


KubeCon | CloudNativeCon

North America 2023

Middleware for Quantum: Enabling Advanced Quantum Computing Workflows

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Speakers

KubeCon CloudNativeCon North America 2023

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Senior Software Engineer at IBM

Knative Technical Oversight Committee

Qiskit Advocate

Kubernetes Contributor

Agenda

- Introduction to Quantum
- Quantum Middleware
- Example Application
- Q&A

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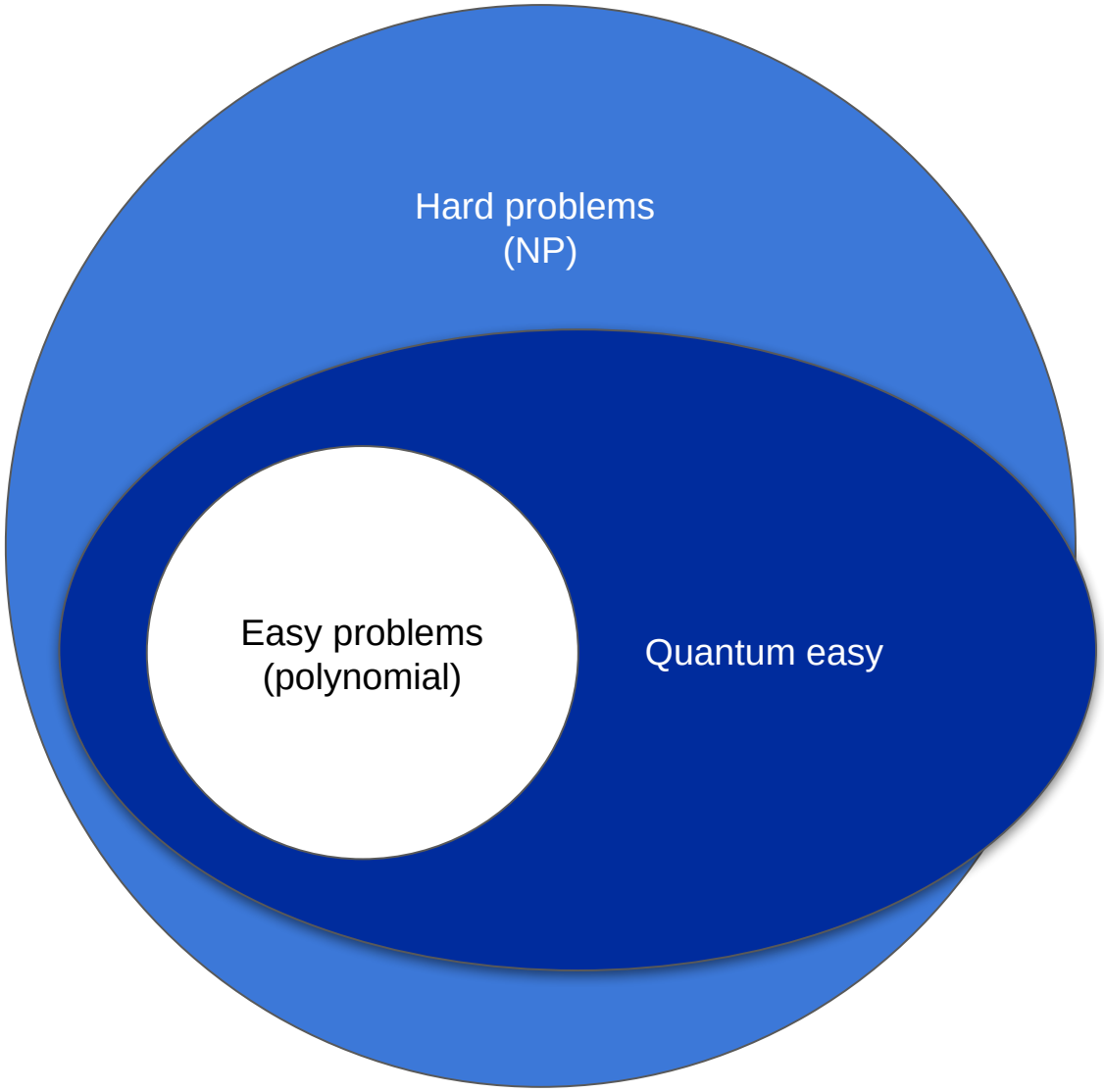
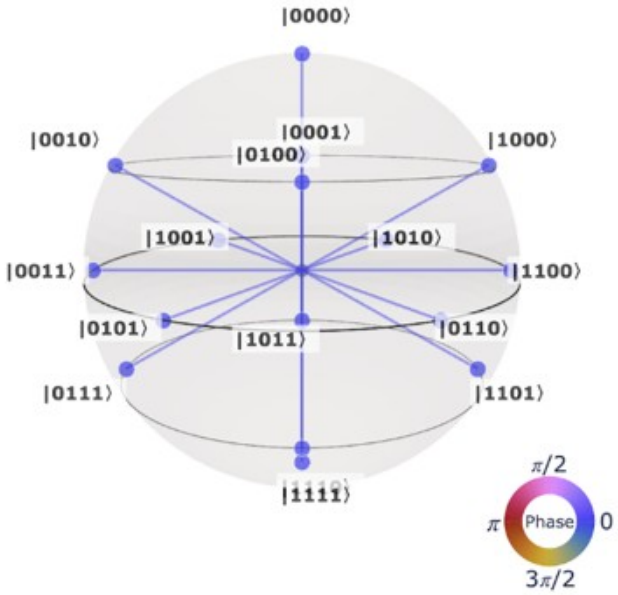
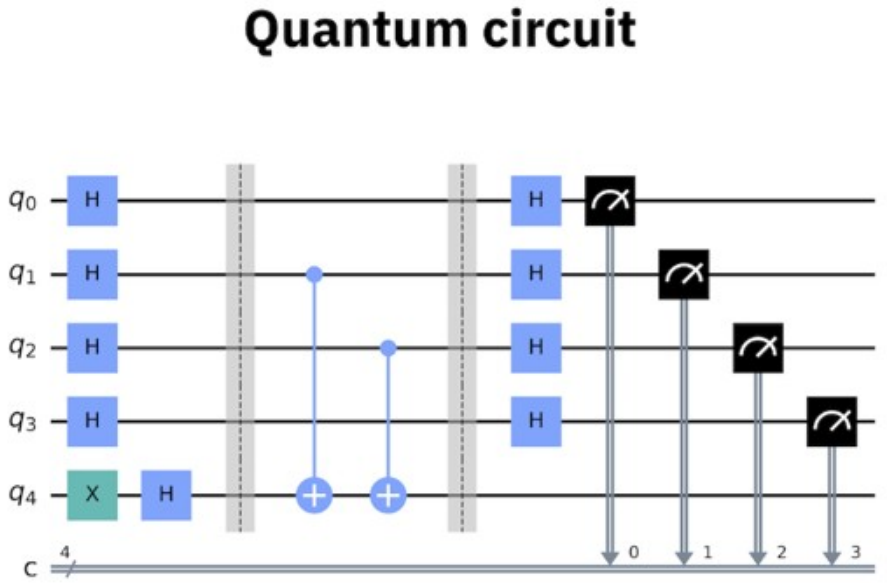
Why quantum?



