Quantum Computing in the Cloud with Amazon Braket

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Amazon Web Services

Quantum Computing at AWS

AWS Center for Quantum Computing

Research and development

AWS Center for Quantum Networking

Research and development

AWS Partner Network

Community of quantum computing partners

Quantum Solutions Lab

State-of-the-art quantum and classical solutions

Amazon Braket

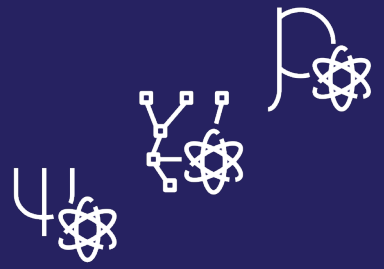
Fully managed quantum computing service

Amazon Braket – the AWS Quantum Computing Service

A fully managed service that makes it easy for scientists and developers to explore quantum computing

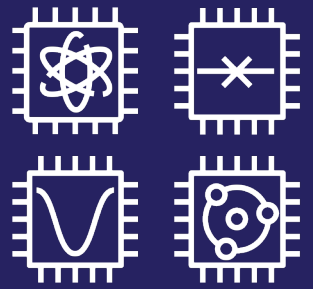
Build

- Amazon Braket SDK
- Jupyter notebooks
- Command line interface



Test

- Local simulators for rapid testing
- High-performance simulators



Run

- Access multiple quantum computers
- Combine quantum and classical resources

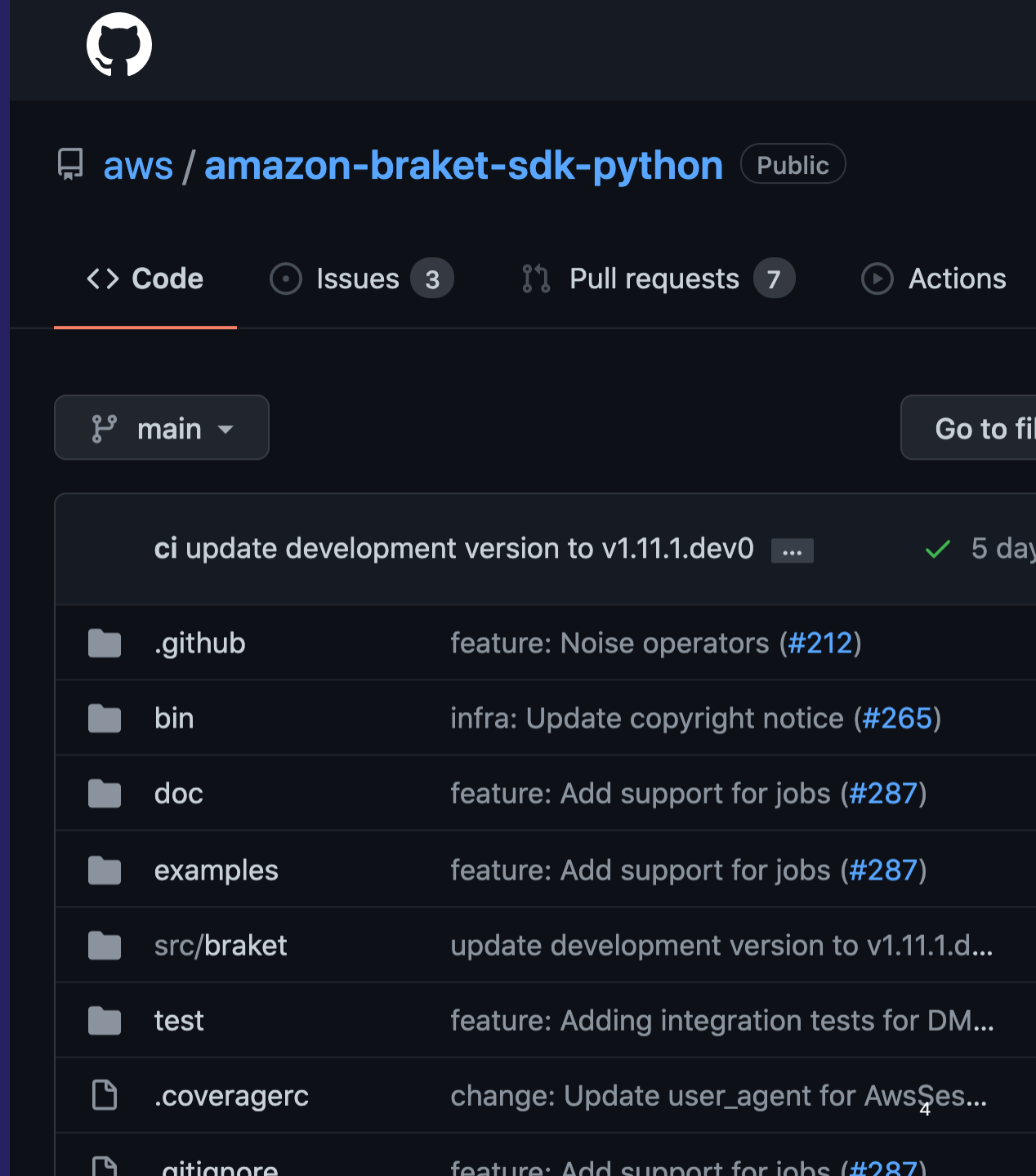
Analyze

- Monitor algorithms in almost real time
