aws | aQuantum® Software Engineering

Day 1

Quantum Computing

Introduction to Amazon Braket and QPath®

Agenda

Day 1

- Introductions
- Setup the hands-on environment
- Demo: QPU cost estimation
- Break
- Technical introduction to Amazon Braket
- Hands-on session
- Break
- Creating complete QuantumPath® solutions
- QuantumPath® Solutions preparation Hands On Lab

Day 2

- Summary of Day 1
- Creating complete QuantumPath® solutions
- Introduction to QuantumPath lifecycle and assets catalog
- Demo: Gate-based algorithm development in QuantumPath
- Break
- Demo: Quantum annealing software development in QPath®
- Preparing for Enterprise solutions: Hybrid Quantum-Classic architectures with qSOA®
- Summary and wrap up

Agenda – Day 1 *(*)*

- ❑ 14:00 – Introductions
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(*) All times are UTC

Your speakers

Nihit Pokhrel

Nihit Pokhrel is a Partner Solutions Architect at Amazon Web Services, working with HPC and Quantum Computing partners to help them build well-architected solutions. Her background is in computational chemistry focusing in the area of Molecular Dynamics. Nihit specializes in HPC for the Life Sciences industry.

José Luis Hevia

Software Architect & Software Solutions IT Manager of Alhambra IT. 25+ years of experience in consulting, design of HA-FT Enterprise Multilayer Solutions and technical training, using state of the art technologies. aQuantum Founder & Chief Technology Officer (CTO)

Juan Moreno

Juan is a Senior Amazon Braket Solutions Architect. His background is in infrastructure support for strategic customers, also managing teams and running operations at scale. He is passionate about quantum technologies and helping customers to get started with quantum computing. In his spare time he likes learning Chinese, practicing and teaching yoga, and spending quality time with his wife and friends.

