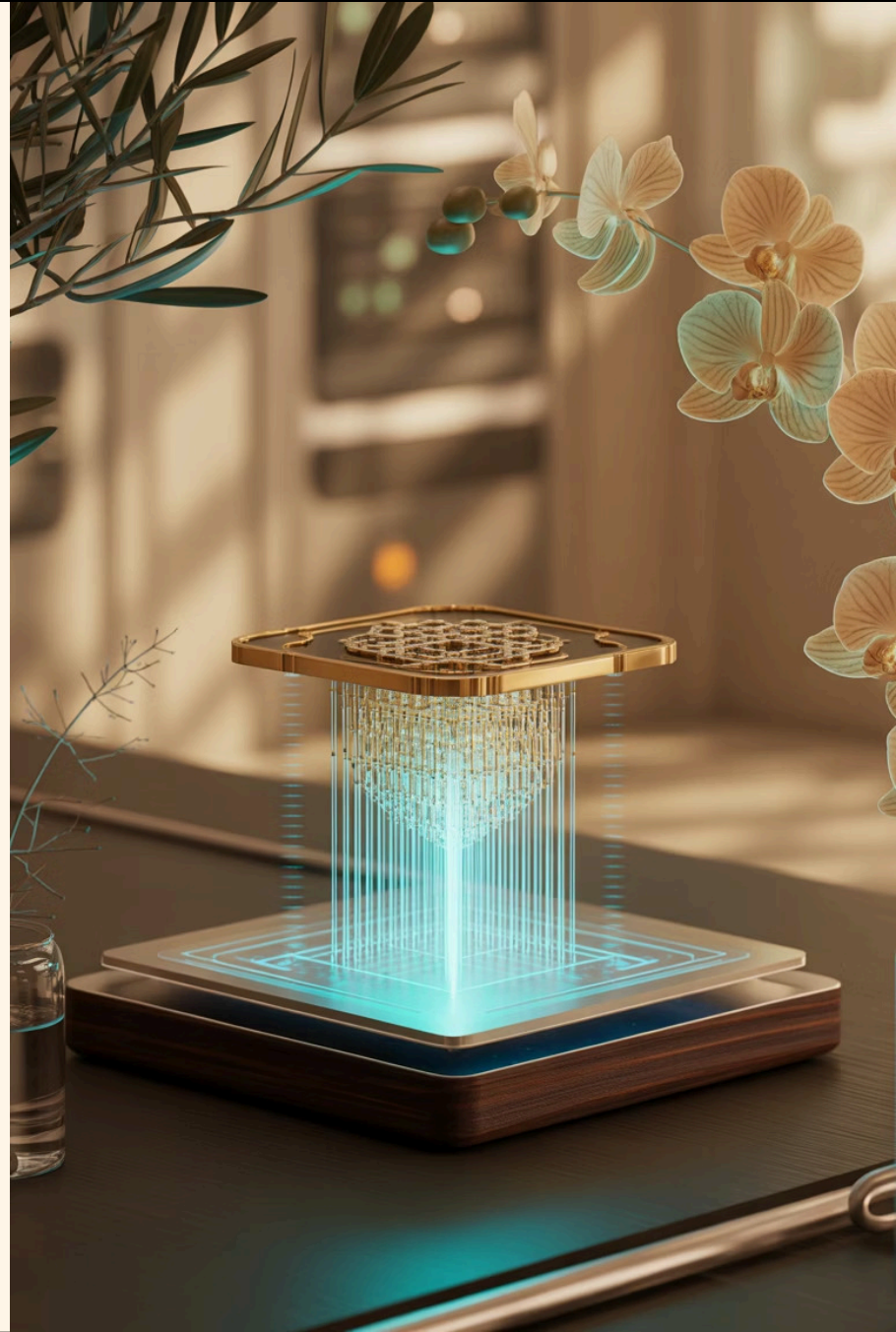
Quantum Computing Meets the Cloud

Quantum computing promises to revolutionize how we solve complex problems, from cryptography to drug discovery. By harnessing the strange behavior of quantum particles, quantum computers can perform certain calculations exponentially faster than classical computers.

This deck explores how AWS is democratizing access to quantum technology, empowering more organizations to explore the next computing frontier.

