



# Amazon Braket:

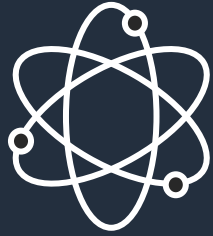
*an integrated software development environment for quantum computing in the cloud*

Dr. Fabio Baruffa  
Sr. HPC & QC Solutions Architect

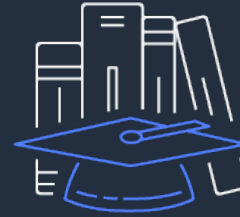
# Quantum Computing at AWS

A brief overview

# Quantum Computing at AWS



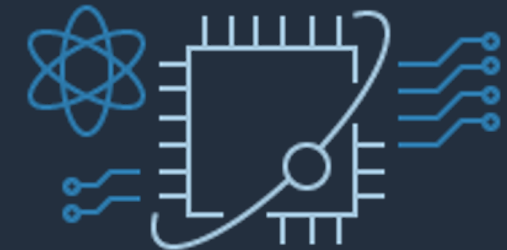
**AWS Center for  
Quantum Computing**  
Research and development



**Quantum Solutions Lab**  
State-of-the-art quantum and  
classical solutions



**AWS Partner Network**  
Community of quantum  
computing partners



**Amazon Braket**  
Fully managed quantum  
computing service

# AWS Center for Quantum Computing

Our long-term commitment



**Push** the boundaries

Original research on quantum  
algorithms and hardware

Near-term applications

Error correction



October 2021

[aws.amazon.com/blogs/quantum-computing/announcing-the-opening-of-the-aws-center-for-quantum-computing/](https://aws.amazon.com/blogs/quantum-computing/announcing-the-opening-of-the-aws-center-for-quantum-computing/)



# Amazon Quantum Solutions Lab

- Collaborative research engagements
- Identify the most promising applications
- Dive deep and learn about the science of quantum computing
- Develop and benchmark new algorithms and solutions
- Build the internal expertise and strategies for the future of quantum computing



Machine learning

Build and optimize deep learning approaches on AWS



Quantum Computing

Build quantum computing prototypes and algorithms

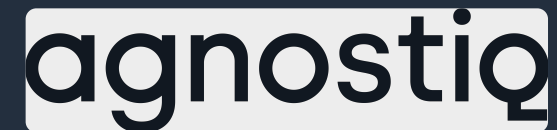
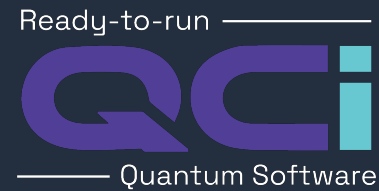


HPC

Build and optimize HPC and nature inspired approaches

[aws.amazon.com/quantum-solutions-lab/](https://aws.amazon.com/quantum-solutions-lab/)

# AWS Partners and Startups with quantum focused solutions and services on AWS



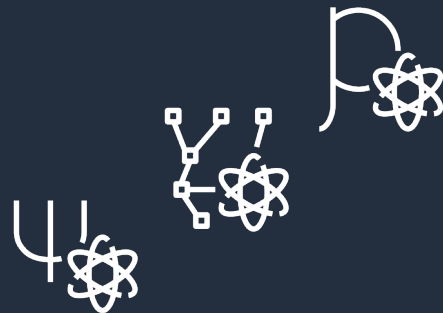
# Amazon Braket – the AWS quantum computing service

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



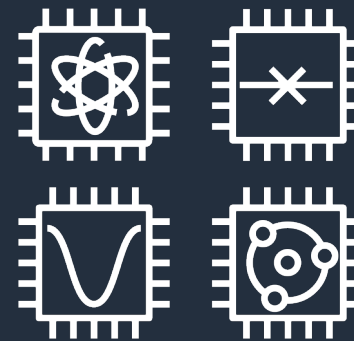
## Build

- Amazon Braket SDK
- Jupyter notebooks
- Command line interface
- Leverage multiple cloud services