- Analyze algorithm results and performance

The Amazon Braket SDK

Open source Python library

- Design and build quantum circuits
- Submit tasks and jobs to devices
- Track and monitor their execution
- Local installation
  - pip install amazon-braket-sdk
- Local simulators (free)
  - braket_sv
  - braket_dm
  - braket_ahs



The Amazon Braket Workflow

aws_bell.py

```
1  from braket.aws import AwsDevice
2  from braket.circuits import Circuit
3
4  device = AwsDevice("aws_device_ARN")
5
6  # Choose S3 bucket to store results
7  bucket = "amazon-braket-unique-aabbcdd"
8  prefix = "results"
9  s3_folder = (bucket, prefix)
10
11 bell = Circuit().h(0).cnot(0, 1)
12 print(bell)
13
14 task = device.run(bell, s3_folder, shots=1000)
15 print("Measurement Results")
16 print(task.result().measurement_counts)
17
```

Amazon Braket provides AWS customers access to multiple types of quantum computing technologies.

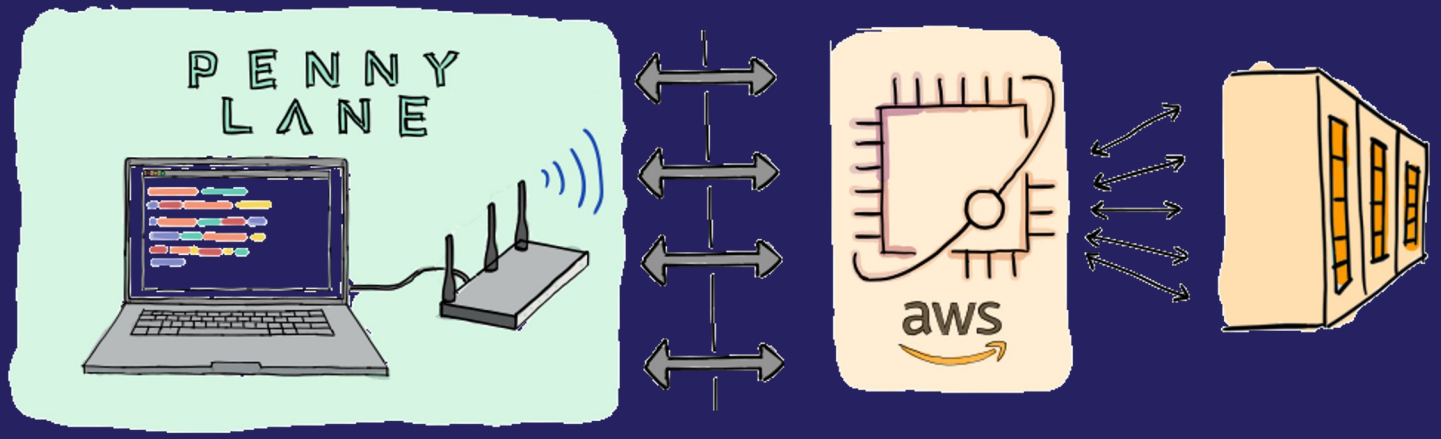
In Amazon Braket, a device represents a QPU or simulator.