NK **by Naga Murali Krishna Koneru**



Topics Covered in This Presentation

- Classical vs. Quantum Computing
- Hybrid Quantum-Classical Computing
- AWS Quantum Computing Portfolio
- AWS Ocelot Innovation
- How Amazon Braket Works
- Getting Started with AWS Quantum
- Future of Quantum Computing
- Quantum Computing Applications
- Quantum Programming Languages
- Quantum Hardware on AWS
- Amazon Braket Overview
- Braket Architecture Design
- Quantum Computing Access Models

Classical vs. Quantum Computing

Classical Computing

Uses bits (0 or 1)

Linear power increase

Add more bits = incremental improvement

Quantum Computing

Uses qubits (0, 1, or both)

Exponential power scaling

Each added qubit doubles computational power

Quantum Computing Applications

Molecular Simulation

Drug discovery and new materials research

Complex Optimization

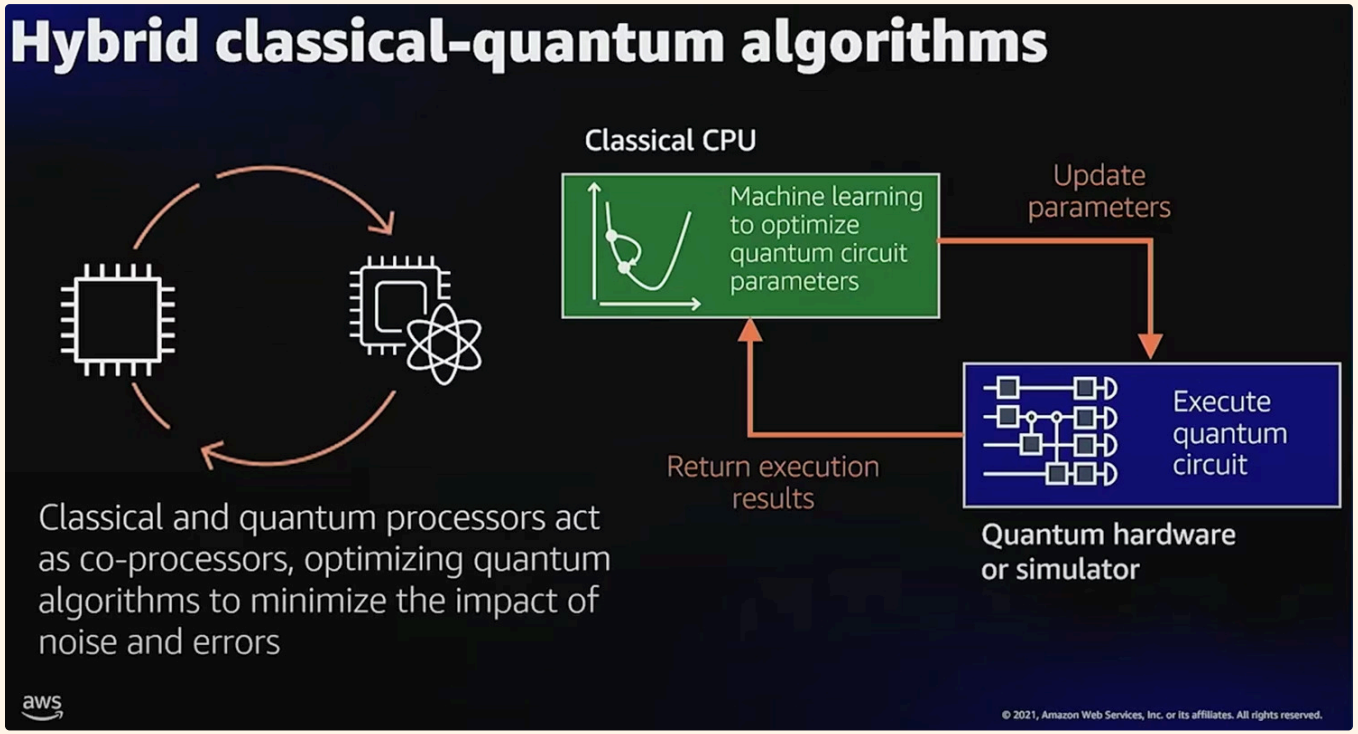
Supply chain and traffic flow improvements

Advanced Machine Learning

Enhanced pattern recognition systems

Financial Modeling

Portfolio optimization and risk analysis



Classical Computer Handles Most Work:

- Does initial setup, pre-processing, and final analysis.
- Controls the quantum computer like a "co-processor."

Quantum Computer Tackles the Hard Part:

- Runs short, optimized quantum routines where quantum effects (superposition/entanglement) help.
- Sends results back to the classical computer for interpretation.