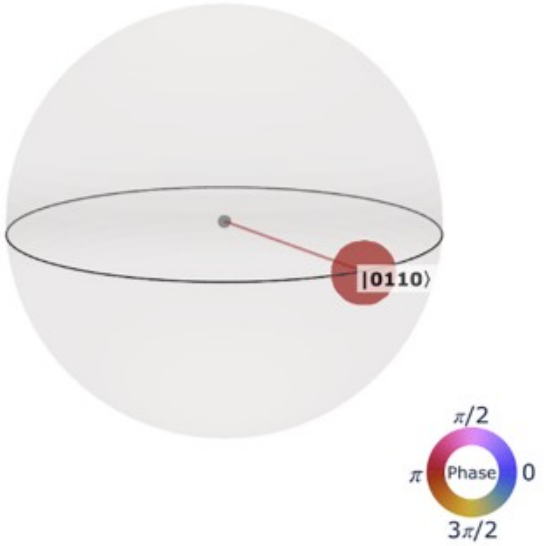
Quantum computers use qubits



Superposition of all possibilities



Computation driven interference



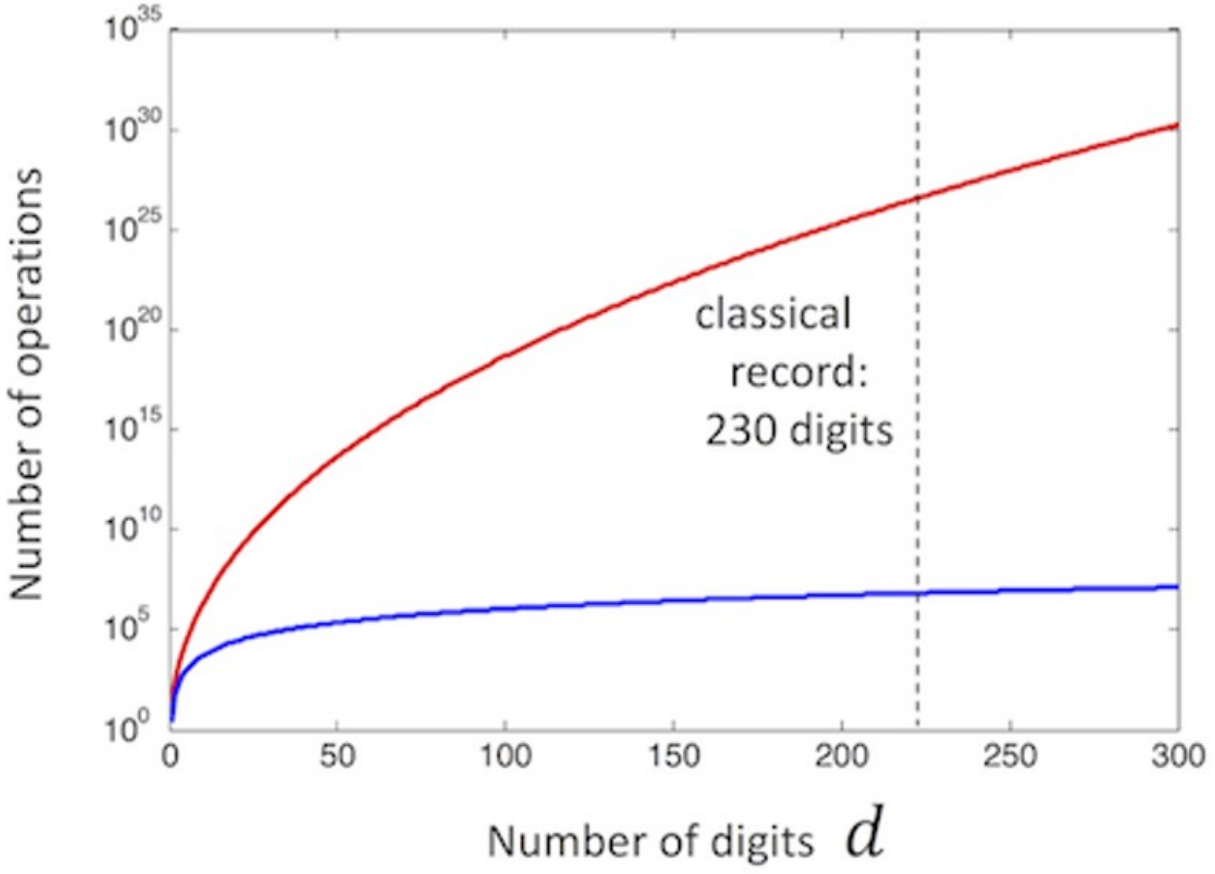
Solution

Why is it important?