Devices are selected using the device Amazon Resource Name (ARN).

https://docs.aws.amazon.com/braket/latest/developerguide/braket-devices.html

The Amazon Braket SDK

Enhance functionality with open-source plugins



A cross-platform Python library for differentiable programming of quantum computers.

Train a quantum computer the same way as a neural network.

https://pennylane.ai/qml

The Amazon Braket SDK

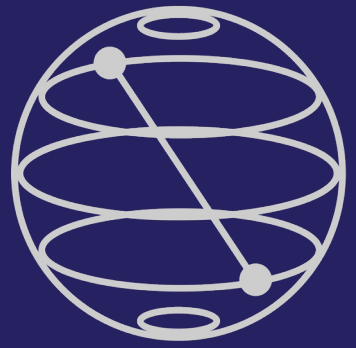
Enhance functionality with open-source plugins

Run Amazon Braket code from Qiskit development toolkit

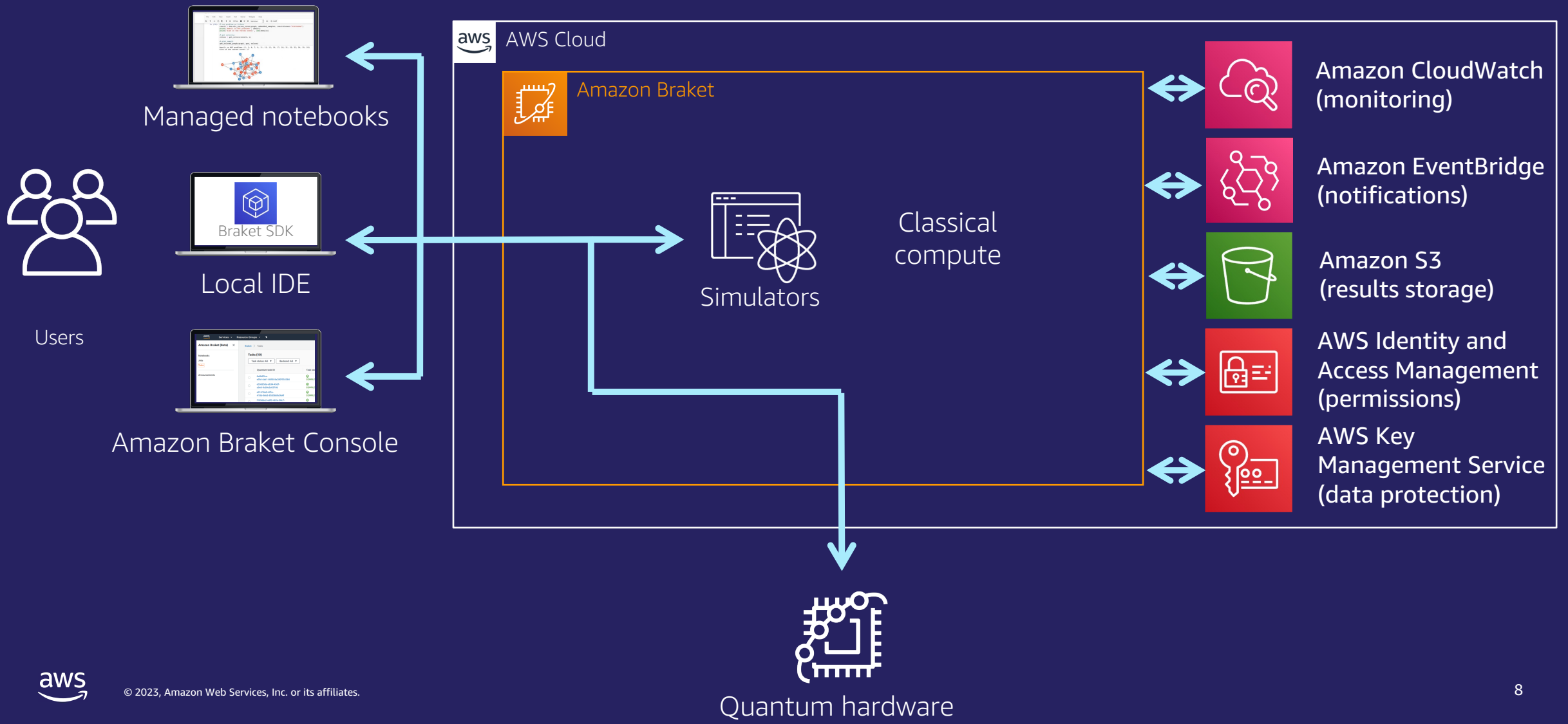
https://github.com/qiskit-community/qiskit-braket-provider

