

# Large Scale Quantum / HPC hybridization with Atos QLM

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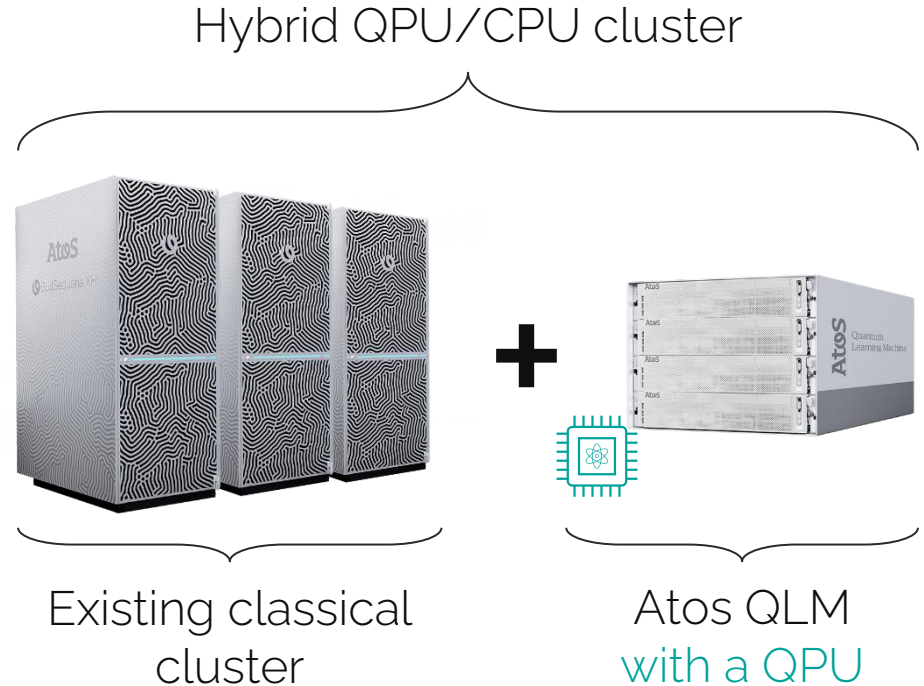
# Atos QLM extends existing clusters to make them hybrid

## Hybrid clusters

**Hybridization:** ability to perform advanced computations using both classical and quantum resources

HPC centers have classical resources. How to rely on these classical resources?

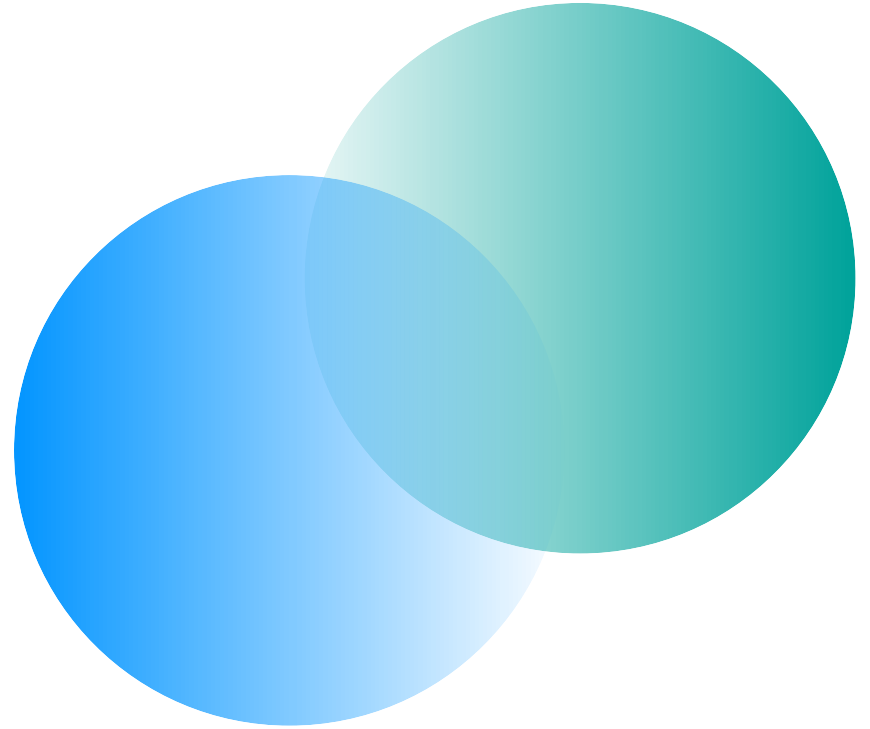
HPC centers are managed by advanced scheduling systems. How to rely on these systems.