2*N: 2, 4, 6 … 20 … 200

$\mathbf{2}^{\mathbf{N}}$: 2, 4, 8 … 1024 … $1e^{30}$

Ex: Shor's algorithm for factoring



$\exp(\text{const} \times d^{1/3})$

best classical
algorithm
(number field sieve)

$\text{const} \times d^3$

Shor's algorithm

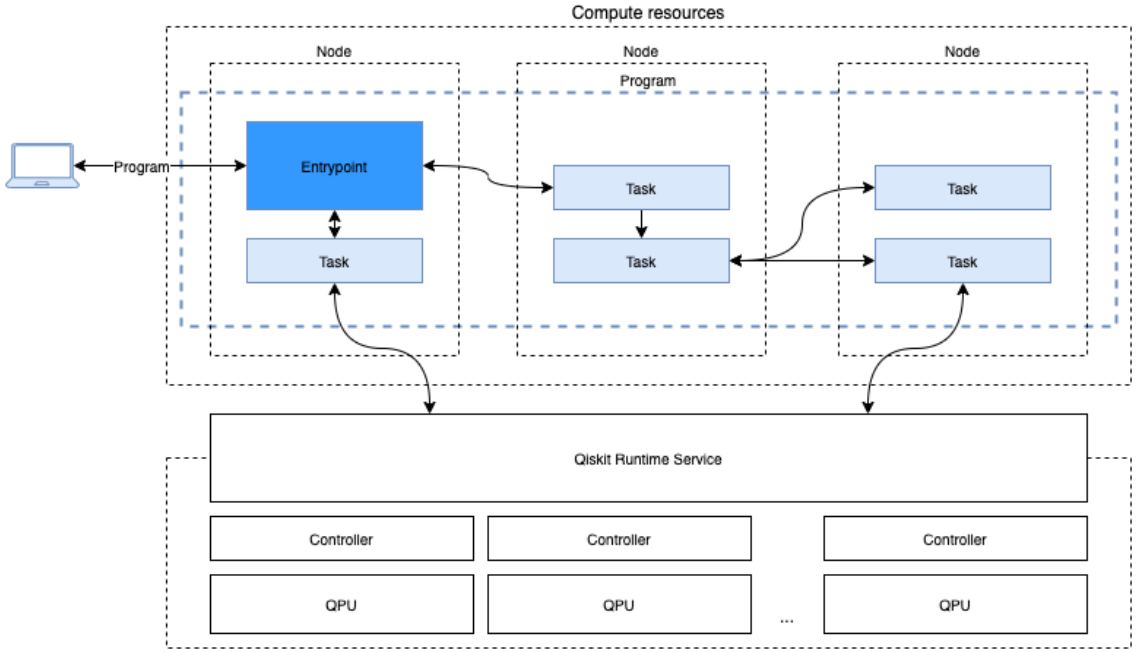
How to factor N, a product of two primes

1. Make a guess, g<N that shares no factors with N
2. Find r such that $g^r = mN+1$
3. If r is even, calculate $(g^{r/2}+1)$ and $(g^{r/2}-1)$. If r is odd, go back to step 1
4. Use Euclid's algorithm to find the greatest common divisor

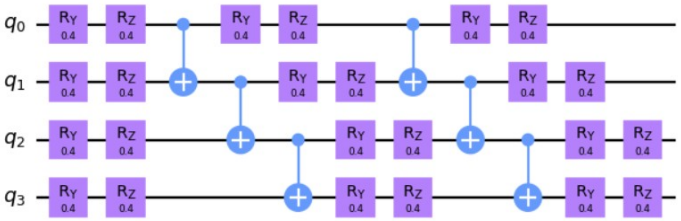
https://www.youtube.com/watch?v=-UrdExQW0cs

Quantum Middleware: Classical + Quantum

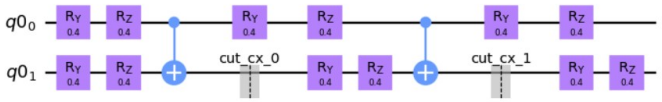
Quantum Serverless



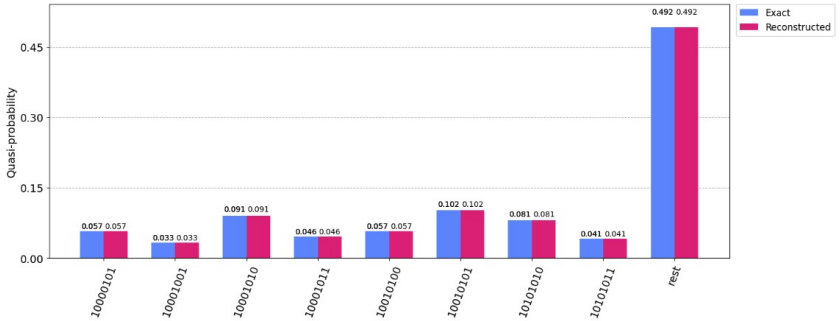
CKT




```
subcircuits["A"].draw("mpl", scale=0.8)
```




```
subcircuits["B"].draw("mpl", scale=0.8)
```