qiskit_connector.py

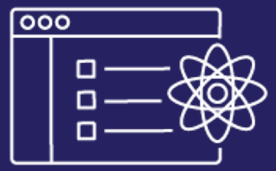
```python
from qiskit_braket_provider import BraketLocalBackend

local_simulator = BraketLocalBackend()
task = local_simulator.run(circuit, shots=1000)

```



The Amazon Braket Architecture



Local and On-Demand Simulators



Local simulator

Part of Braket SDK

Fast and convenient prototyping

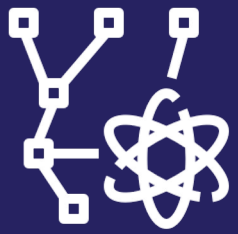
Number of qubits based on hardware

SV1: State Vector simulator

Quantum circuit with up to 34 qubits

Stores the full wave function state

Concurrency: Default 35, max 50

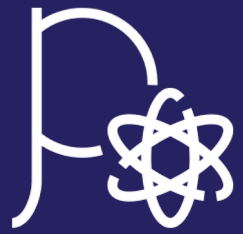


TN1: Tensor Network simulator

Quantum circuit with up to 50 qubits

Encodes quantum circuits into a structured graph

Concurrency: Default 10, max 10



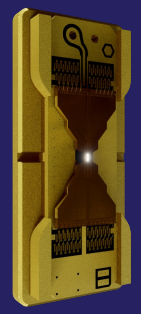
DM1: Density Matrix simulator

Quantum circuit with up to 17 qubits

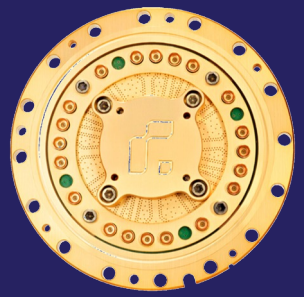
Run multiple circuits in parallel with noise simulation

Concurrency: Default 35, max 50

Available Quantum Computers



IONQ



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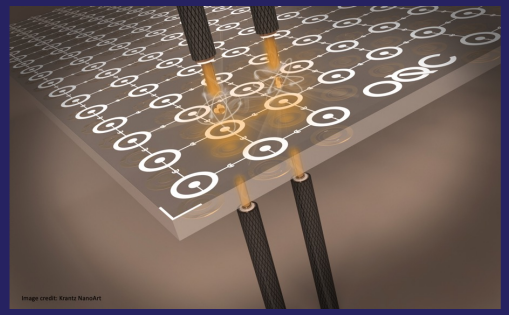
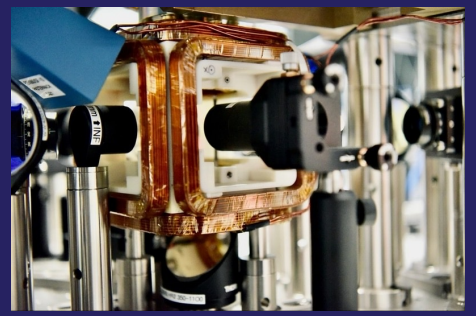
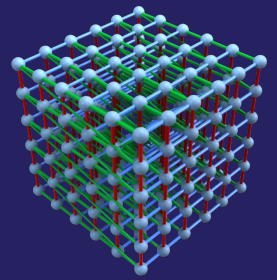


OQC

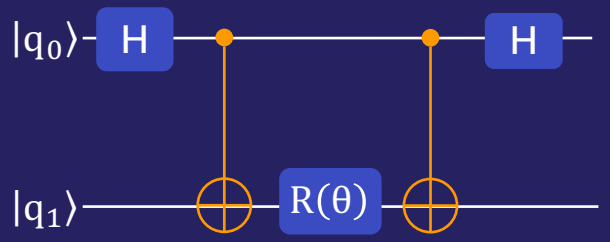


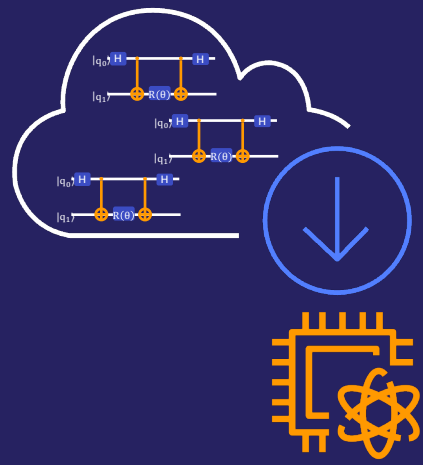
IQuEra COMPUTING INC.