# Content Overview

01. Atos QLM and hybrid computation stacks
02. Accessing QPUs remotely
03. Scheduling hybrid jobs on the cluster

# 01. Atos QLM and hybrid computation stacks

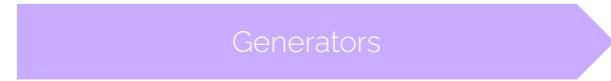
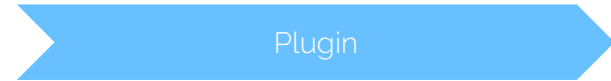


# QLM computation chains can be composed of classical components

## Design of Atos QLM

QLM defines 3 type of services

- Executes a quantum job, can either be:
  - *A simulator (running on CPU / GPU / ...)*
  - *A QPU*
- Manipulates quantum jobs classically before and / or after their execution by a QPU
- Generates inputs (i.e. quantum jobs)



# QLM computation chains can be composed of classical components

## Design of Atos QLM

A computation chains can be built by stacking services. A chain is composed of:

- 1 QPU
- One or more plugins *optional*
- A list of quantum jobs *or* a strategy to build jobs



# QLM computation chains can be composed of classical components

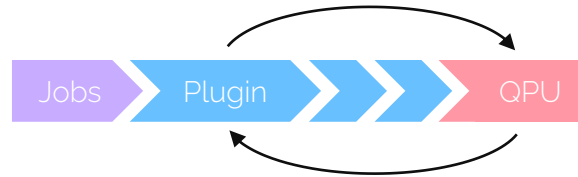
## Design of Atos QLM

A computation chains can be built by stacking services. A chain is composed of:

- 1 QPU
- One or more plugins *optional*
- A list of quantum jobs *or* a strategy to build jobs



Moreover, plugins can resubmit quantum jobs:



# Plugins could be used to run variational jobs on the QLM

## Example of QLM python code

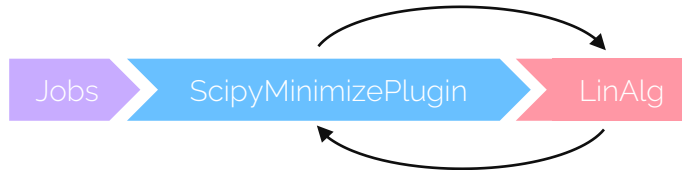
```
jobs = ...

from qat.qpus import LinAlg
from qat.plugins import ScipyMinimizePlugin

# Create a new QPU having classical capabilities
# The classical capabilities are used to perform
# classical optimization
stack = ScipyMinimizePlugin() | LinAlg()

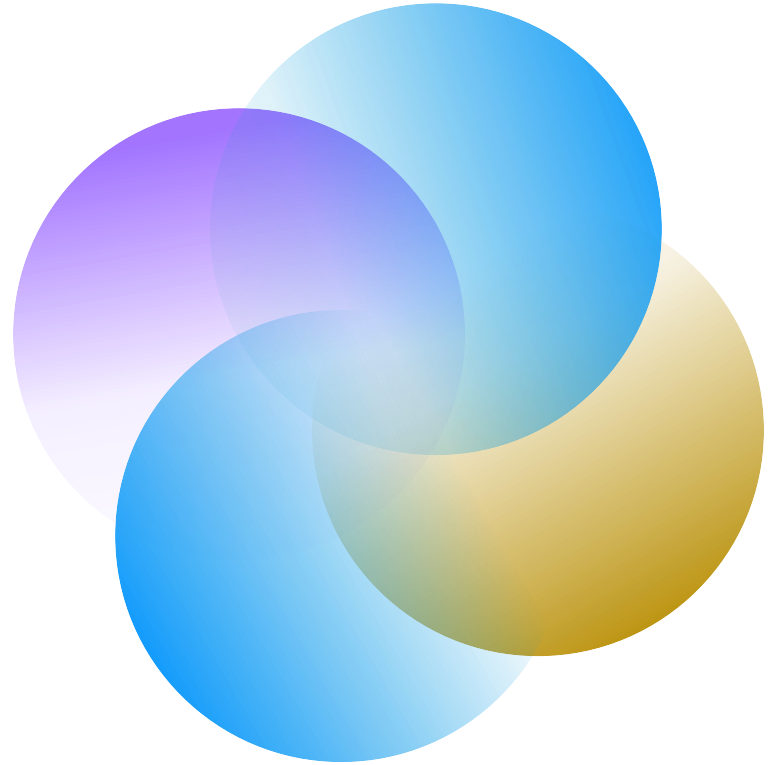
# Submit "jobs" to "stack"
results = stack.submit(jobs)
```

- Create a quantum job
- Import plugins and QPUs used by the simulation
- Create a processing stack
- Submit the job