## Test

- Local simulators for rapid testing
- High-performance simulators



## Run

- Access multiple quantum computers
- Combine quantum and classical resources



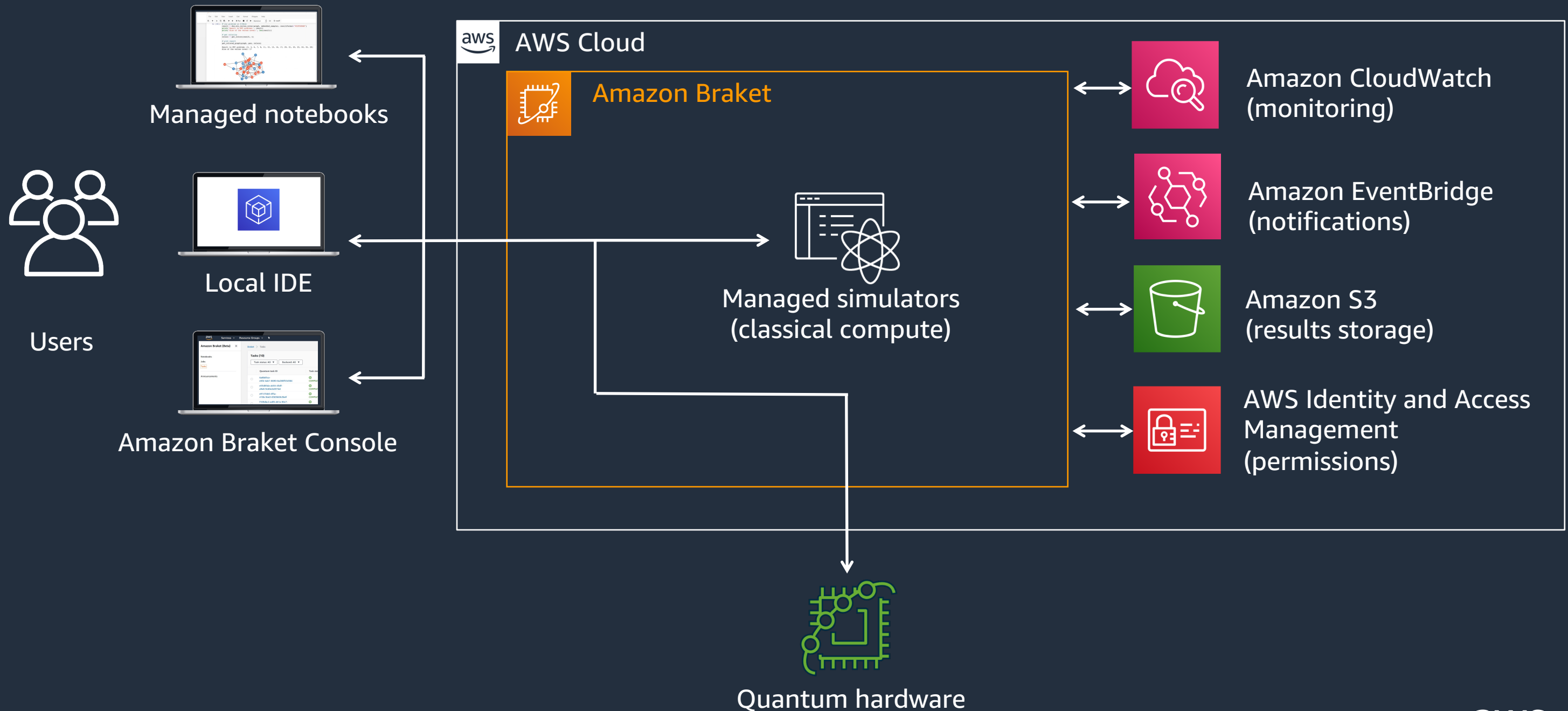
## Analyze

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

# Amazon Braket

Introduction to the AWS quantum computing service

# Amazon Braket architecture





# Local and managed simulators



## Local simulator

Pre-installed with Braket SDK

Fast and convenient prototyping

Number of qubits based on hardware

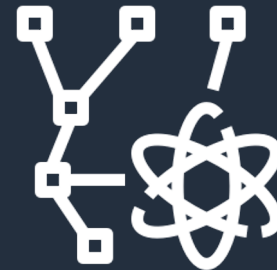


## SV1: State Vector simulator

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.



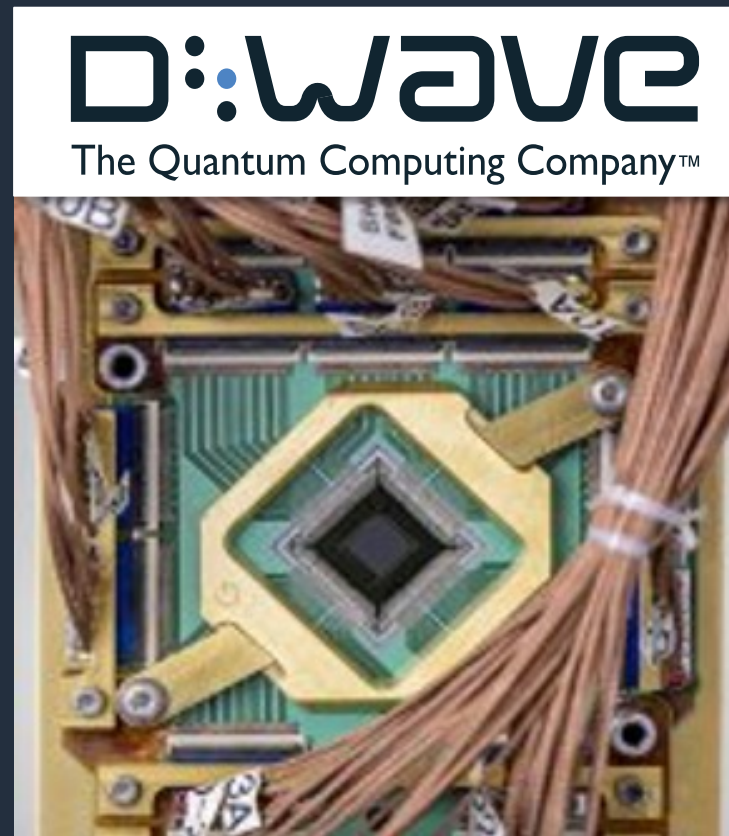
## DM1: Density Matrix simulator

Quantum circuit with up to 17 qubits

Run multiple circuits in parallel with noise simulation

Concurrency: Default 35, max 50.