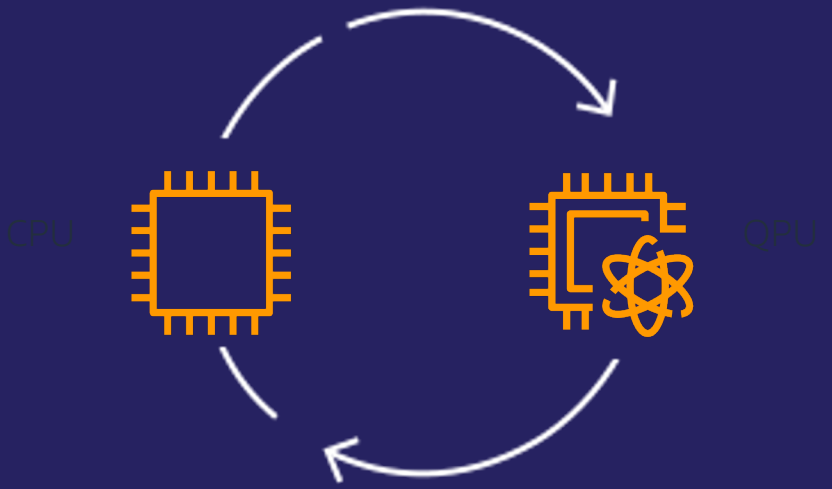


XANADU

Shots, Tasks, and now Hybrid Jobs







Shot

Single execution of quantum operation on a device

Task

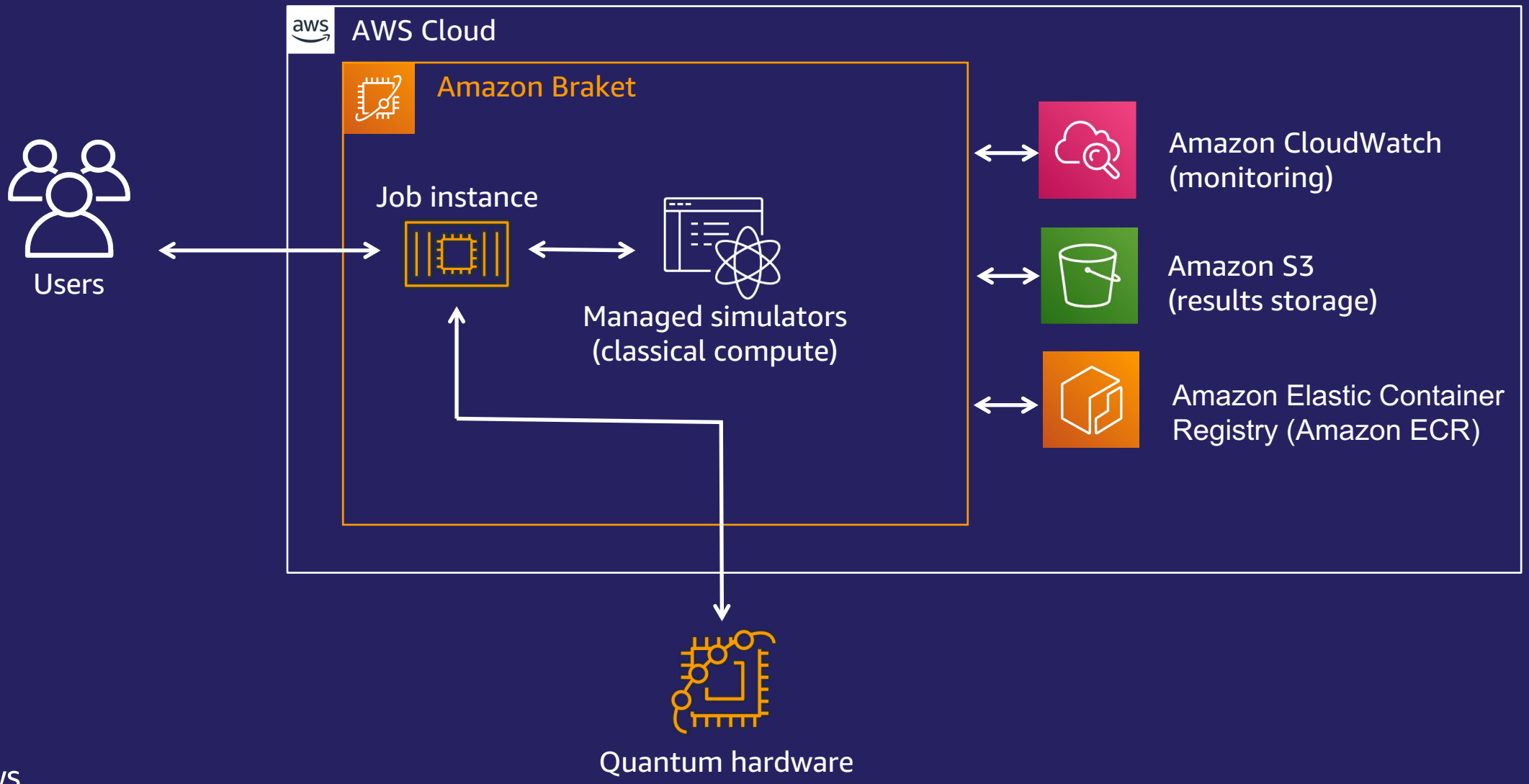
Series of repeated shots on a device (10s–10,000s shots per task)

