Amazon Braket: an integrated software development environment for quantum computing in the cloud

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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
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

aws.amazon.com/quantum-solutions-lab/
AWS Partners and Startups with quantum focused solutions and services on AWS

- QCWare
- QCi Quantum Software
- Qu & Co
- blueqat
- CLASSIQ
- QunaSys
- agnostiq
- Strange Works
- Jij
- qBraid
- SUPERTECH
- Multiverse Computing
- Infosys
- Meta-Analytics
- ENTROPICA LABS
- REPLY DATA
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

- Users
  - Local IDE
  - Amazon Braket Console

- AWS Cloud
  - Amazon Braket
  - Amazon CloudWatch
    - (monitoring)
  - Amazon EventBridge
    - (notifications)
  - Amazon S3
    - (results storage)
  - AWS Identity and Access Management
    - (permissions)

- Managed simulators (classical compute)

- Quantum hardware
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).

docs.aws.amazon.com/braket/latest/developerguide/braket-devices.html
Amazon Braket Hybrid Jobs

A new service feature
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 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)

docs.aws.amazon.com/braket/latest/developerguide/braket-jobs.html
Amazon Braket Hybrid Jobs

AWS Cloud

Amazon Braket

Job instance

Managed simulators (classical compute)

Users

Amazon CloudWatch (monitoring)

Amazon S3 (results storage)

Amazon Elastic Container Registry (Amazon ECR)

Quantum hardware

docs.aws.amazon.com/braket/latest/developerguide/braket-jobs.html
Amazon Braket Hybrid Jobs: customized containers

- Classical EC2 instance to manage hybrid job execution
  - Three pre-built container
  - Bring your own container and store in Amazon ECR

- Managed simulators
  (classical compute)

- Amazon Elastic Container Registry (Amazon ECR)

- Quantum hardware

- Users

- Amazon Braket

- AWS Cloud

- Amazon S3 (results storage)

- Amazon CloudWatch (monitoring)
Amazon Braket Hybrid Jobs: custom metrics

Job instance

Managed simulators (classical compute)

Quantum hardware

Users

AWS Cloud

Amazon Braket

Job monitoring and algorithm metrics in Amazon Braket Console and CloudWatch

Amazon CloudWatch (monitoring)

Amazon S3 (results storage)

Amazon Elastic Container Registry (Amazon ECR)
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
Custom APIs for quantum and classical resources

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

AWS Cloud

Amazon Braket

Users

Amazon Cognito

Amazon API Gateway

Classical Compute

Amazon EC2

AWS Batch

AWS ParallelCluster
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
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Amazon Braket and PennyLane

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.
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Demos
Take a dive into quantum machine learning by exploring cutting-edge algorithms on near-term quantum hardware.
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Videos
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https://pennylane.ai/qml
AWS free tier

Amazon Braket

Accelerate quantum computing research

Get Started with Amazon Braket

1 free hour of simulation time per month for a year with AWS Free Tier

aws.amazon.com.braket/pricing/?loc=ft#AWS_Free_Tier
The AWS Public Sector Cloud Credit for Research Program supports researchers who seek to:

- Build cloud-hosted publicly available science-as-a-service applications, software, or tools to facilitate their future research and the research of their community
- Perform proof of concept or benchmark tests evaluating the efficacy of moving research workloads or open data sets to the cloud
- Train a broader community on the use of cloud for research workloads via workshops or tutorials
Q&A