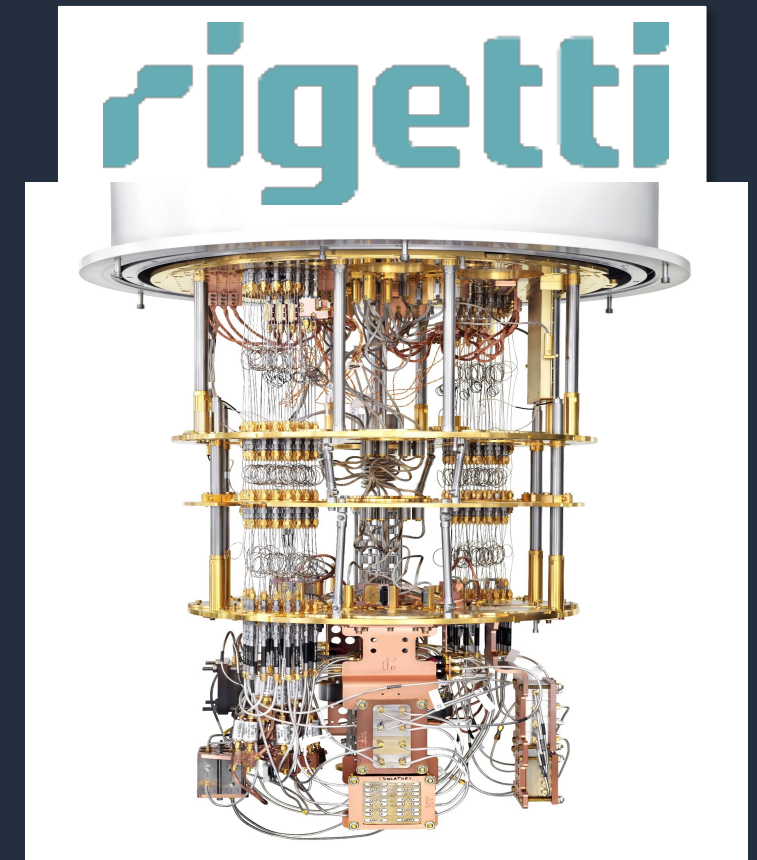
# Quantum Computers



Quantum annealer



Trapped ions

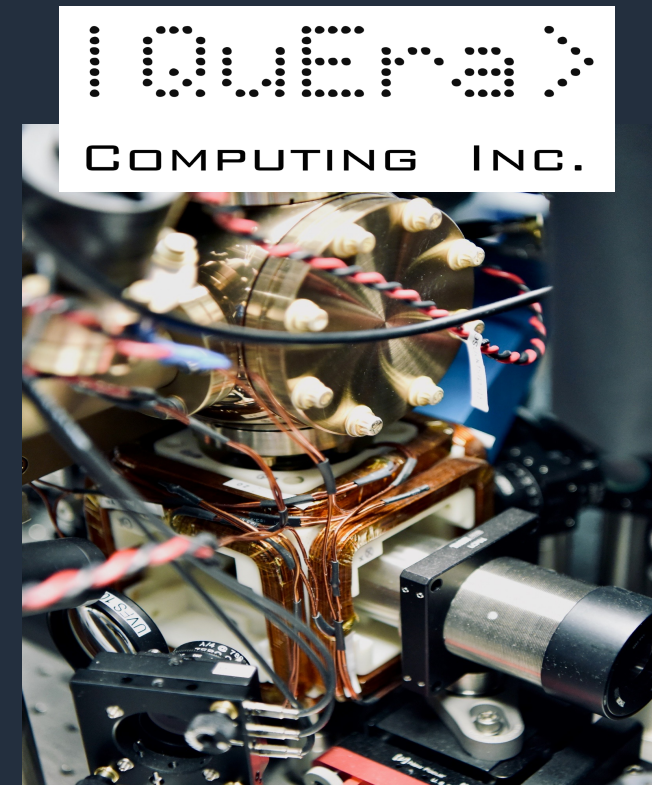


superconducting

# New hardware coming to Amazon Braket



superconducting



Rydberg atoms



# Selecting a device

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)

```
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-aabbccdd"
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
```

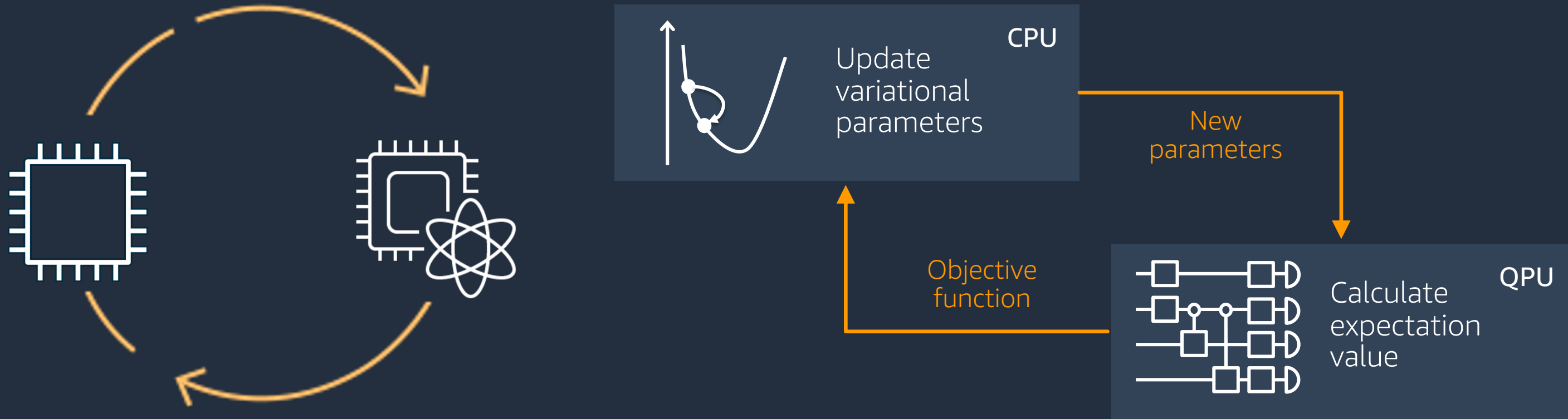
[docs.aws.amazon.com/braket/latest/developerguide/braket-devices.html](https://docs.aws.amazon.com/braket/latest/developerguide/braket-devices.html)

# Amazon Braket Hybrid Jobs

A new service feature



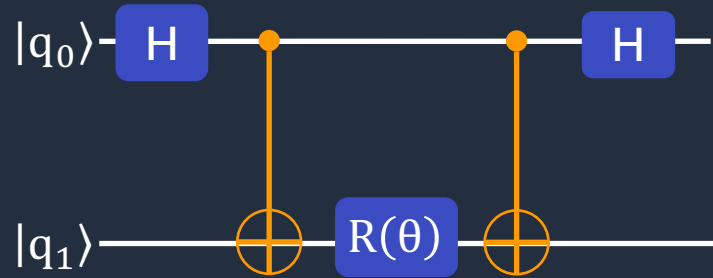
# Hybrid Classical-Quantum Algorithms



Hybrid algorithms use **fewer qubits** and **shorter circuits**

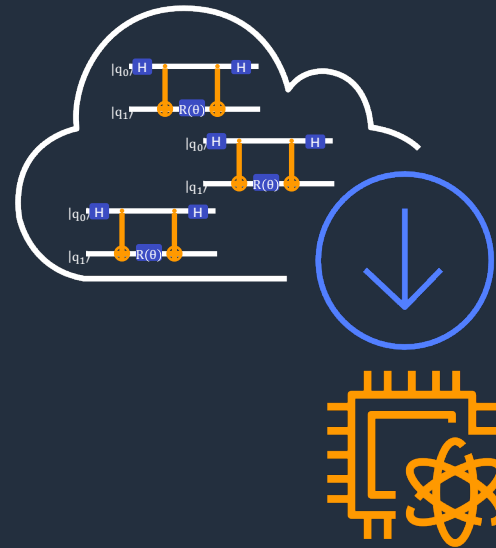
The quantum computer used as a **co-processor**