Quantum Programming Languages

Python with Qiskit

Most used quantum SDK from IBM

Q#

Microsoft's quantum language

Cirq

Google's python framework

Amazon Braket SDK

AWS's quantum development kit

AWS Quantum Computing Portfolio

Amazon Braket

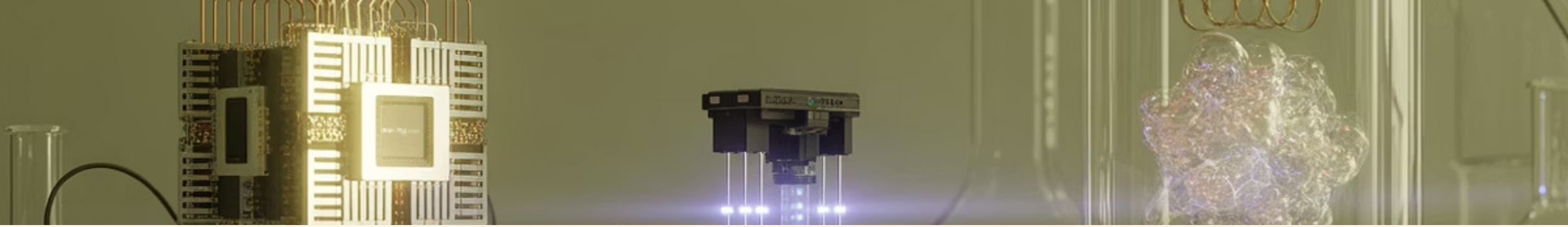
Fully managed quantum computing service that lets design, test, and run quantum algorithms on different types of quantum hardware and simulators

AWS Center for Quantum Computing

Research partnership with Caltech to advance quantum hardware and algorithms

Amazon Quantum Solutions Lab

Experts collaborating on real-world quantum solutions



Quantum Hardware on AWS

Superconducting Qubits

These are among the most mature quantum technologies

Provided by IQM and Rigetti

Ion-Trap Quantum Computers

These use trapped ions to represent qubits and are known for high fidelity

Offered by IonQ

Neutral Atom Processors

These use arrays of neutral atoms manipulated by lasers

Provided by QuEra Computing

Quantum Simulators

Test algorithms before using real quantum hardware

AWS Ocelot Innovation

New Quantum Chip

Announced February 2025

"Cat Qubit" Design

Stays in a **superposition of two states** (like 0 and 1 at the same time) while being **more resistant to errors** than regular qubits

Reduces error correction by 90%

Reliability

Development of smaller, more reliable quantum computers

Amazon Braket Overview

Launch

December 2019, now generally available

Unified Environment

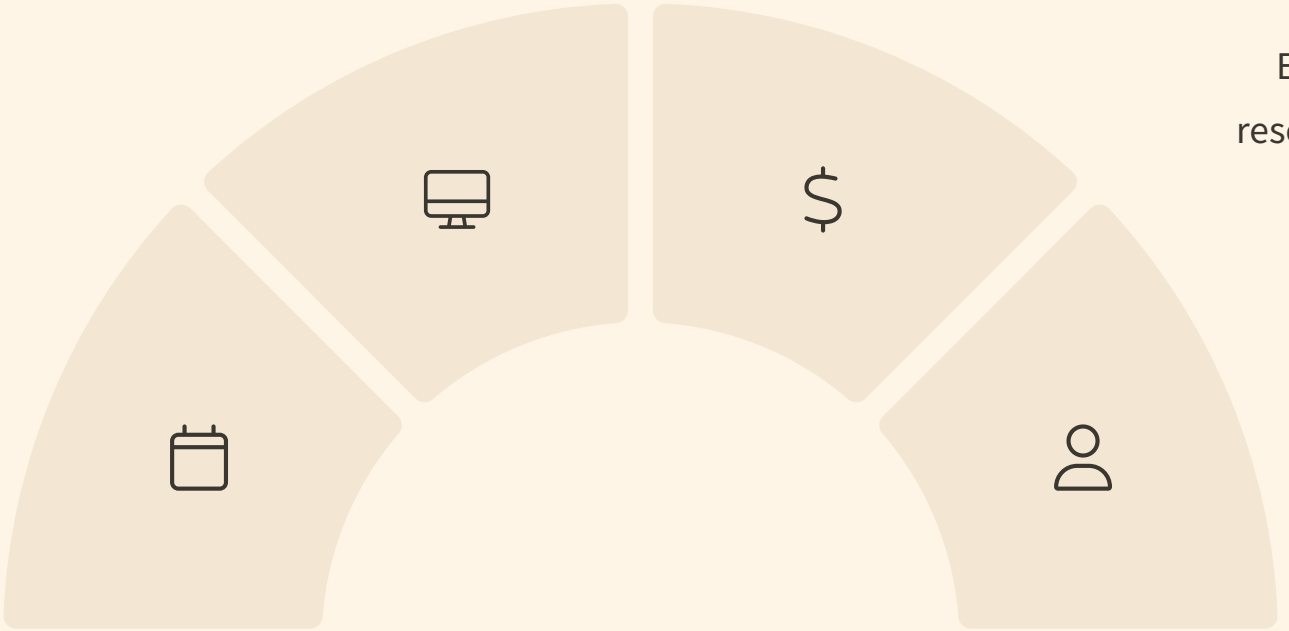
Single platform for multiple quantum hardware types