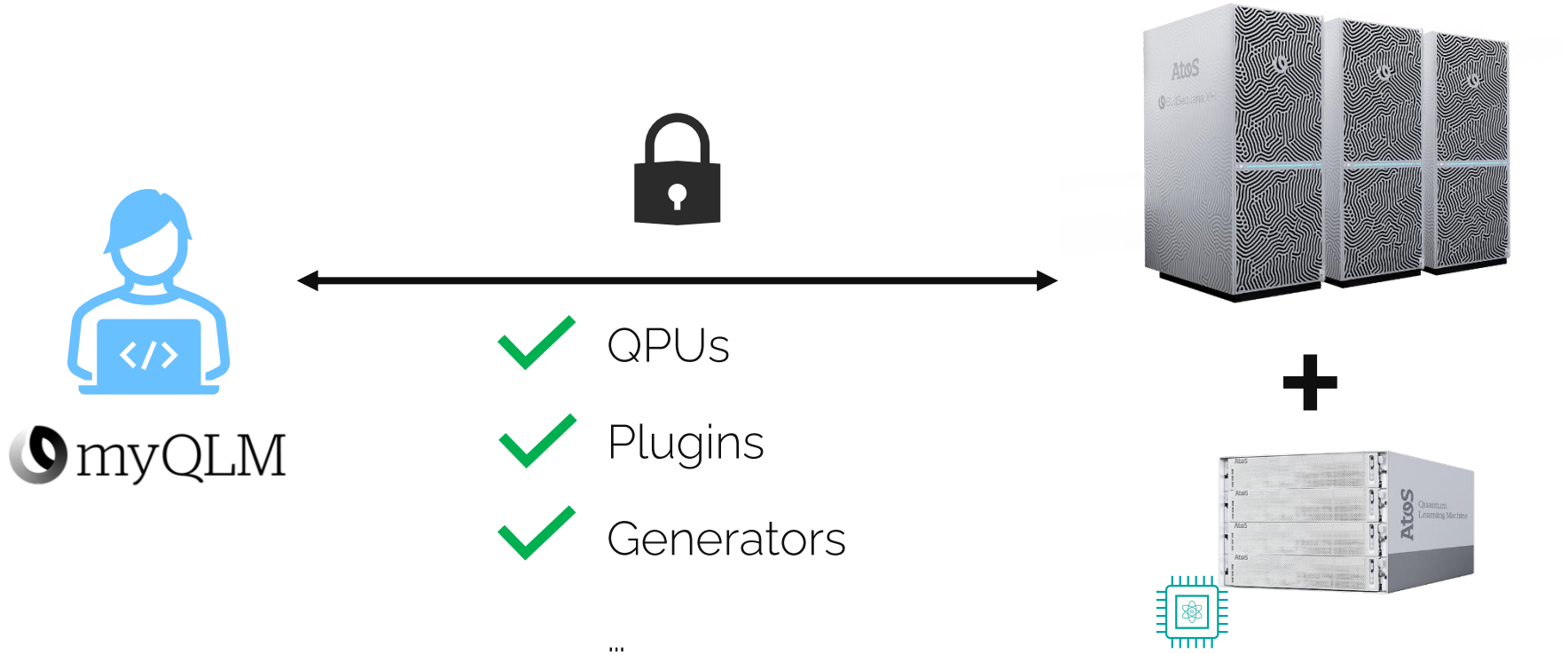


## 02. Accessing QPUs remotely



# The hybrid cluster can be accessed remotely using Atos QLM

## Introduction to myQLM Power Access



# Local and remote computation use the same structure

## Example of QLM python code

```
jobs = ...

from qlmaas.qpus import LinAlg
from qlmaas.plugins import ScipyMinimizePlugin

# Create a new QPU having classical capabilities
# The classical capabilities are used to perform
# classical optimization
stack = ScipyMinimizePlugin() | LinAlg()

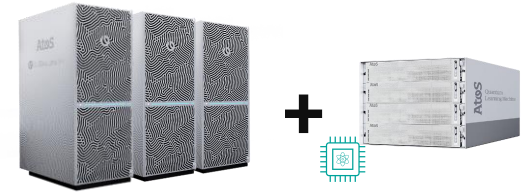
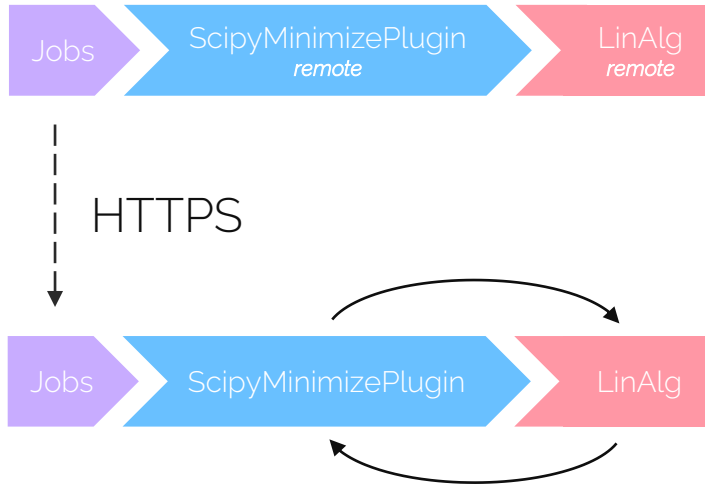
# Submit "jobs" to "stack"
future_results = stack.submit(jobs)
results = future_results.join()
```

- Create a quantum job
- Import plugins and QPUs used by the simulation
- Create a processing stack
- Submit the job