# Shots, tasks, and now Hybrid Jobs



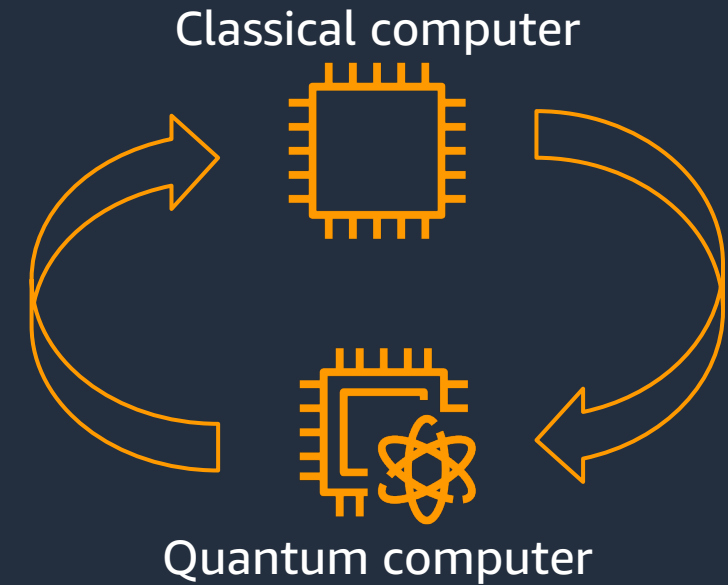
## Shot

Single execution of quantum operation on a device



## Task

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

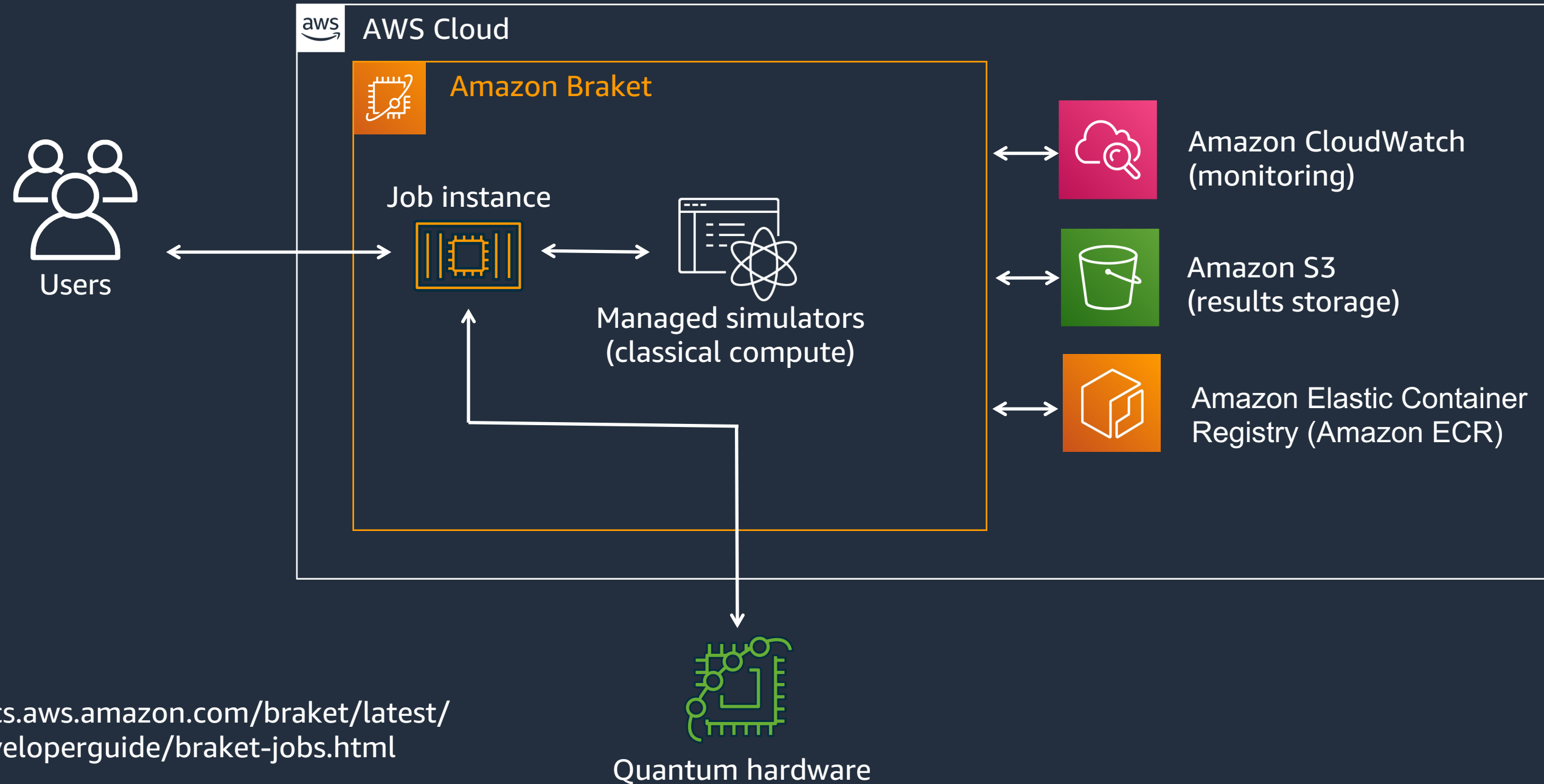


## Hybrid job

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

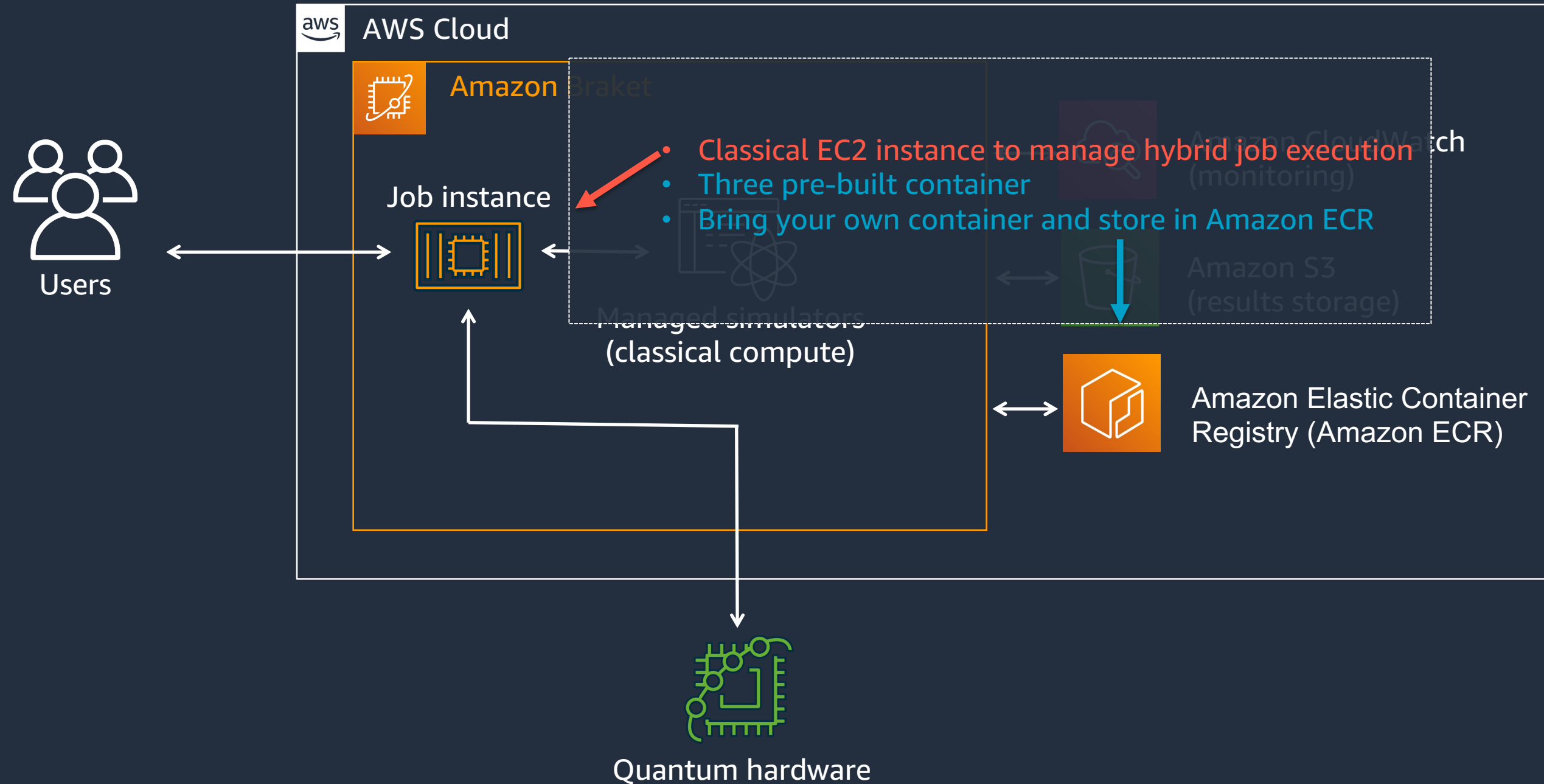
[docs.aws.amazon.com/braket/latest/developerguide/braket-jobs.html](https://docs.aws.amazon.com/braket/latest/developerguide/braket-jobs.html)