Pay-as-you-go

No large upfront investments needed

Democratized Access

Enables innovation for researchers and businesses



How Amazon Braket Works

Design

Create algorithms with Python SDK

Submit

Send quantum tasks to devices or simulators

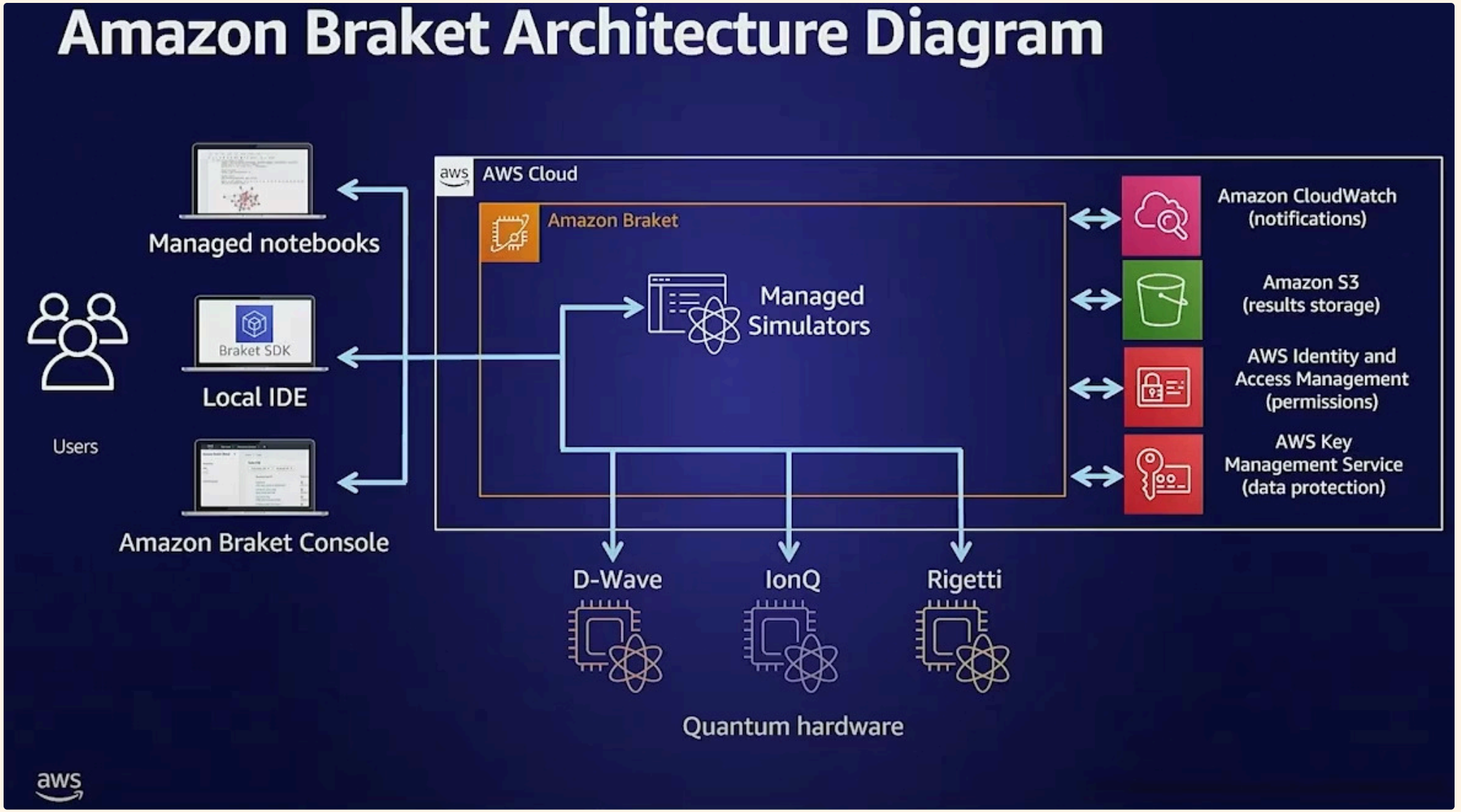
Process

Run hybrid classical-quantum jobs

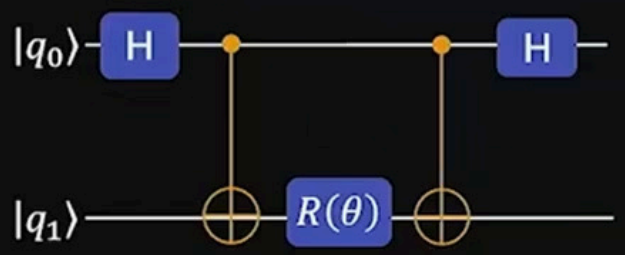
Compare