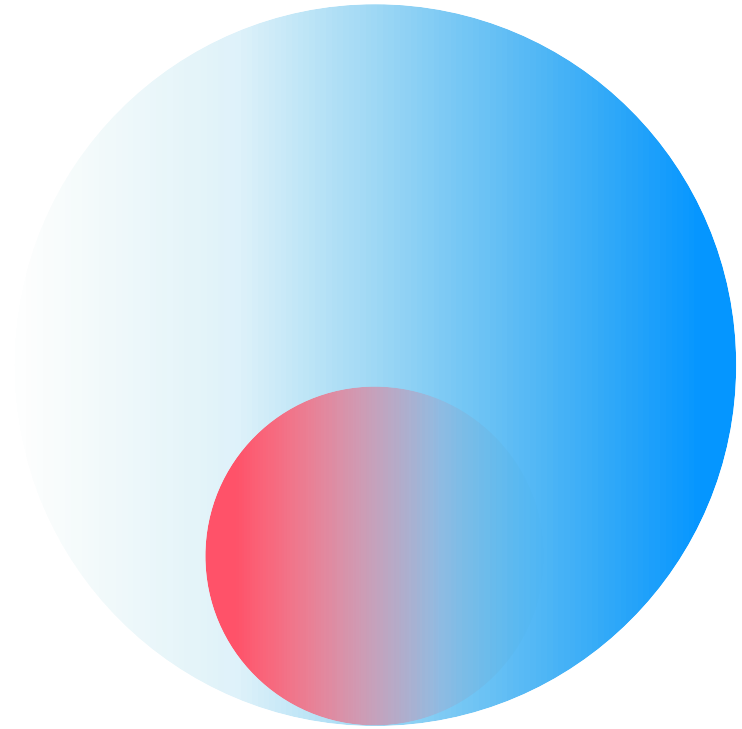


# Remote stacks are rebuilt on the server side

## Example of QLM python code

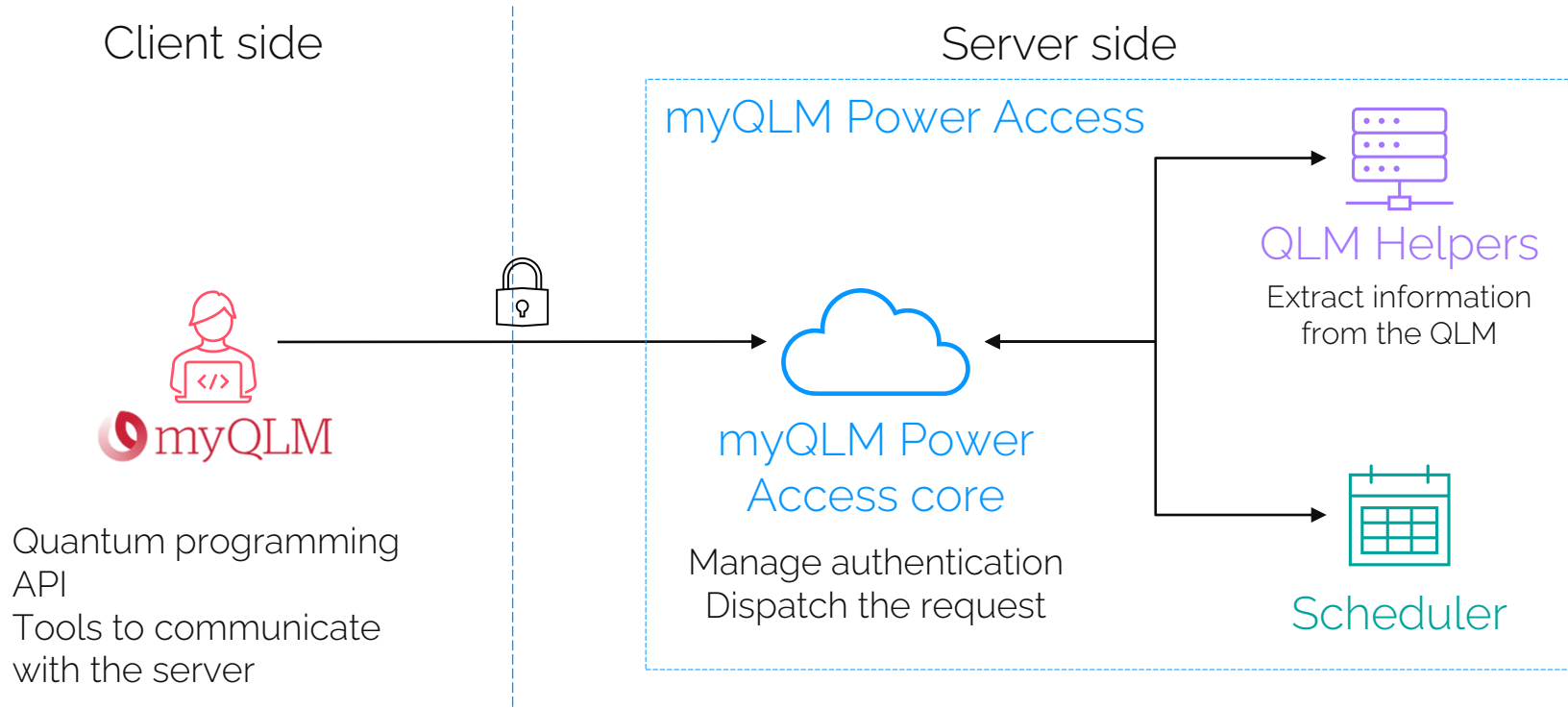


### 03. Scheduling hybrid jobs on the cluster



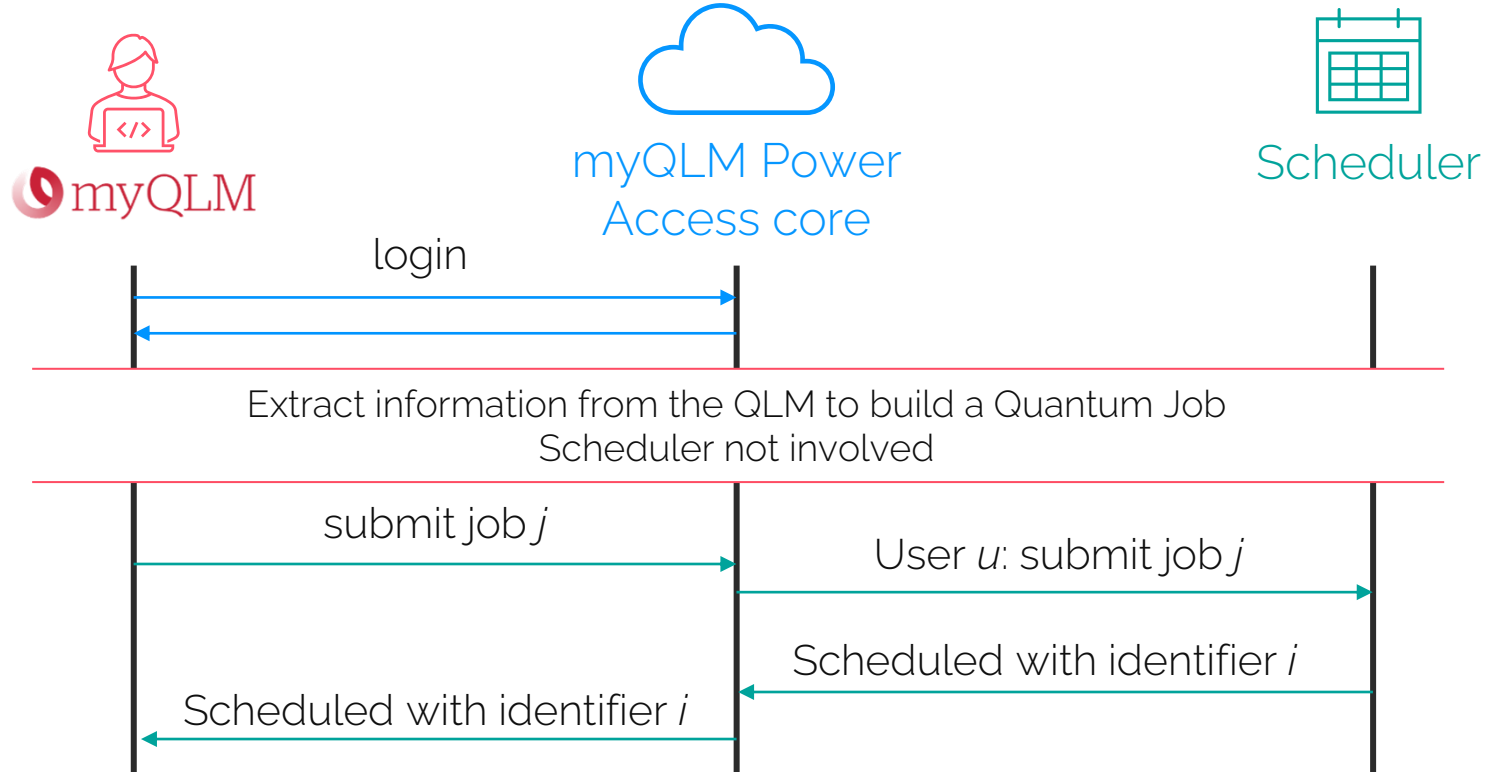