# Amazon Braket Hybrid Jobs

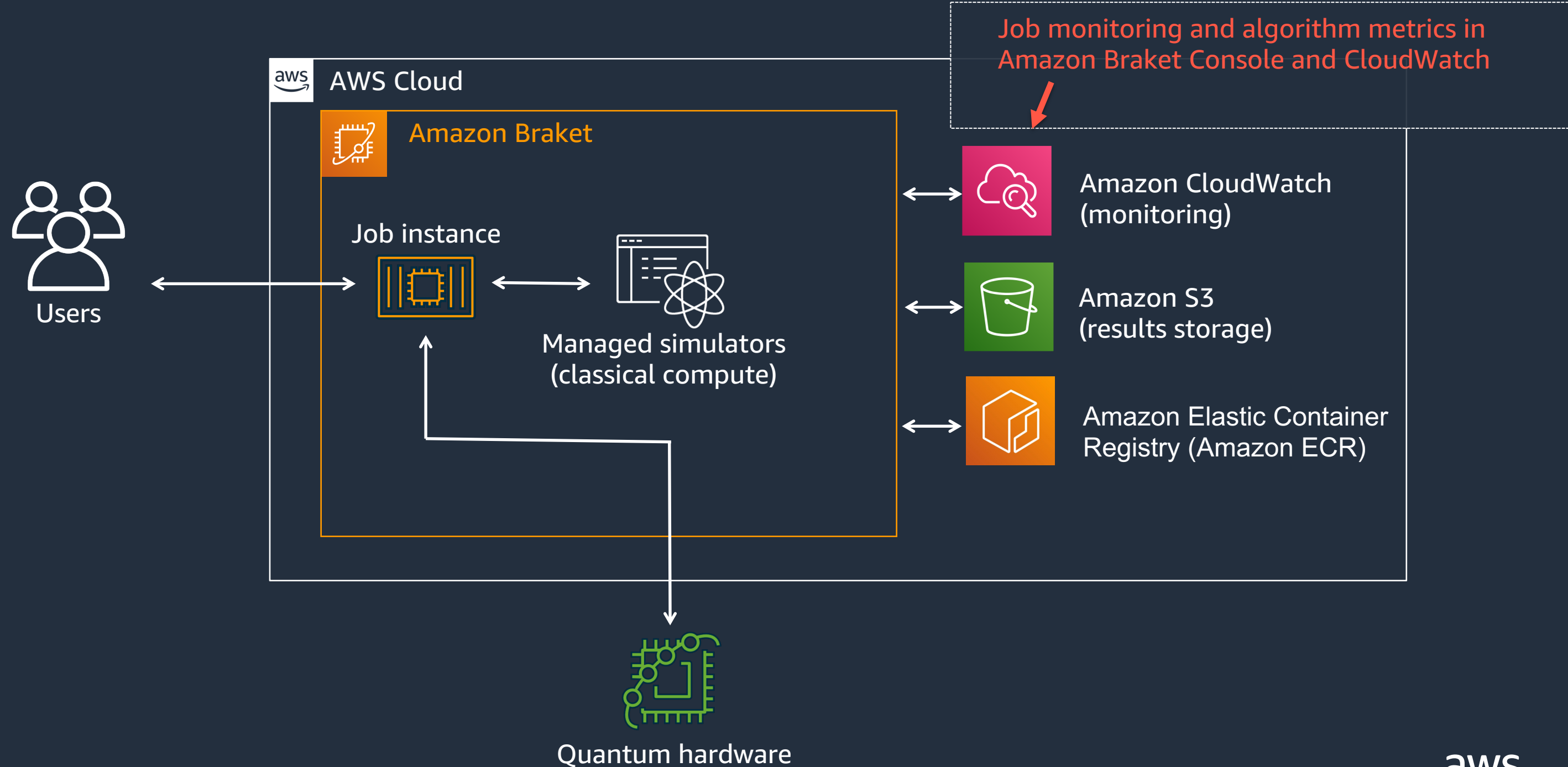


[docs.aws.amazon.com/braket/latest/developerguide/braket-jobs.html](https://docs.aws.amazon.com/braket/latest/developerguide/braket-jobs.html)