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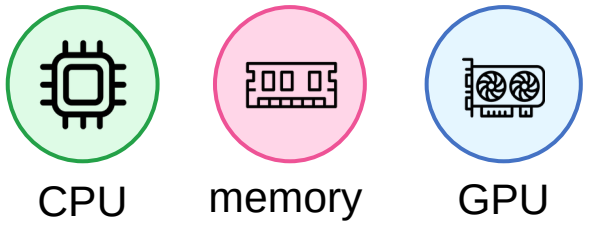
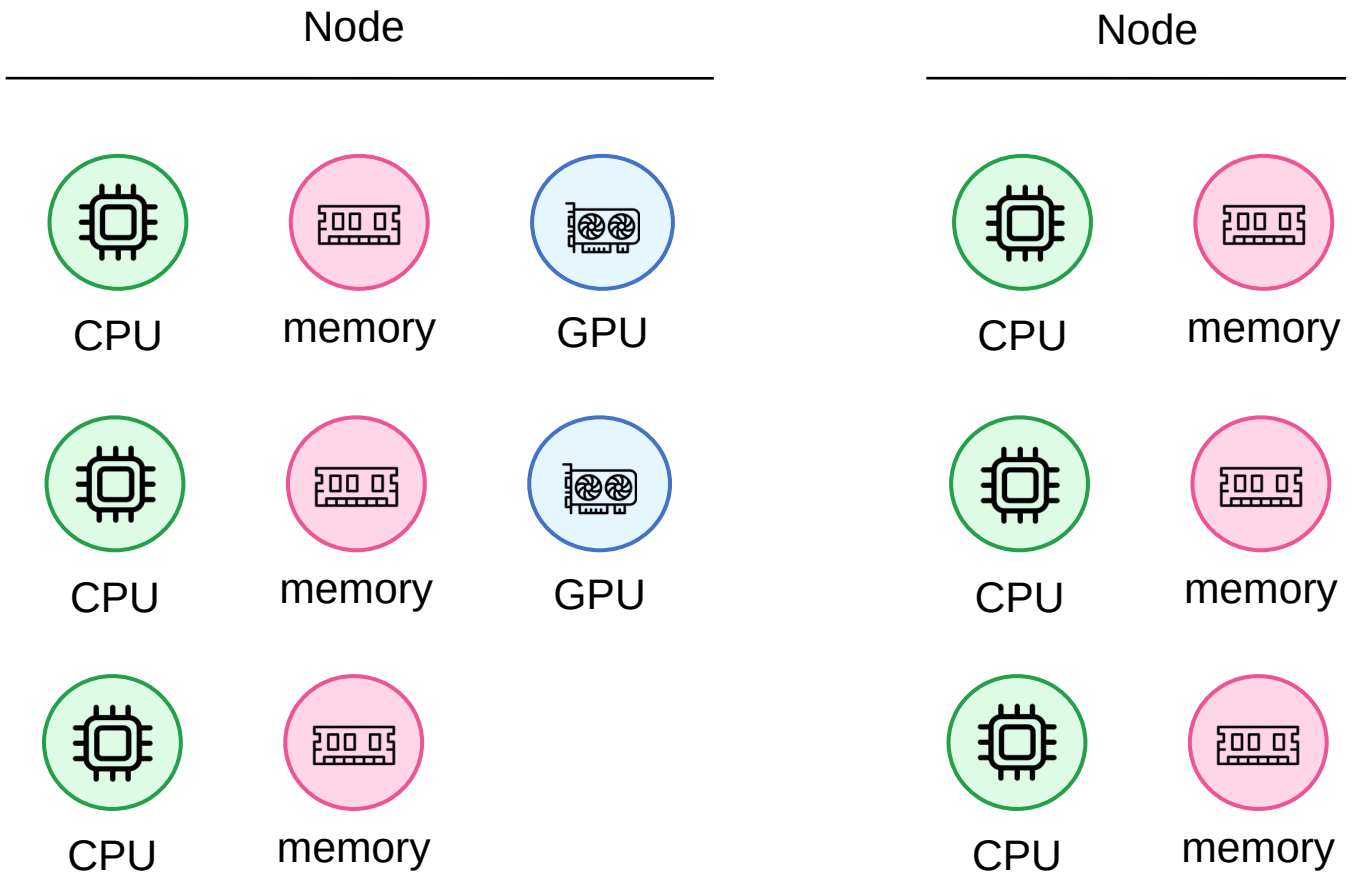
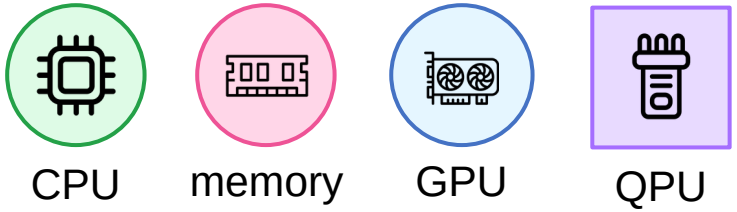
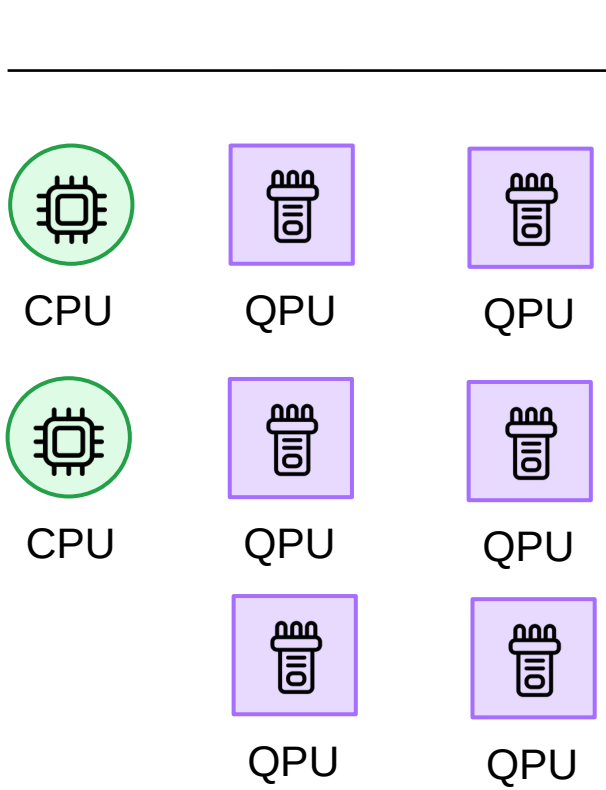
Classical Compute Resources