# myQLM Power Access Overview

## Components involved in myQLM Power Access



# myQLM Power Access Overview

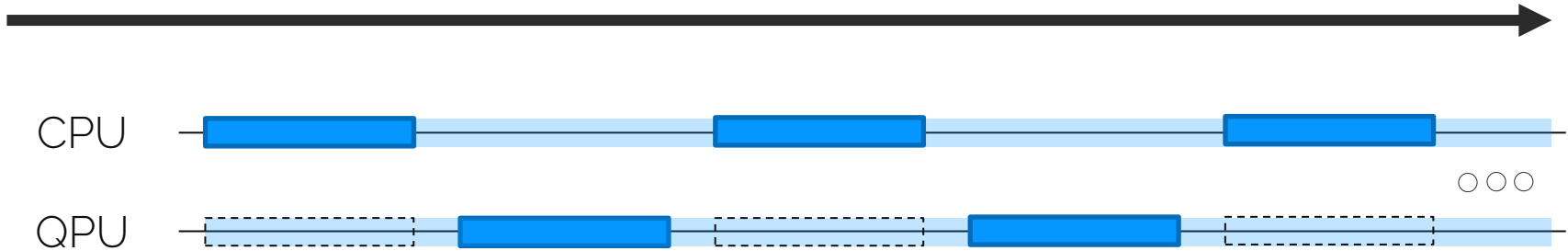
## Components involved in myQLM Power Access