# Amazon Braket Hybrid Jobs: customized containers

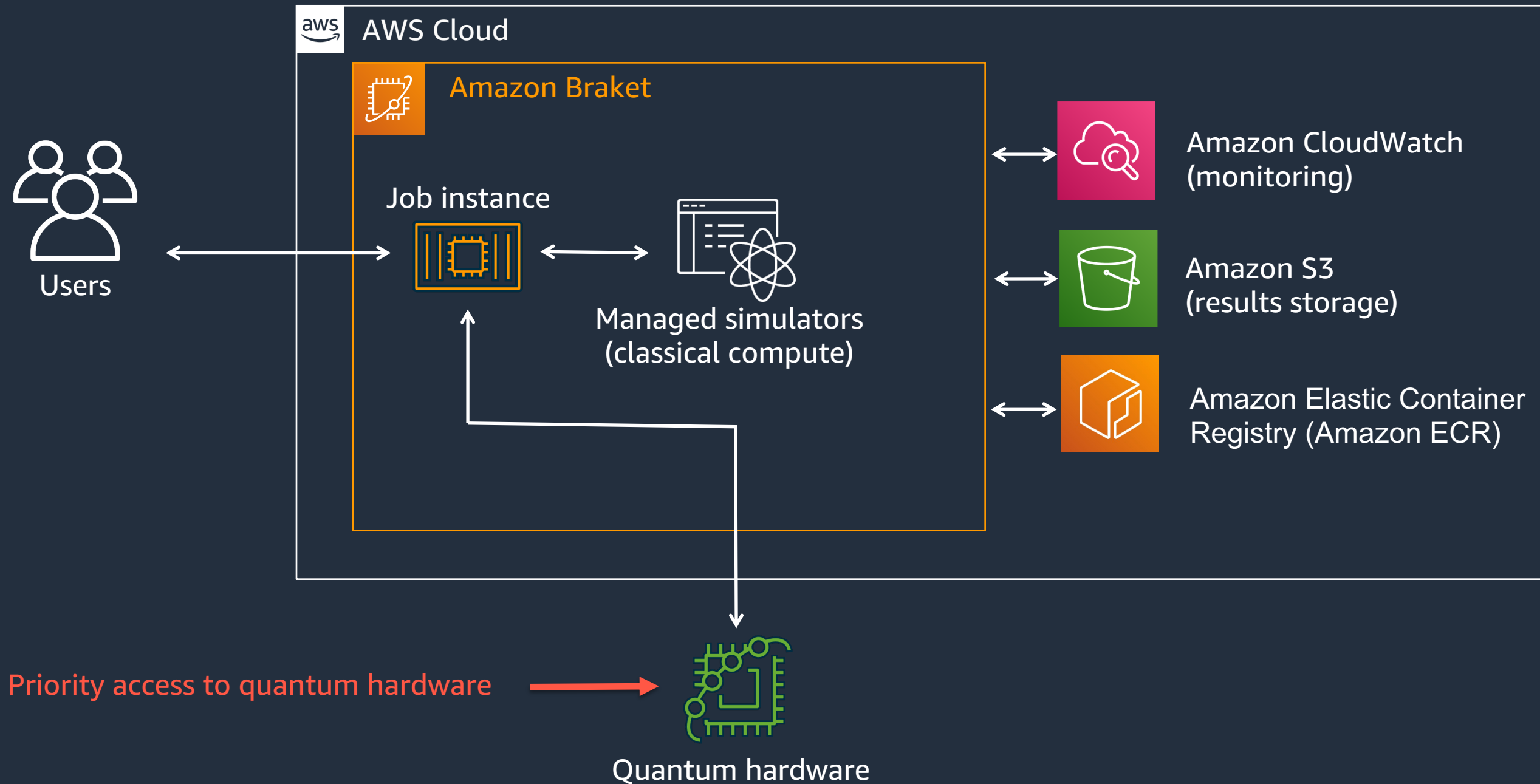


# Amazon Braket Hybrid Jobs: custom metrics





# Amazon Braket Hybrid Jobs: priority access



# Building with Amazon Braket

Customized cloud solutions

# Build with Braket

Amazon Braket is **one of over 175 fully featured cloud services**