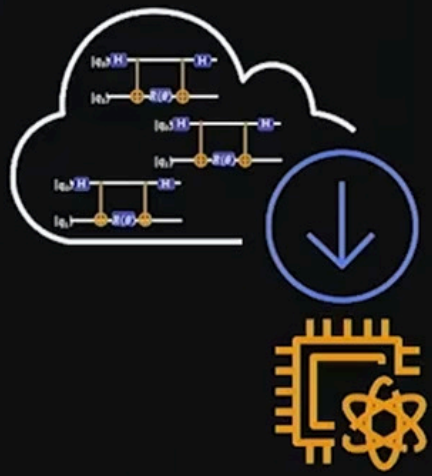
Switch between hardware with minor code changes

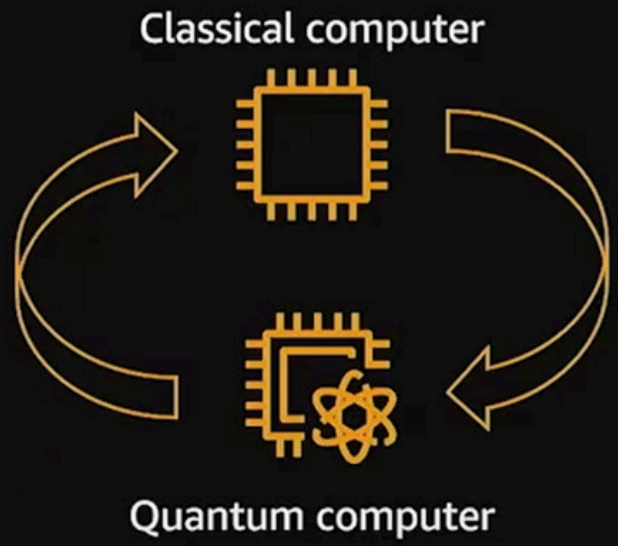
Amazon Braket Architecture Diagram



Shots – Tasks – Jobs







Shot

Single execution of quantum operation on a device

Task

Series if repeated shots on a device (10s–10,000s shots per task)

Hybrid job

Sequence of classical and quantum compute cycles (10s to 1,000s of tasks per job)