# Quantum job scheduling

## High-level scheduling and QPU idleness

Time



Job 1

Resource reservation

QPU idle



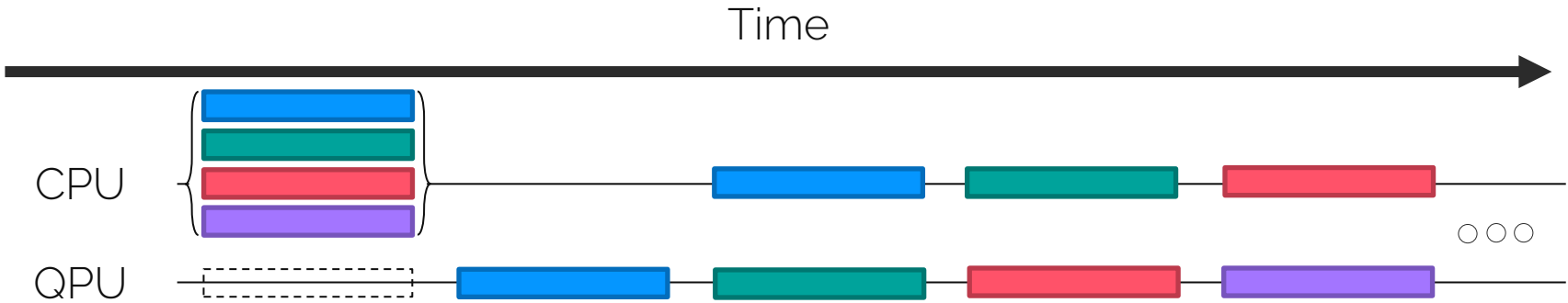
Not at scale

QPU is idle



# Quantum job scheduling

## Low-level scheduling and slow Quantum jobs



- Job 1
- Job 2
- Job 3
- Job 4
- QPU idle

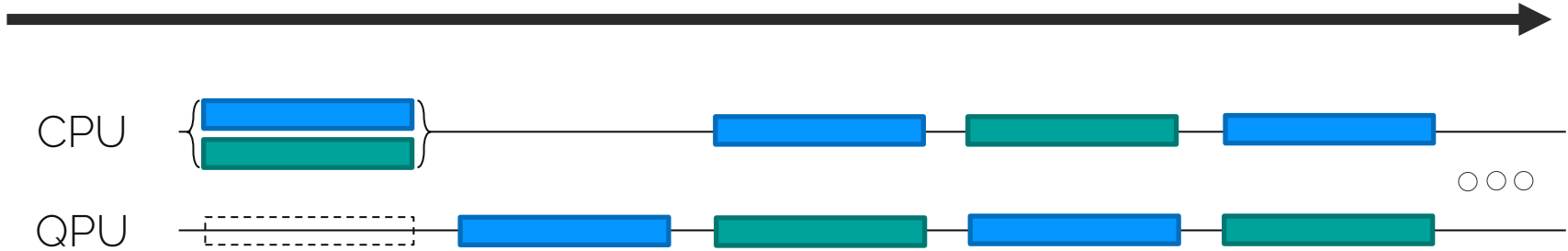
⚠ Not at scale

Jobs are slow

