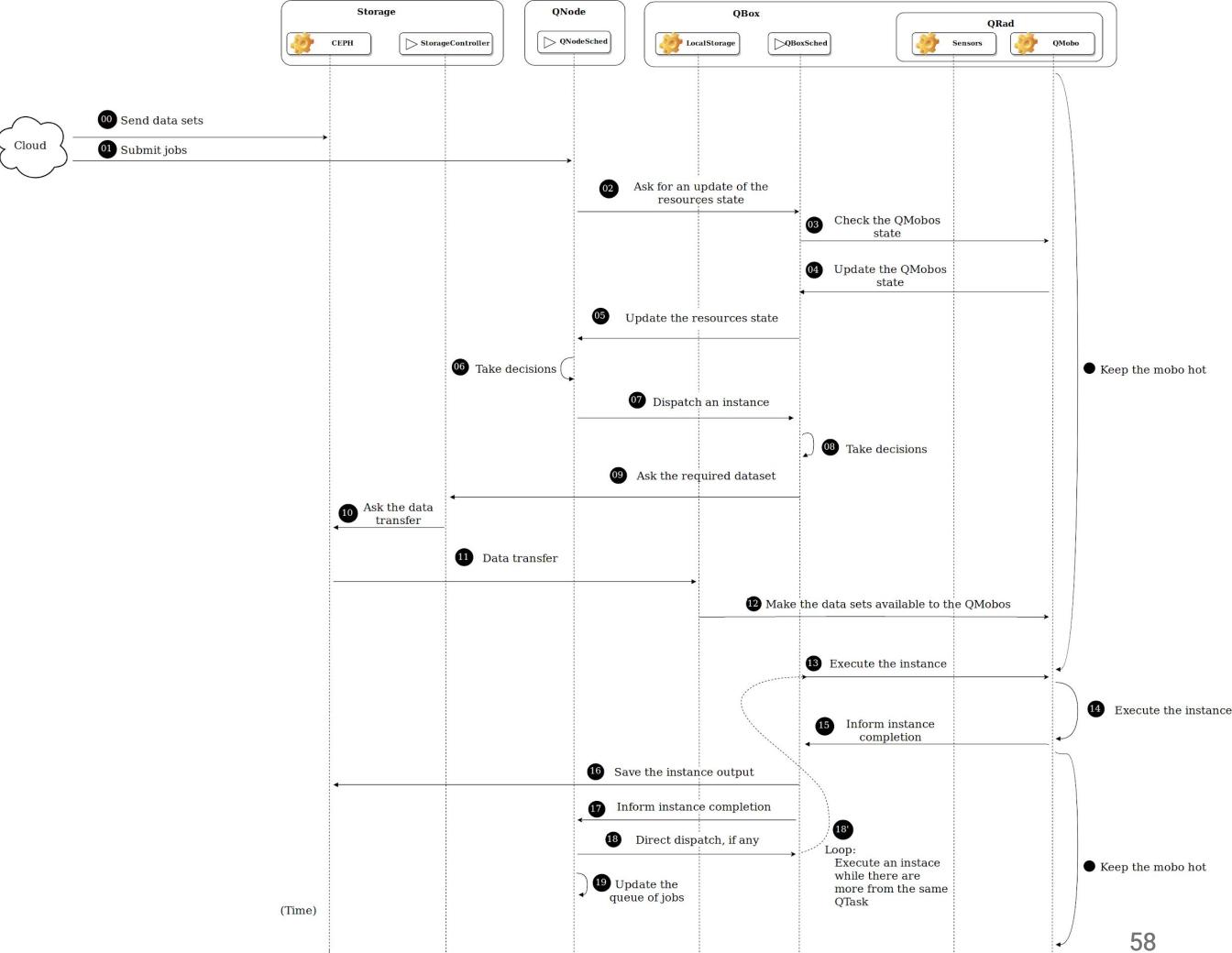






Overview

Based on this platform
we have developed
our simulation.



From the real platform to the simulated one