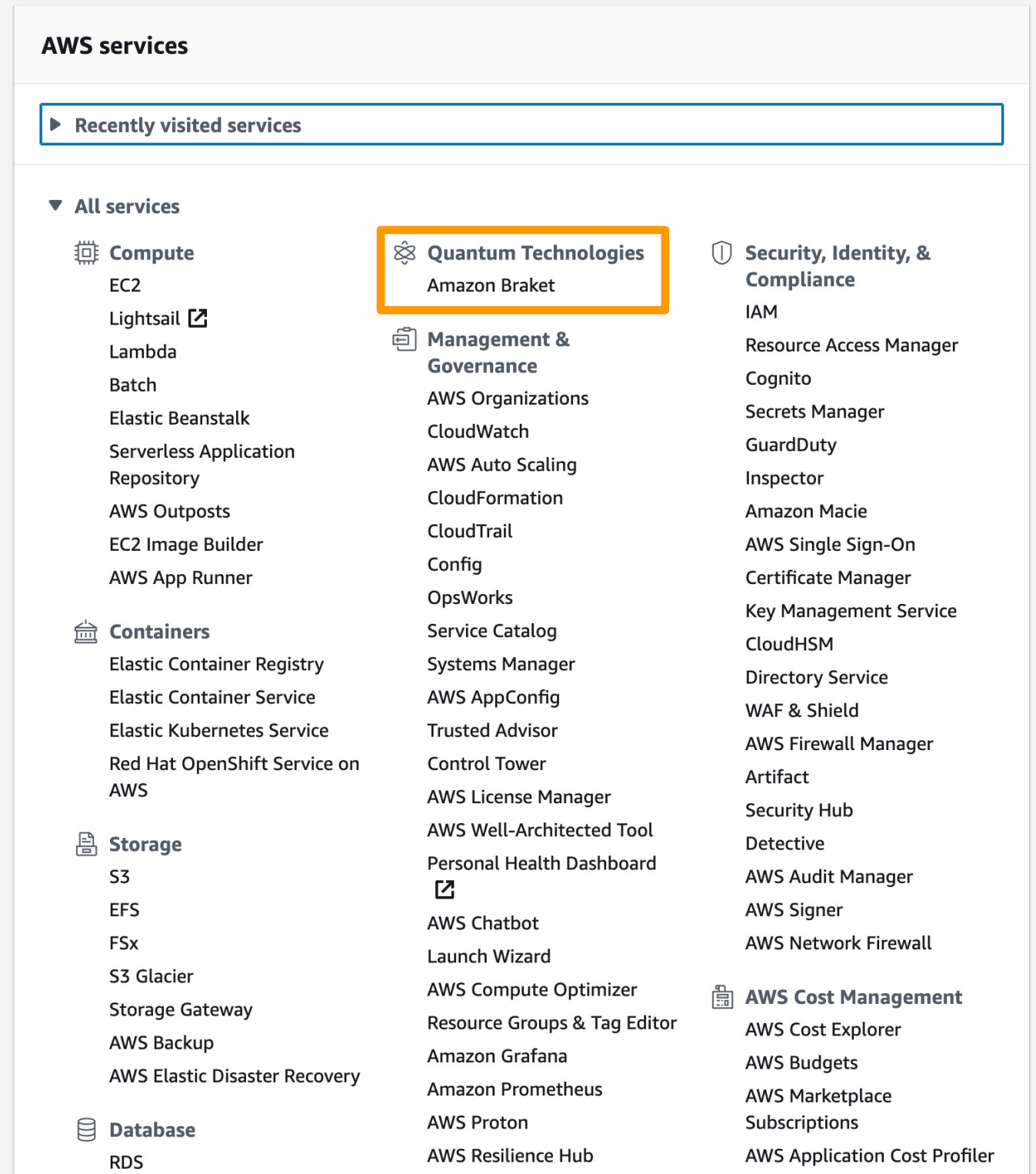
Build custom solutions

Prepare for advances in quantum technologies

Manage access to quantum and classical resources for many users

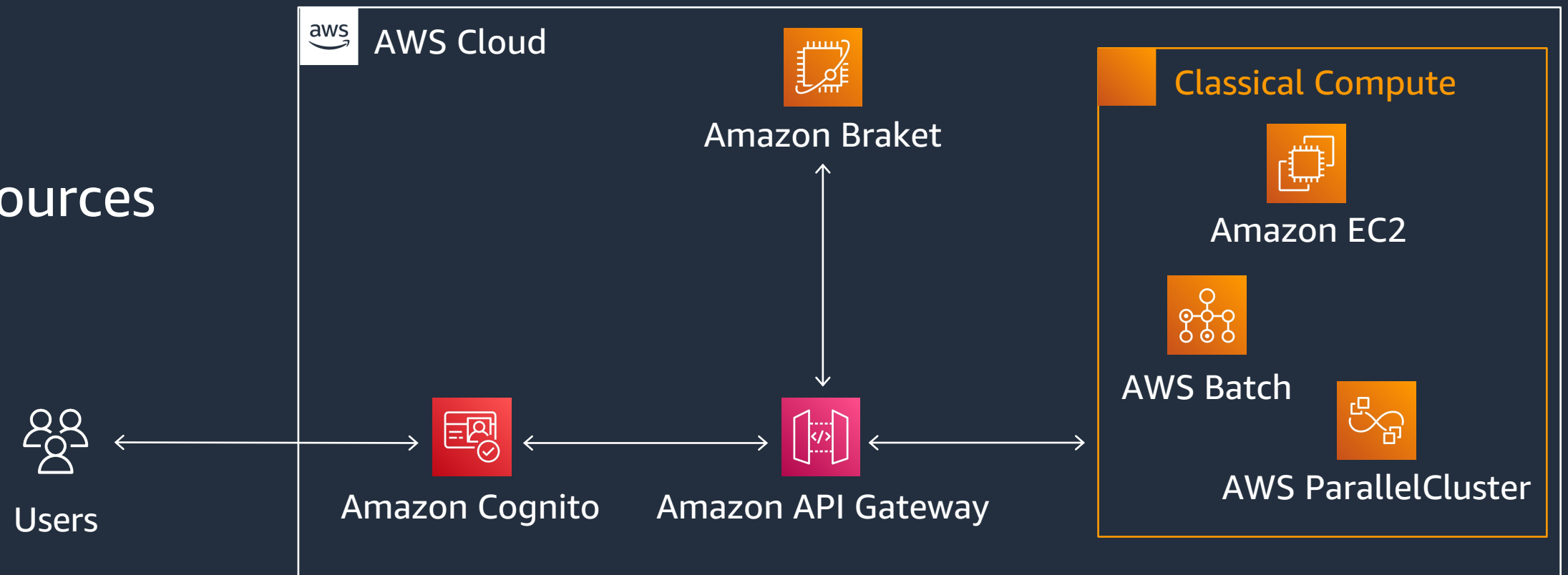
Leverage other cloud services

## AWS Management Console



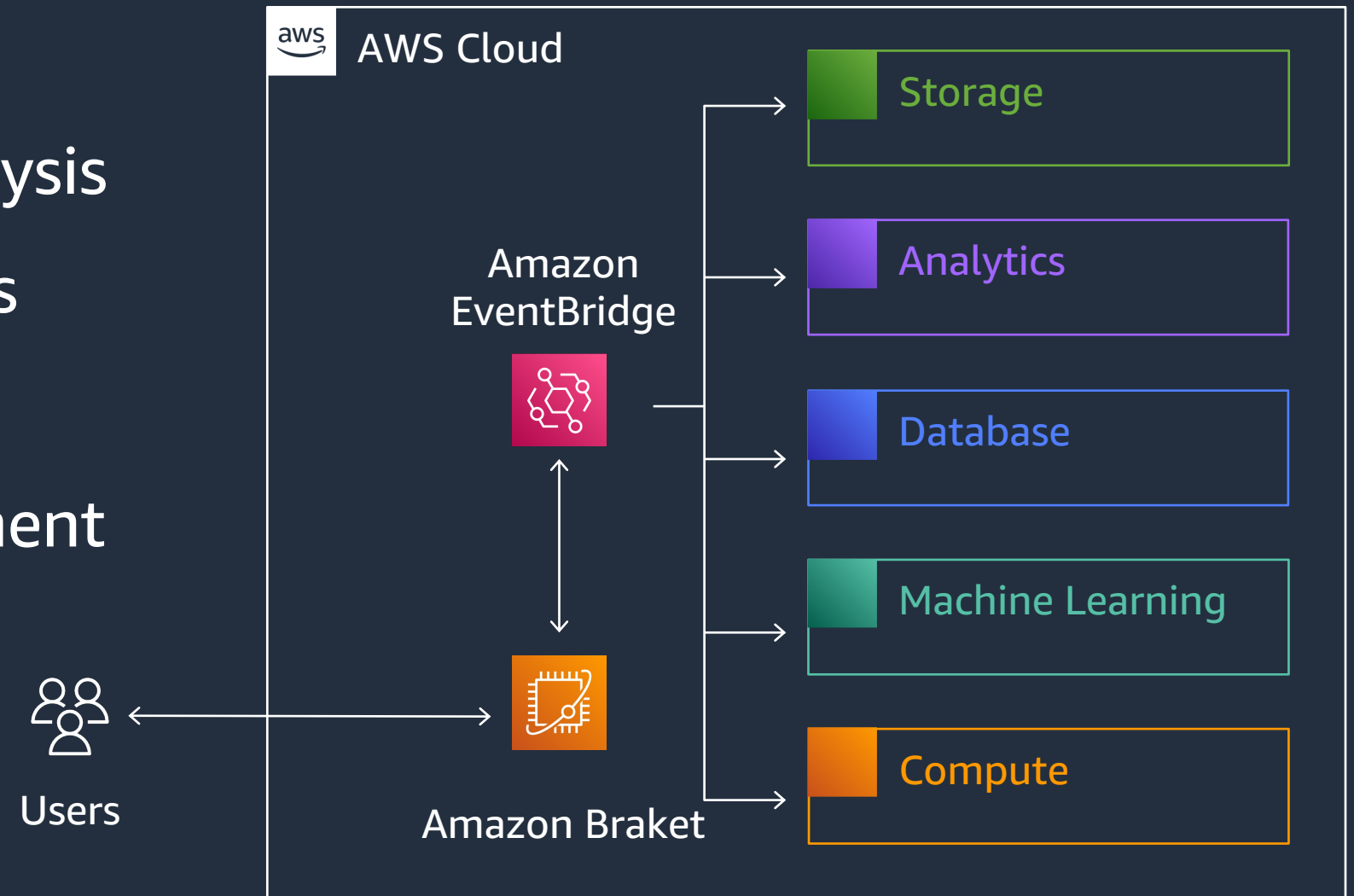
# Custom APIs for quantum and classical resources