aws

Quantum Computing Access Models

Cloud Access

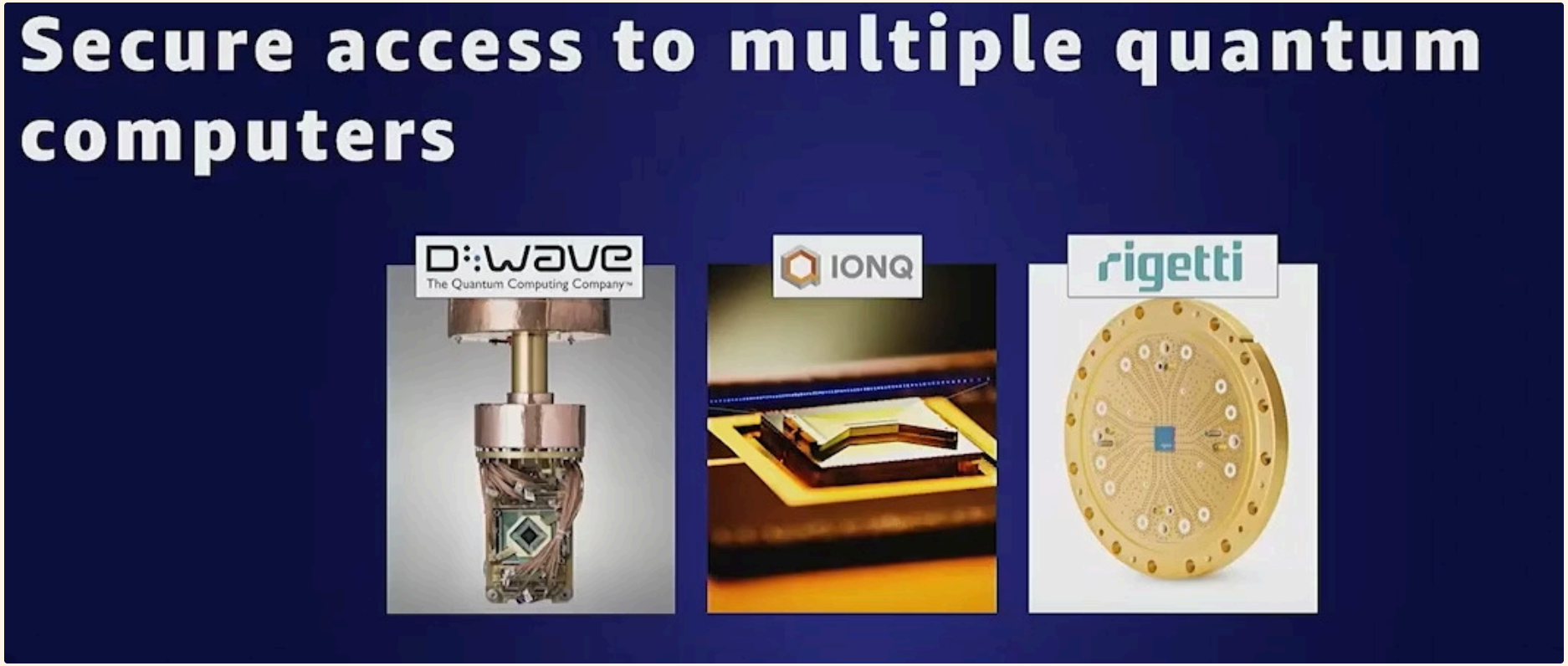
Pay-as-you-go quantum computing via AWS

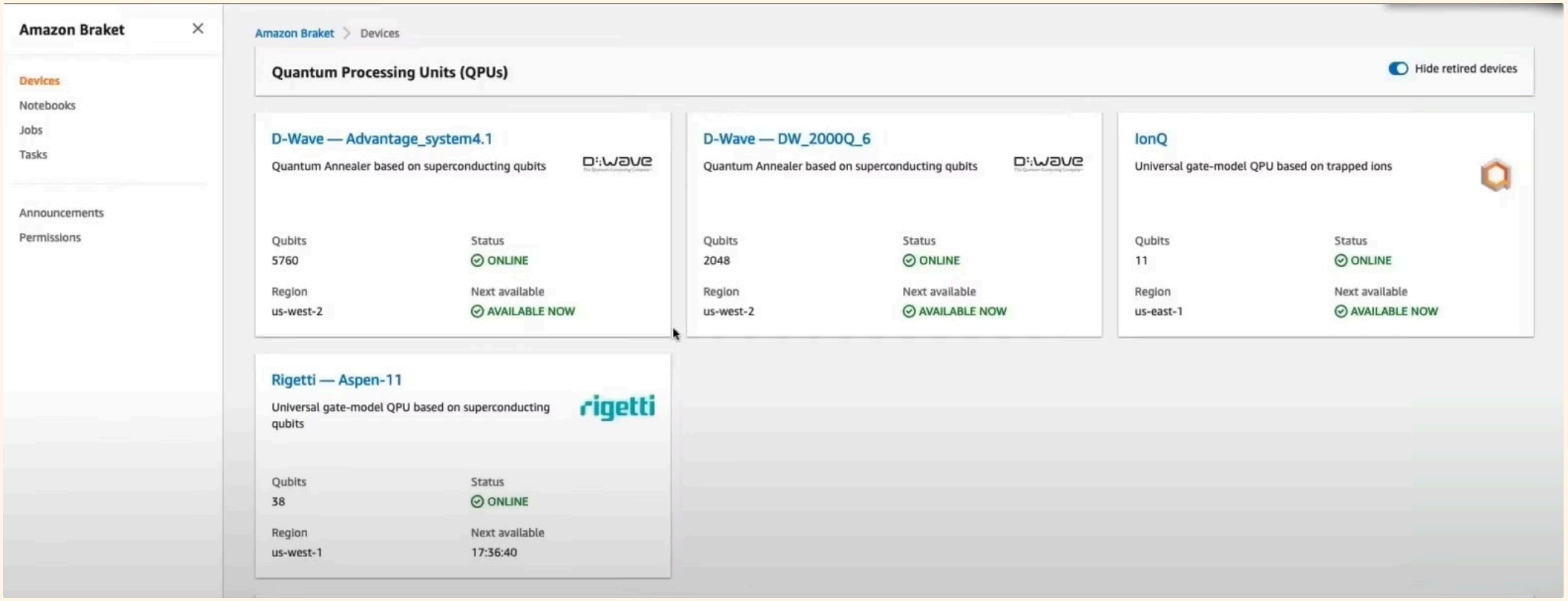
On-Premises

Direct hardware ownership for specific needs

Hybrid Models

Combination of cloud and local resources

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Universal gate-model QPU based on trapped ions
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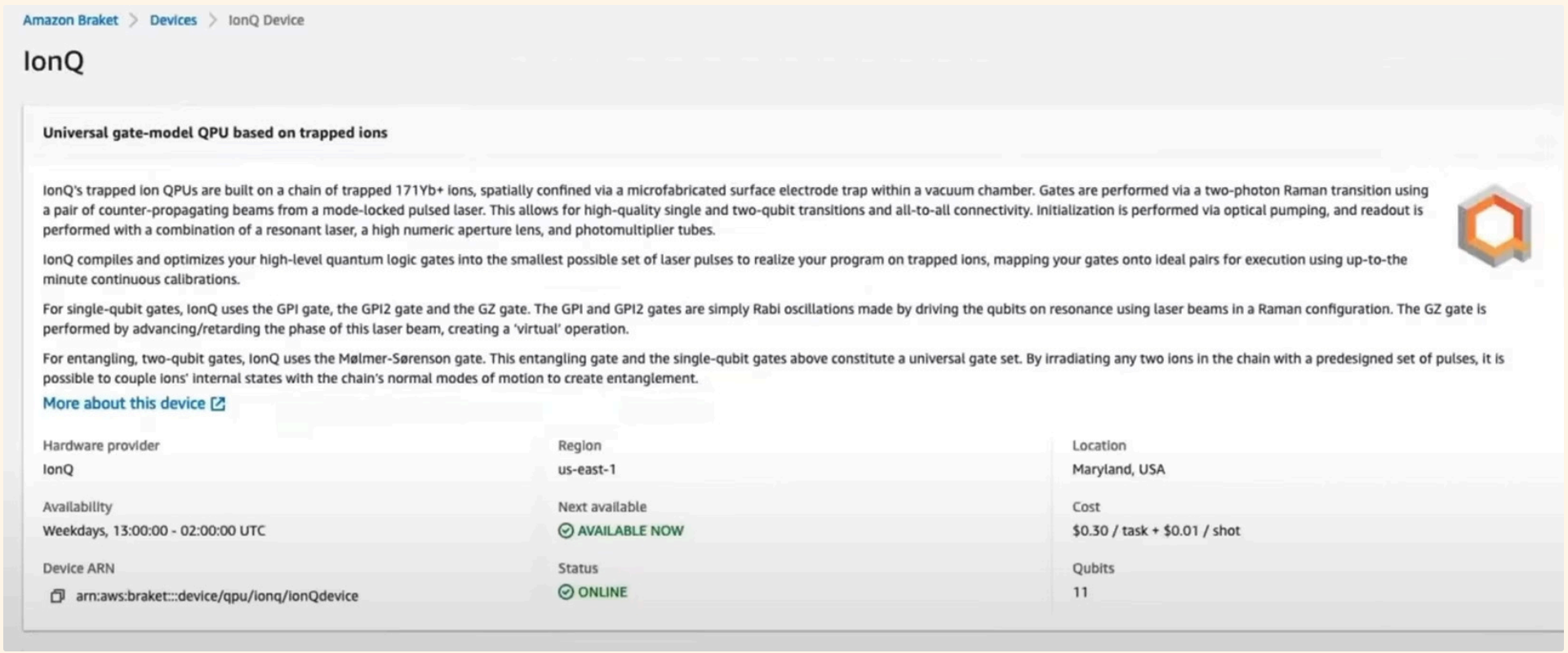
Amazon Braket > Devices > IonQ Device
IonQ
Universal gate-model QPU based on trapped ions
IonQ's trapped ion QPUs are built on a chain of trapped 171Yb+ ions, spatially confined via a microfabricated surface electrode trap within a vacuum chamber. Gates are performed via a two-photon Raman transition using a pair of counter-propagating beams from a mode-locked pulsed laser. This allows for high-quality single and two-qubit transitions and all-to-all connectivity. Initialization