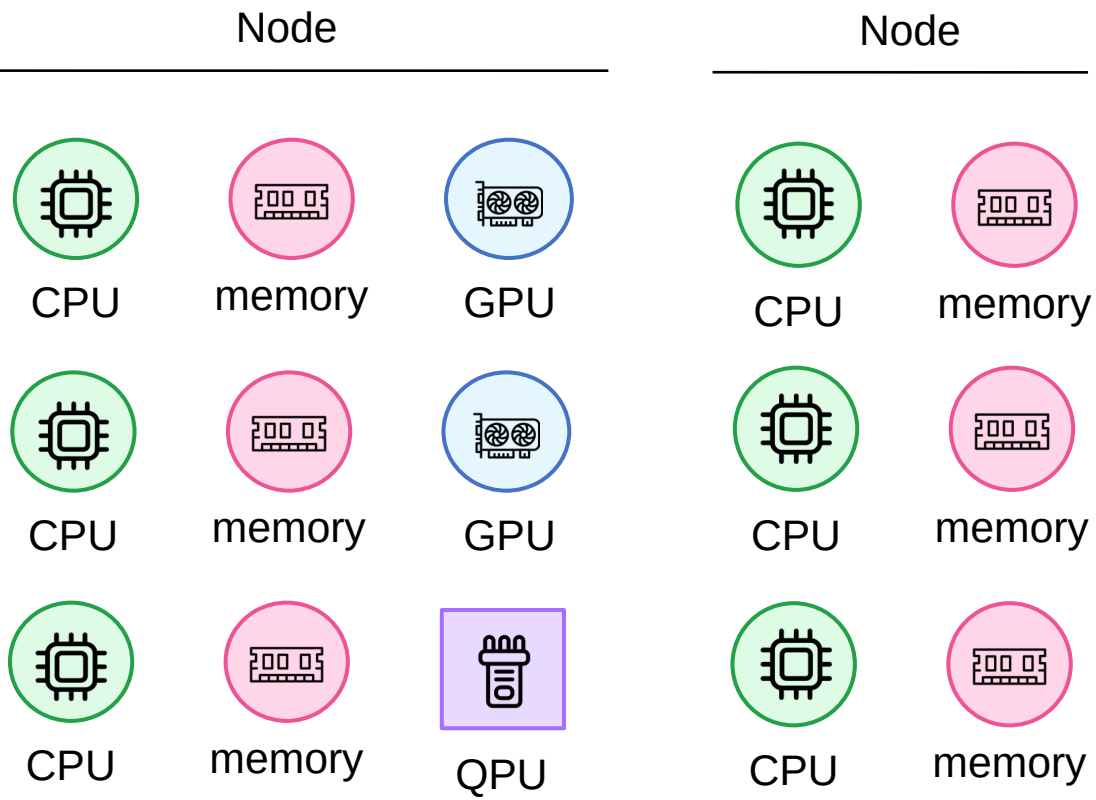




Quantum Compute Resources

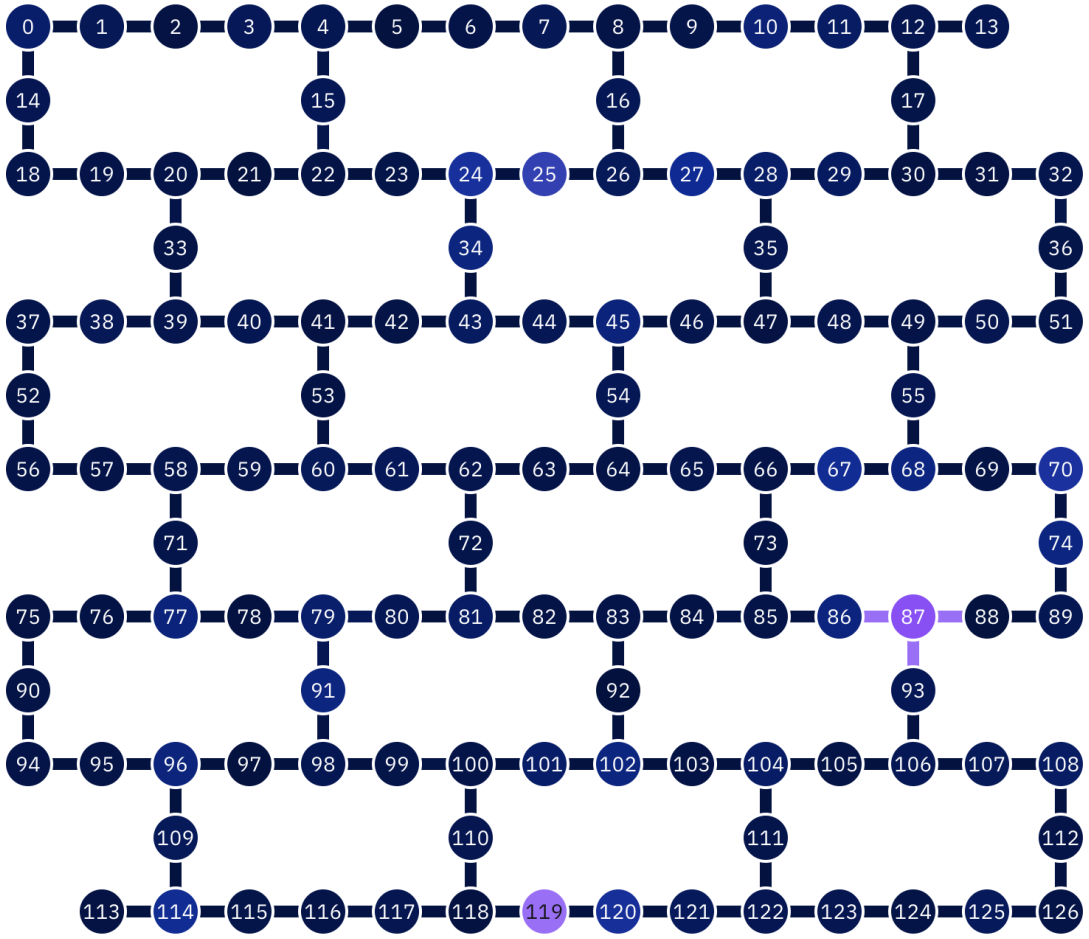




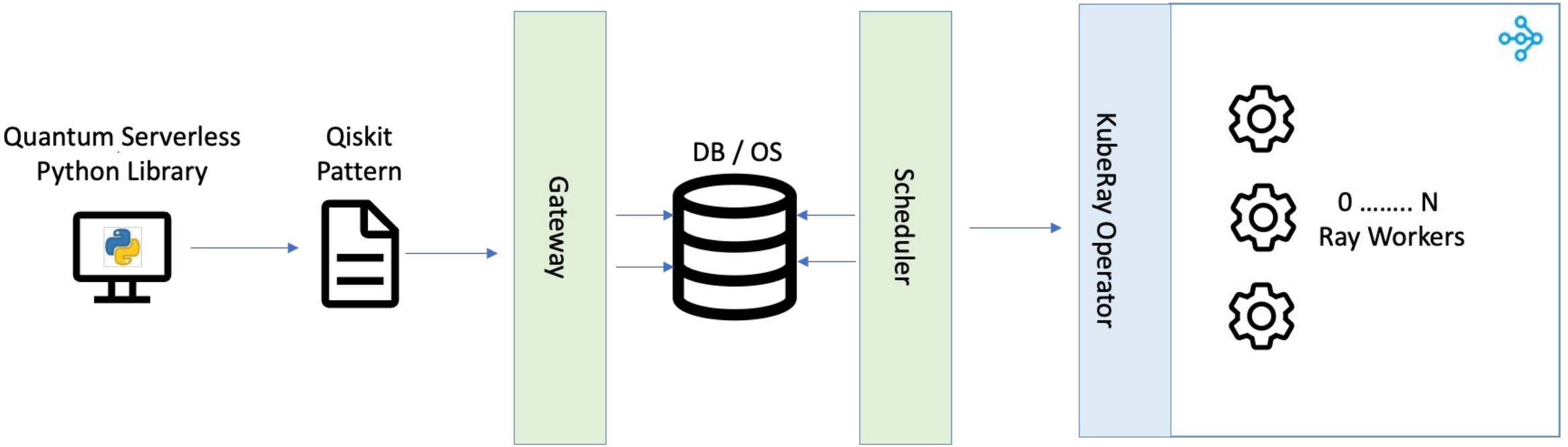


Quantum Compute Resources