Hands On Workshop

Agenda – Day 1 *(*)*

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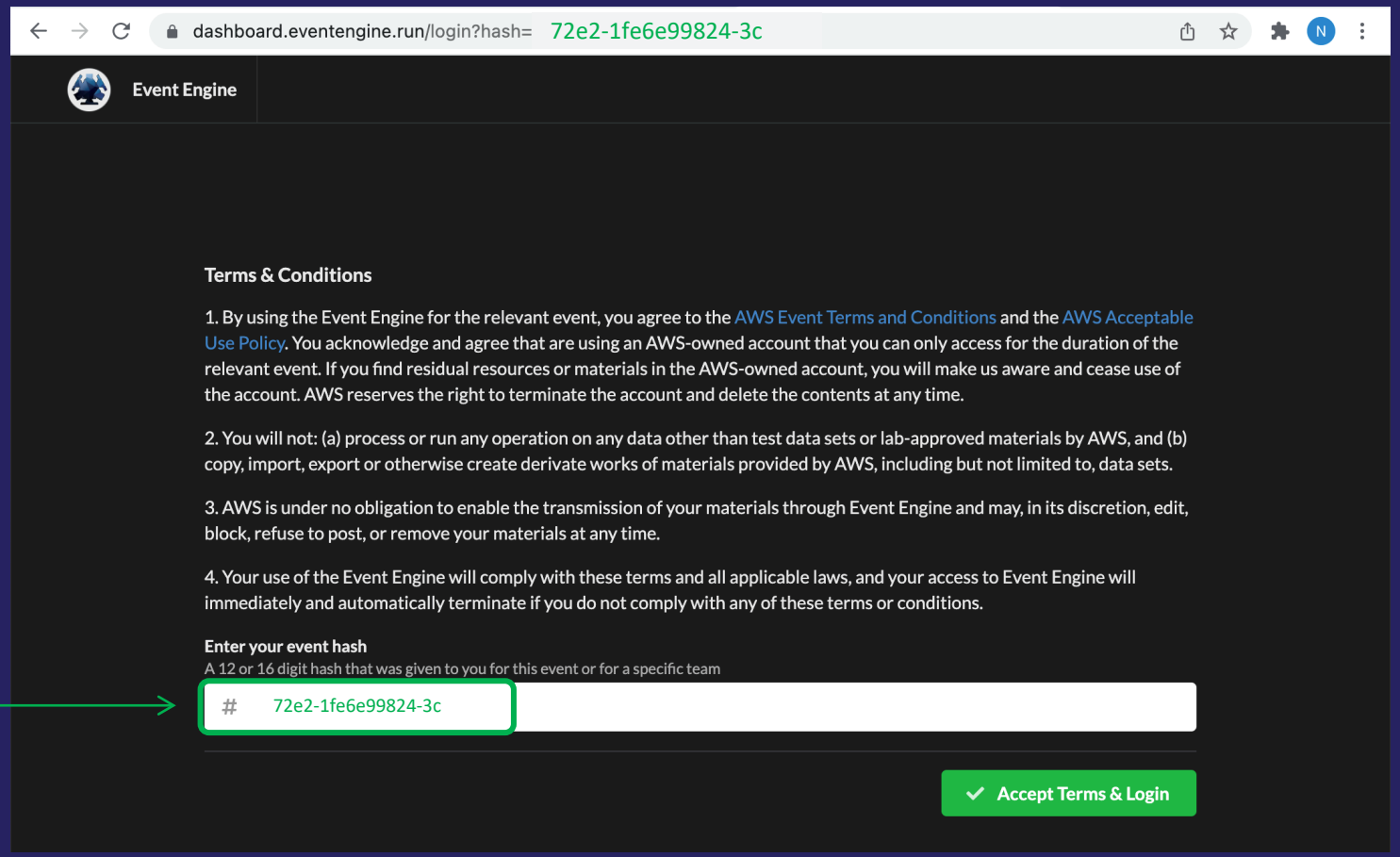
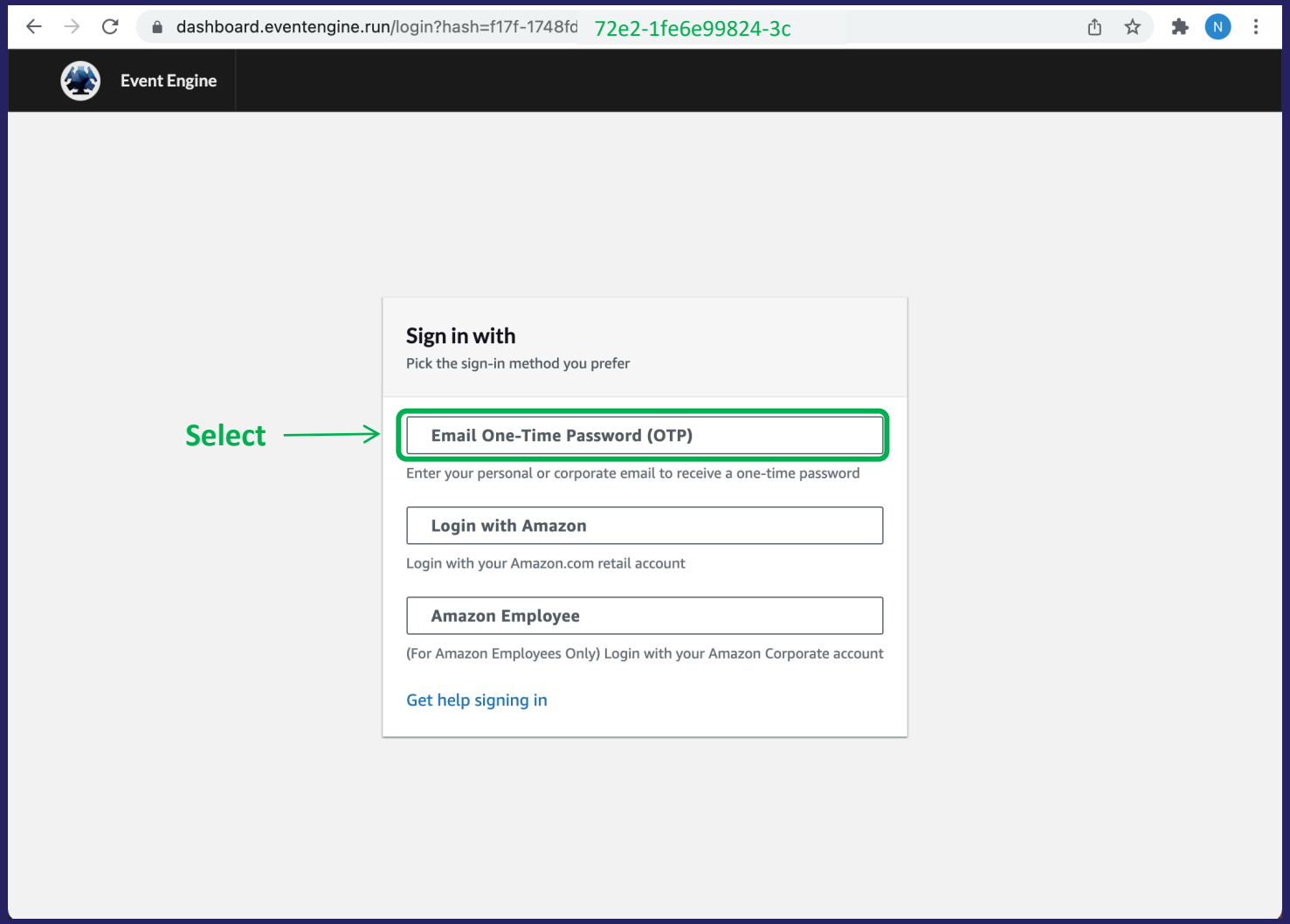
Setup your environment: Event Engine Login