# Quantum job scheduling

## High/Low-level scheduling

Time



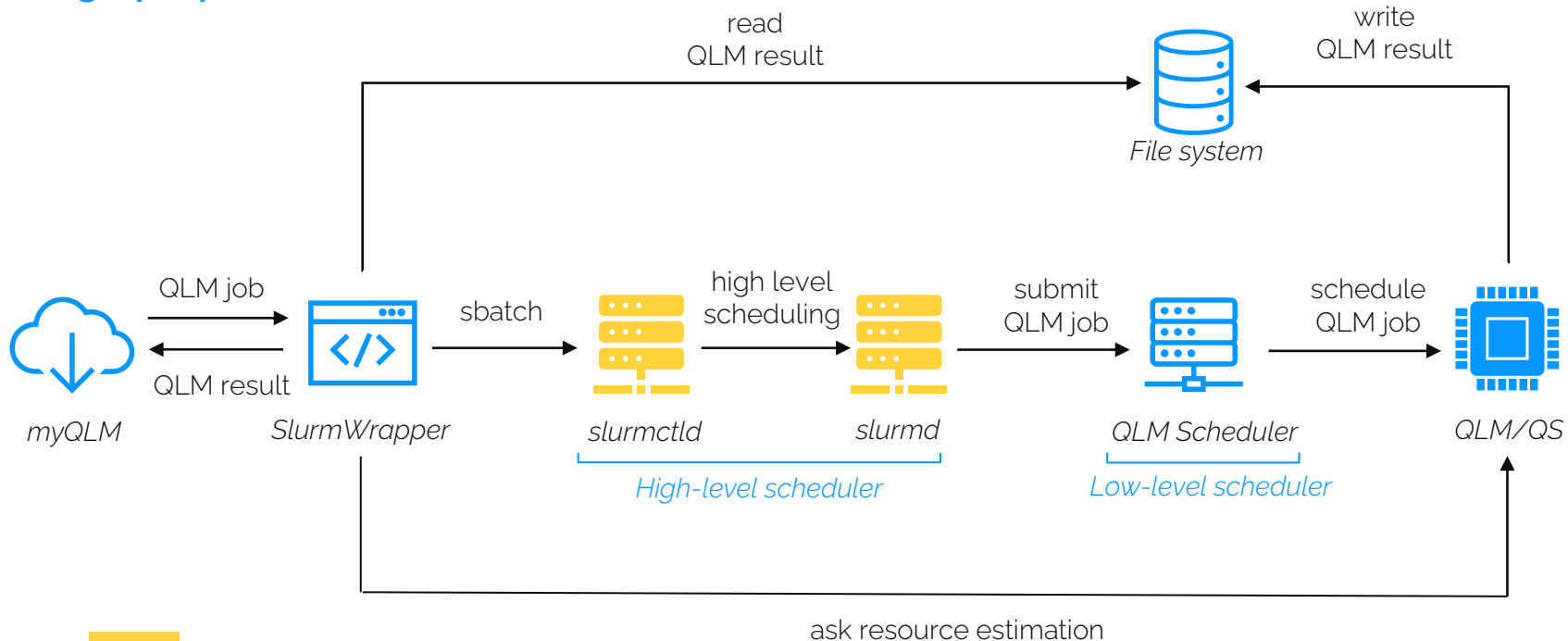
- Job 1
- Job 2
- QPU idle

! Not at scale

Best speed  
QPU not idle

# Quantum job scheduling

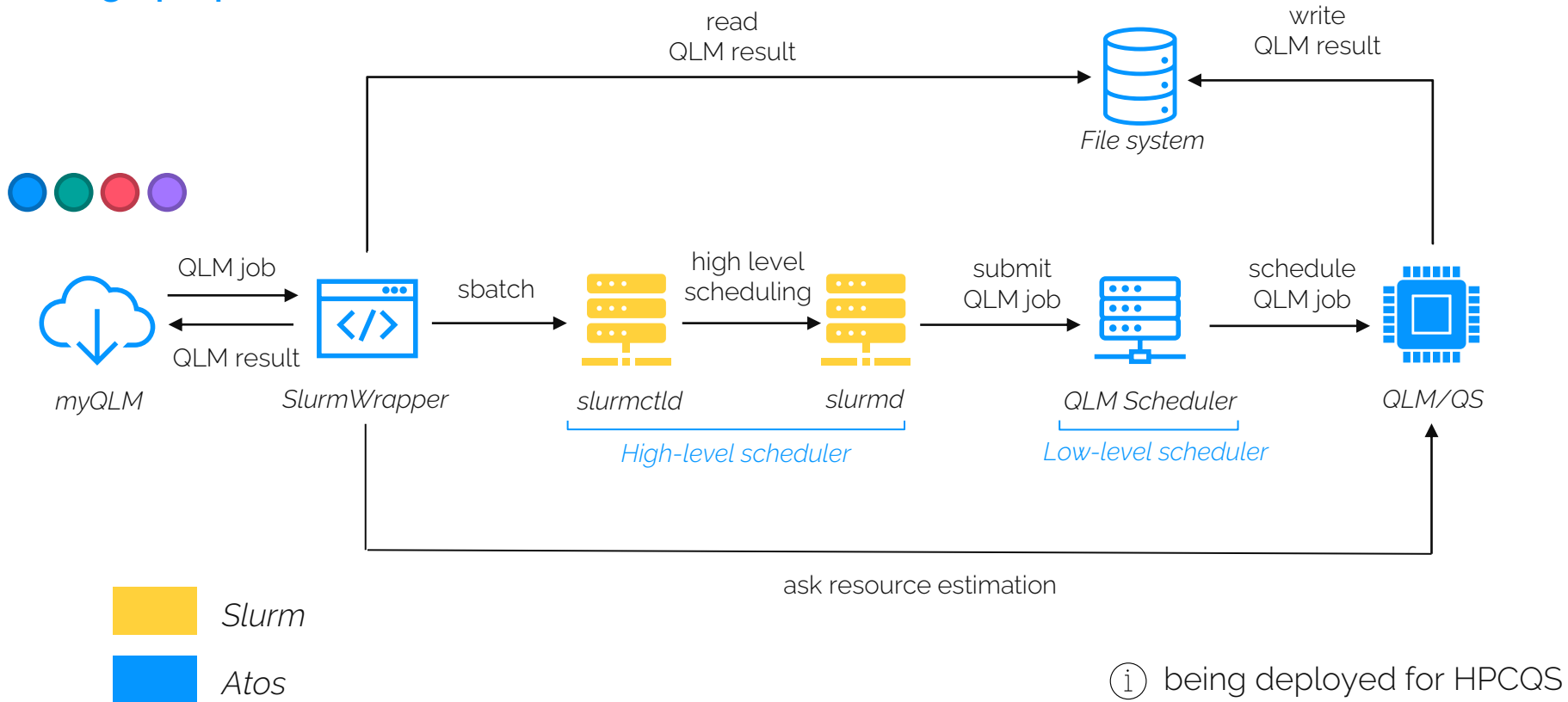
## Design proposal



① being deployed for HPCQS

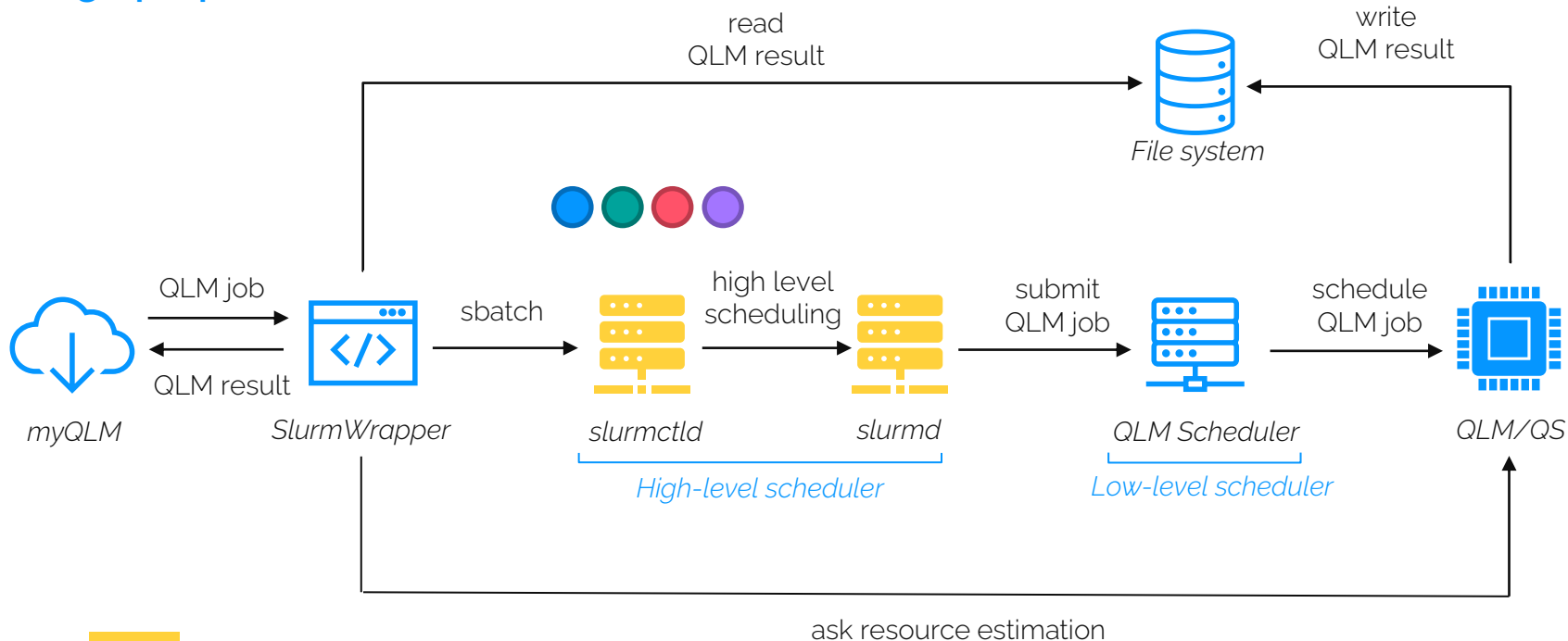