https://quantum.ibm.com/



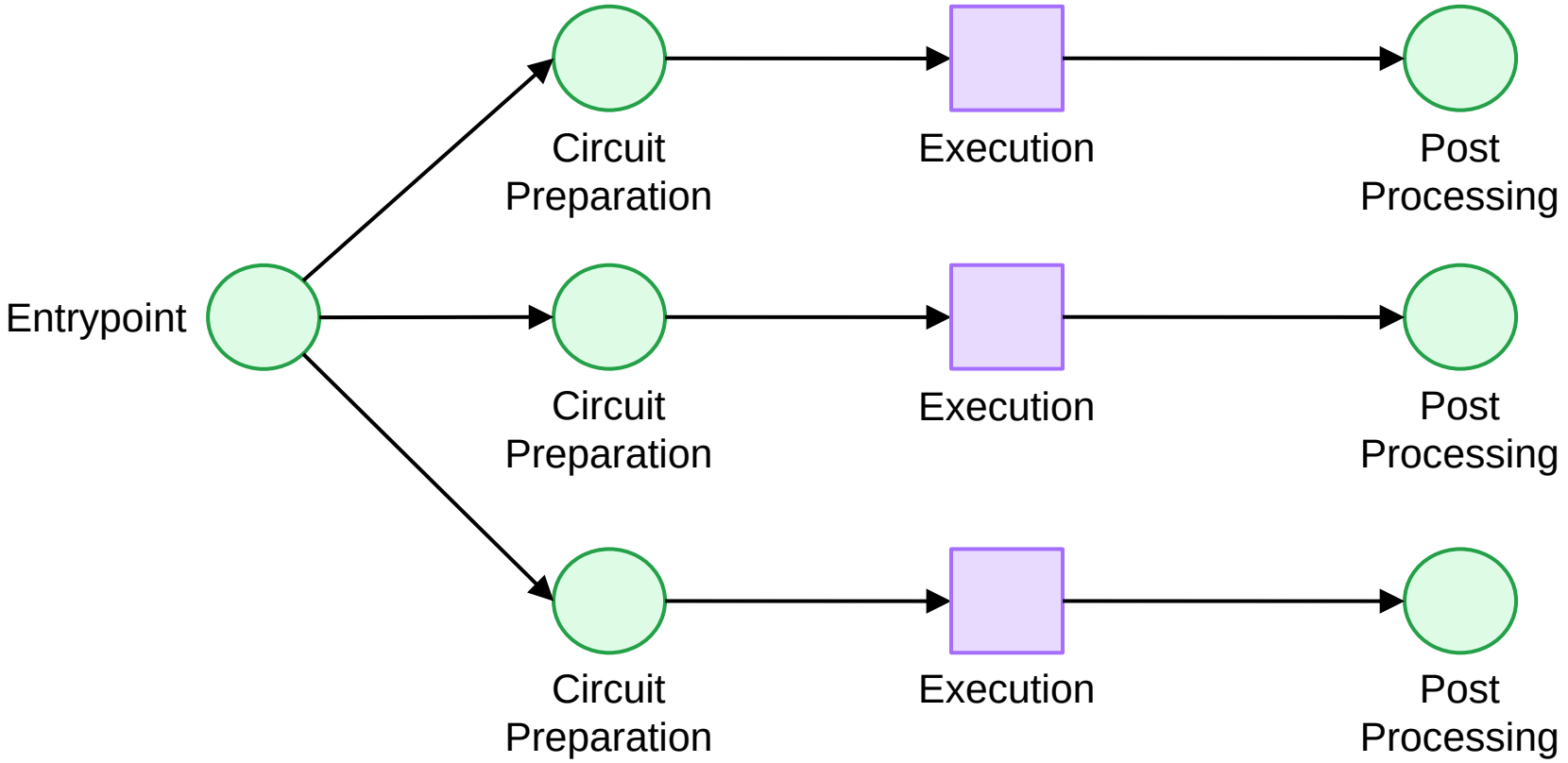
Workflow


Quantum Serverless
Python Library
Qiskit
Pattern
Gateway
DB / OS
Scheduler
KubeRay Operator
0 ..... N
Ray Workers