Hybrid job

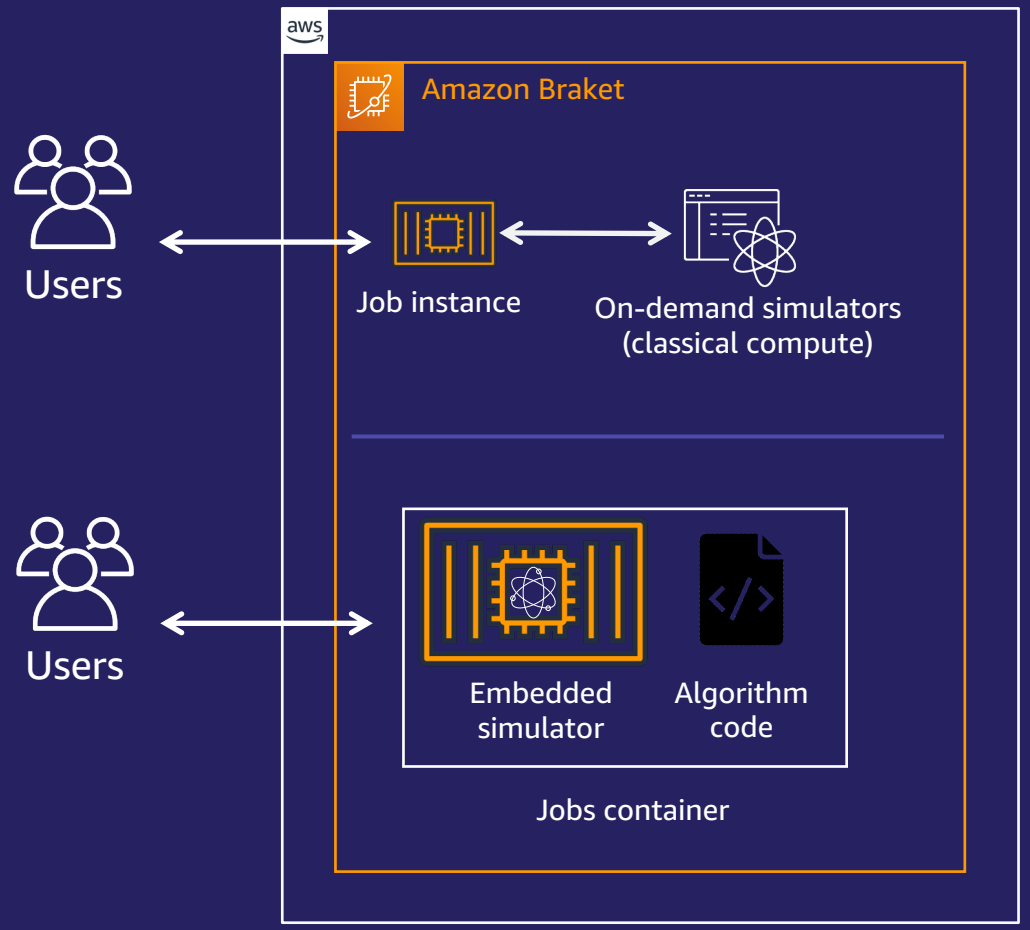
Sequence of classical and quantum compute cycles (10s to 1,000s of tasks per job)