- Access to multiple QPUs
- Secure APIs
- Custom images
- Multiple HPC resources



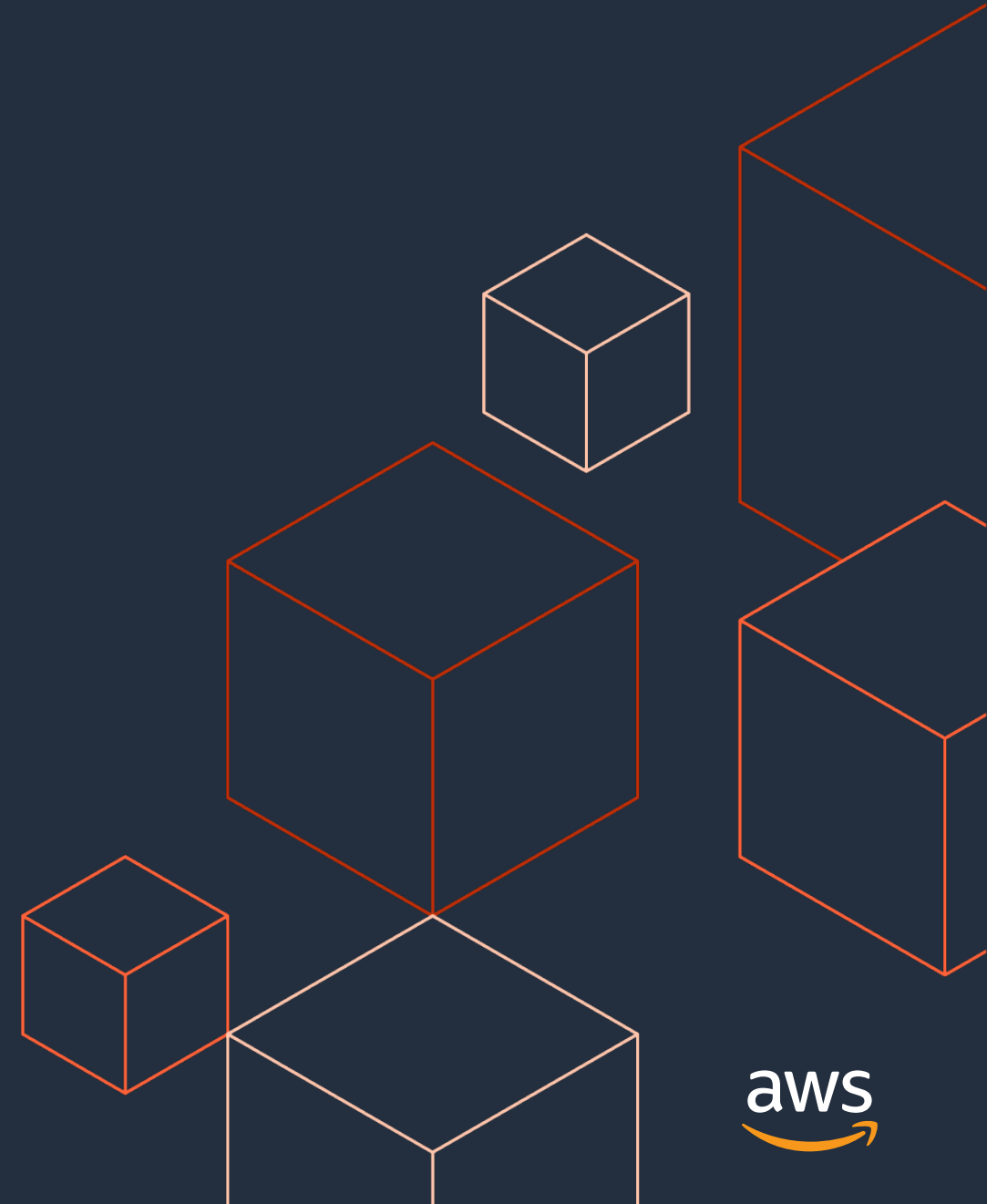
# Build customized event-driven applications

- Store data and results
- Classical post processing and analysis
- Classical HPC and ML comparisons
- Analytics pipelines
- Organization-level user management





# How do to get started?



# Amazon Braket examples

## Topics include:

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

[github.com/aws/amazon-braket-examples/tree/main/examples](https://github.com/aws/amazon-braket-examples/tree/main/examples)

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The screenshot shows the GitHub repository page for `aws / amazon-braket-examples`. The repository is public and has 173 stars. The main branch is `main`. The repository contains a file tree with the following files and folders:

File/Folder	Commit Message	Time Ago
examples	fix: metrics timeout issue i...	4 days ago
test/noteb...	fix: jobs model dependenci...	6 days ago
.gitignore	Add examples for Amazon ...	8 days ago
CODEOW...	infra: Add team to CODEO...	10 months ago
CONTRIB...	Fix typo; update contributi...	3 months ago
LICENSE	Add license and notice file...	14 months ago
NOTICE	Add license and notice file...	14 months ago
README....	Add examples for Amazon ...	8 days ago
environme...	fix: metrics timeout issue i...	4 days ago

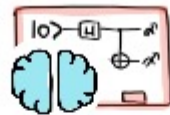
The repository also has a README.md file. The right sidebar shows the repository's description: "Example notebooks that to apply quantum compu Amazon Braket." and links to the README, Apache-2.0 License, and Code of conduct. The Releases and Packages sections show that no releases or packages have been published. The Contributors section shows 28 contributors.

# Amazon Braket and PennyLane

P E N N Y L A N E

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

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



## What is QML?

Find out how the principles of quantum computing and machine learning can be united to create something new.

[Read more >>](#)



## Key Concepts

Explore different concepts underpinning variational quantum circuits and quantum machine learning.

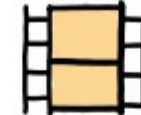
[Read more >>](#)



## Demos

Take a dive into quantum machine learning by exploring cutting-edge algorithms on near-term quantum hardware.

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## Videos

Sit back and explore quantum machine learning and quantum programming with our curated selection of expert videos.

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<https://pennylane.ai/qml>

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« Quantum Technologies

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- Train a broader community on the use of cloud for research workloads via workshops or tutorials



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# Q&A