# Quantum job scheduling

## Design proposal



# Quantum job scheduling

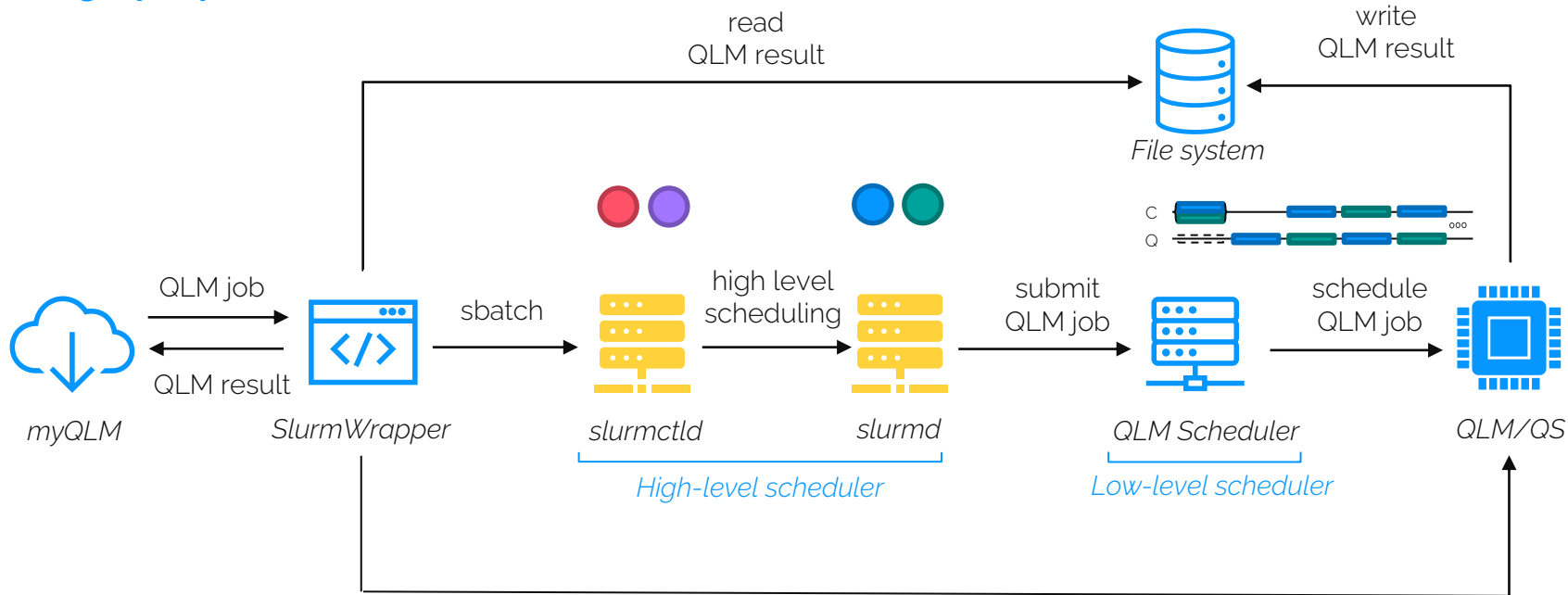
## Design proposal



① being deployed for HPCQS

# Quantum job scheduling

## Design proposal



① being deployed for HPCQS

# Questions

# Thank you!

For more information please contact:  
[arnaud.gazda@atos.net](mailto:arnaud.gazda@atos.net)

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