https://docs.aws.amazon.com/braket/latest/developerguide/braket-jobs.html

Amazon Braket Hybrid Jobs



Embedded Simulators with Hybrid Jobs



Speed up demanding algorithms

- Bring code and simulator together in a single container for faster communication and distributed scale-out.
- NVIDIA cuQuantum state vector simulation library for highly entangled quantum circuits.
- Reduce number of iterations and lower memory usage, decreasing costs.
- lightning.qubit, lightning.gpu or BYOC

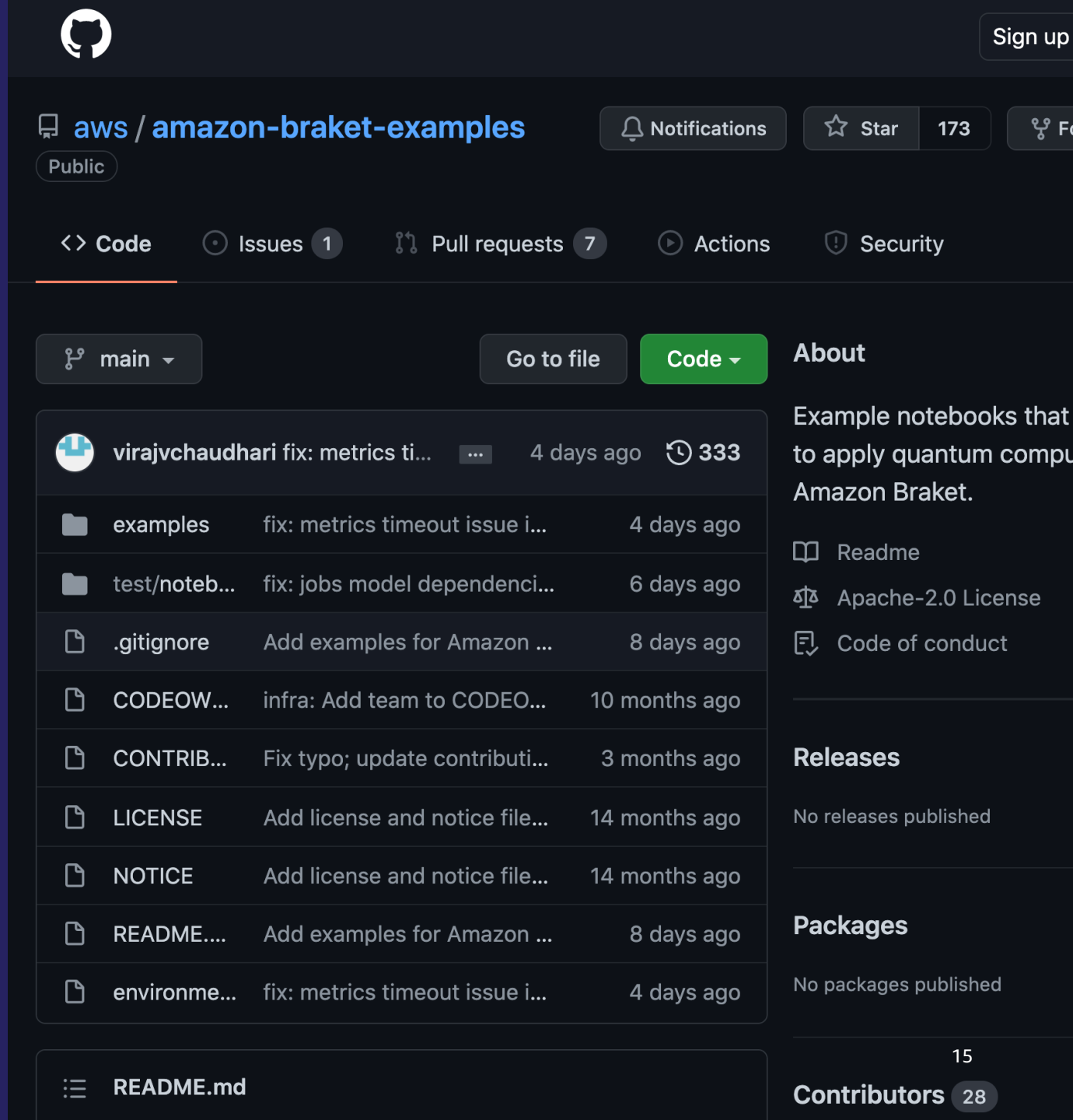
How to get started?