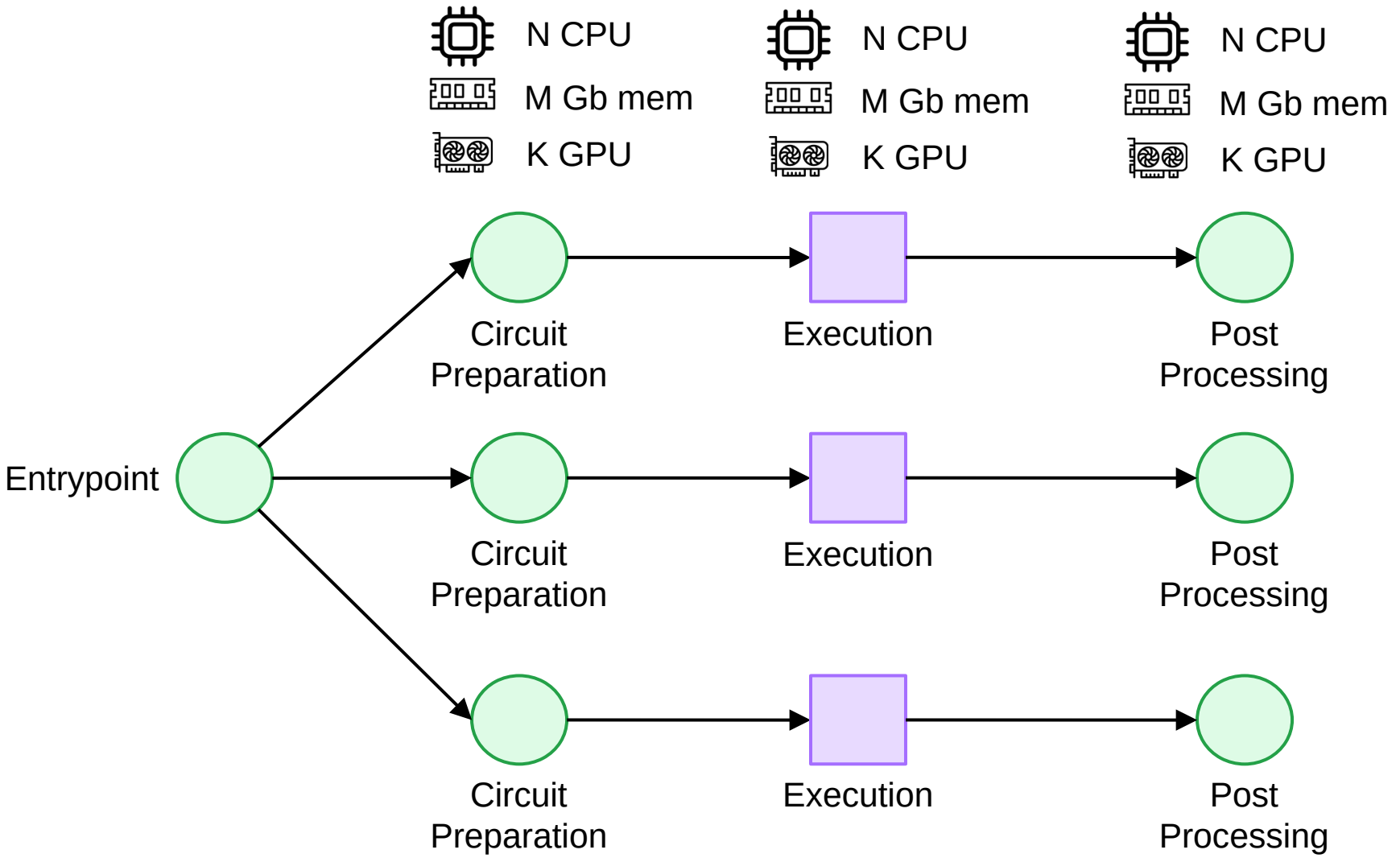
Ray Cluster Configuration


```
ray:
  cpu: 4
  memory: 8
  replicas: 1
  minReplicas: 1
  maxReplicas: 2
limits:
  maxJobsPerUser: 2
  maxComputeResources: 5
```