is performed via optical pumping, and readout is performed with a combination of a resonant laser, a high numeric aperture lens, and photomultiplier tubes.
IonQ compiles and optimizes your high-level quantum logic gates into the smallest possible set of laser pulses to realize your program on trapped ions, mapping your gates onto ideal pairs for execution using up-to-the minute continuous calibrations.
For single-qubit gates, IonQ uses the GPI gate, the GPI2 gate and the GZ gate. The GPI and GPI2 gates are simply Rabi oscillations made by driving the qubits on resonance using laser beams in a Raman configuration. The GZ gate is performed by advancing/retarding the phase of this laser beam, creating a 'virtual' operation.
For entangling, two-qubit gates, IonQ uses the Mølmer-Sørenson gate. This entangling gate and the single-qubit gates above constitute a universal gate set. By irradiating any two ions in the chain with a predesigned set of pulses, it is possible to couple ions' internal states with the chain's normal modes of motion to create entanglement.
More about this device
Hardware provider
IonQ
Region
us-east-1
Location
Maryland, USA
Availability
Weekdays, 13:00:00 - 02:00:00 UTC
Next available
AVAILABLE NOW
Cost
$0.30 / task + $0.01 / shot
Device ARN
arn:aws:braket:::device/qpu/ionq/ionQdevice
Status
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Qubits
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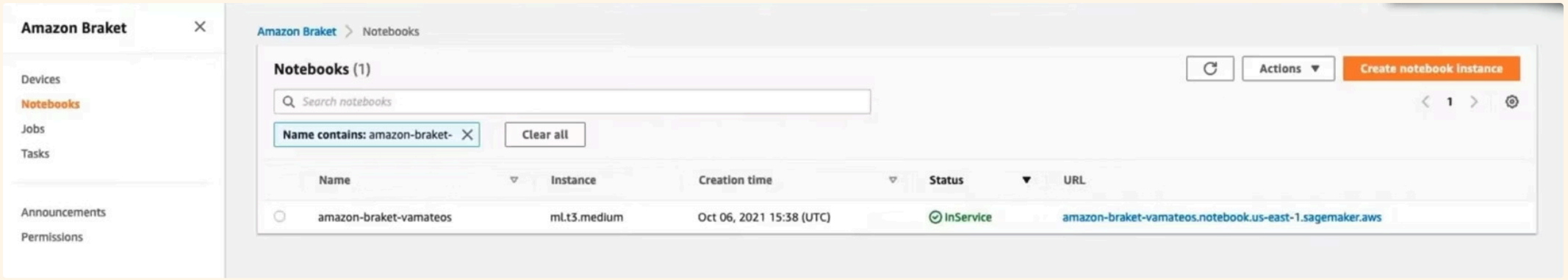
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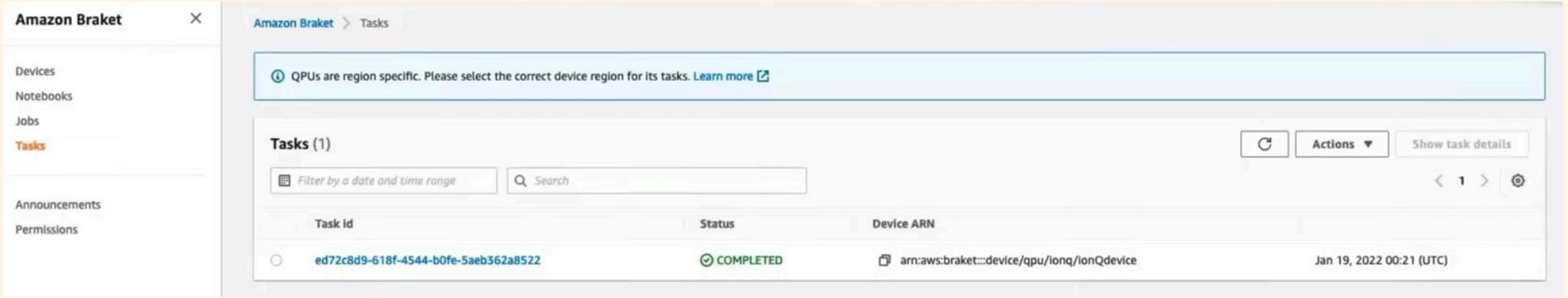
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Future of Quantum Computing

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Fault-Tolerant Systems

Error-corrected quantum computers

Commercial Applications

Mainstream quantum solutions

Post-Quantum Cryptography

New security paradigms

Quantum Education

Workforce development for quantum economy