Amazon Braket Examples

Topics include:

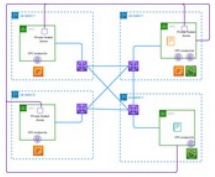
- Getting started
- Braket features
- Hybrid jobs
- Advanced circuits
- Hybrid algorithms
- PennyLane

https://github.com/aws/amazon-braket-examples



AWS Blogs

AWS Quantum Computing Blog



Setting up a cross-Region private environment in Amazon Braket

by Jagadeesh Pusapadi, Juan Moreno, and Niko Borodachuk | on 21 FEB 2022 | in Amazon Braket, Best Practices, Customer Solutions, Quantum Technologies, Technical How-to | Permalink | Share

At AWS we say that security is "job zero", by which we mean it is even more important than any number one priority. Amazon Braket is built around this philosophy; we often have conversations with customers who want to be able to work in a secured environment, and access Amazon Braket through private connections rather […]

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Quantum computing research in Poland with Amazon Braket

by Dariusz Matczak | on 31 JAN 2022 | in Amazon Braket, Announcements, Public Sector, Quantum

With a host of vibrant research centers, scientists and engineers in Poland have mad science over the past 40 years. Today, as a large number of quantum hardware techn experimentation, Polish researchers are turning to Amazon Braket – the AWS quantu

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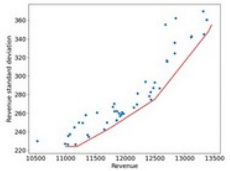

Using quantum annealing on Amazon Braket for price optimization

by Feng Shi, Naz Levent, Helmut Katzgraber, Marco Guerriero, and Martin Schuetz | on 05 JAN 202

Intelligence, Customer Solutions, Quantum Technologies | Permalink | Share

Combinatorial Optimization is one of the most popular fields in applied optimizatio every industry, including both private and public sectors. Examples include supply ch planning, manufacturing layout design, facility planning, vehicle scheduling and rou seasonal planning, telecommunication network […]

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Winners announced in the BMW Group Quantum Computing Challenge

by James Goeders and Martin Schuetz | on 09 DEC 2021 | in Amazon Braket, Amazon Quantum So

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The four winning teams of the BMW Quantum Computing Challenge were announce Santa Clara, California. The challenge, focused on discovering potential quantum cor collaboration between the BMW Group and the Amazon Quantum Solutions Lab Pro

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Open quantum assembly language

Andrew Cross, Ali Javadi-Abhari, Thomas Alexander, Lev Bishop, Colm A. Ryan, Steven Heidel, Niel de Beaudrap, John Smolin, Jay M. Gambetta, Blake R. Johnson | 2022

Open quantum assembly language (OpenQASM 2) [1] was proposed as an imperative programming language for quantum computation based on earlier QASM dialects [2–6]. OpenQASM is one of the programming interfaces of the IBM Quantum services [7]. In the period since OpenQASM 2 was introduced, it has become something of a de… Read More

QUANTUM TECHNOLOGIES

Engineering fast bias-preserving gates on stabilized cat qubits

Qian Xu, Joseph Iverson, Fernando Brandão, Liang Jiang | 2022

Stabilized cat codes can provide a biased noise channel with a set of bias-preserving (BP) gates, which can significantly reduce the resource overhead for fault-tolerant quantum computing. All existing schemes of BP gates, however, require adiabatic quantum evolution, with performance limited by excitation loss and nonadiabatic errors during the… Read More

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Thank you!

Sebastian Stern

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