Workloads


Entrypoint
Circuit Preparation
Execution
Post Processing
Circuit Preparation
Execution
Post Processing
Circuit Preparation
Execution
Post Processing

Workloads


N CPU
M Gb mem
K GPU
N CPU
M Gb mem
K GPU
N CPU
M Gb mem
K GPU
Entrypoint
Circuit Preparation
Execution
Post Processing
Circuit Preparation
Execution
Post Processing
Circuit Preparation
Execution
Post Processing

Ex: Variational Quantum Eigensolver

Calculate energy

$$E = \sum_i c_i \langle \Psi(\theta) | P_i | \Psi(\theta) \rangle \geq E_{\text{exact}}$$

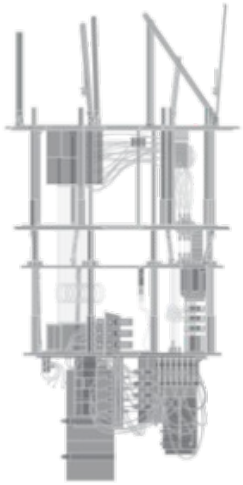
Adjust parameters

$$\{\theta_i\}$$

parameters

Optimize

energy



Prepare trial state

$$|\Psi(\theta)\rangle$$

Measure expectation values

$$\langle \Psi(\theta) | P_i | \Psi(\theta) \rangle$$

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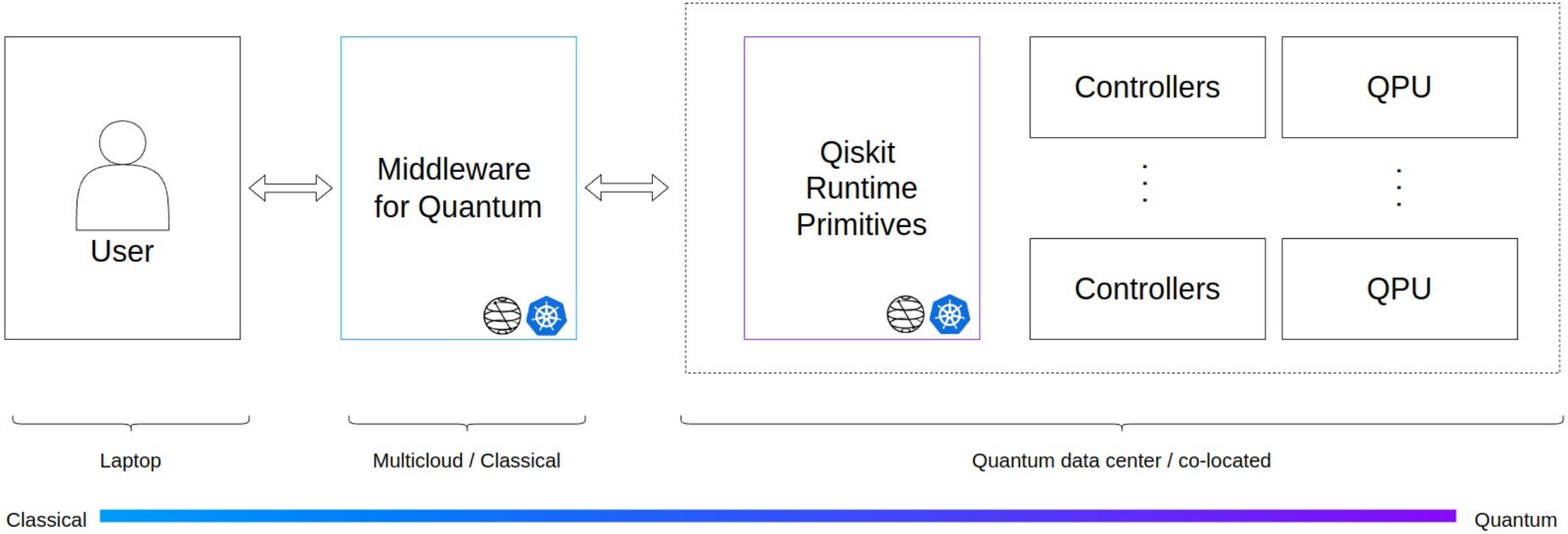
Demo

Pods

Name	Images	Labels	Node	Status
c-629e30800458e7898b0493459a-head-22t68	Show all	Show all	10.241.0.4	Running
c-629e30800458e7898b0493459a-worker-g-mz	Show all	Show all	10.241.0.7	Running

Quantum Middleware: Classical + Quantum



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Learn More

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Quantum computing

Qiskit

Quantum Serverless

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