https://dashboard.eventengine.run/login?hash=72e2-1fe6e99824-3c



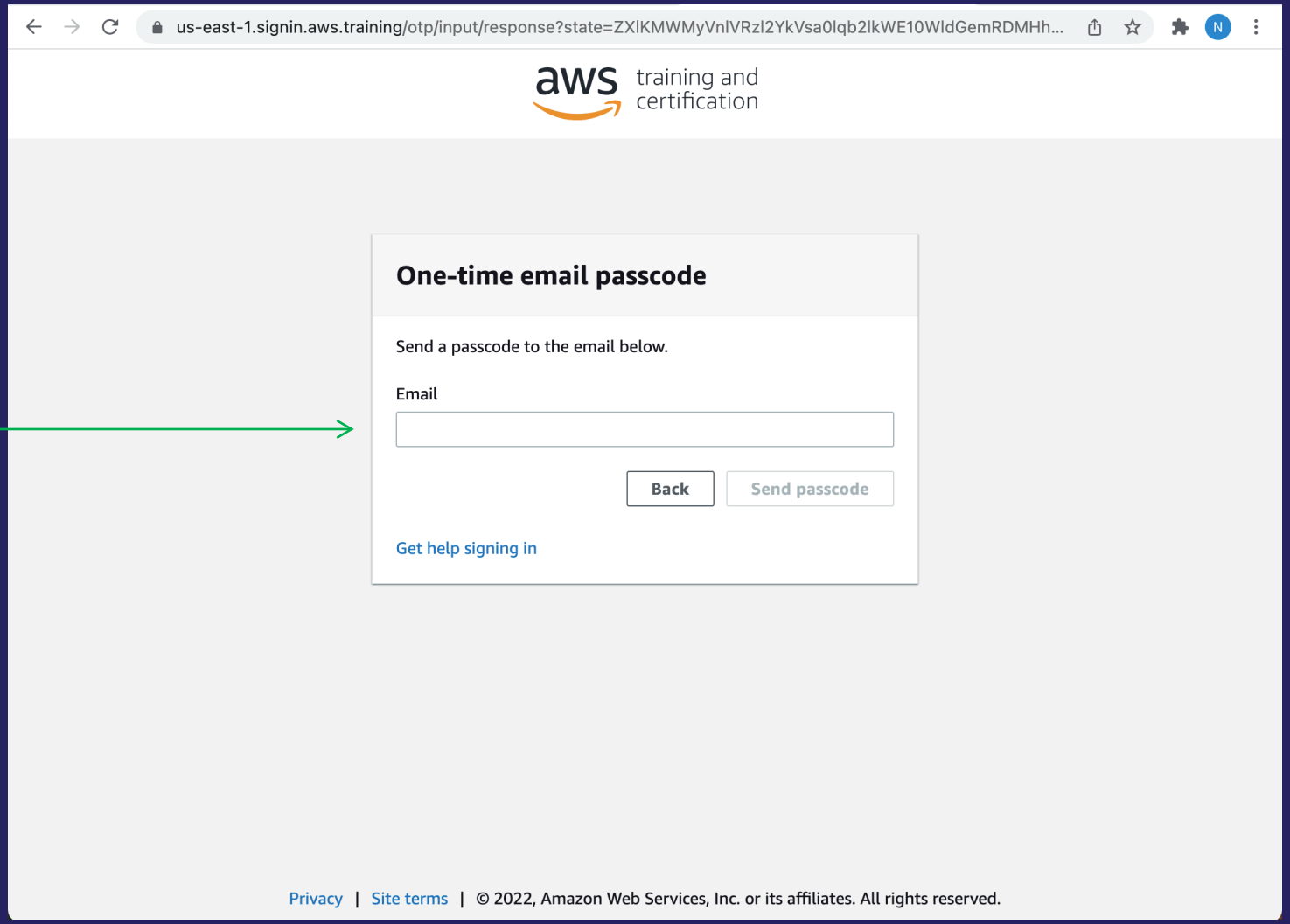
Event Hash →

Setup your environment: Event Engine Login



Setup your environment: Event Engine Login

Enter your corporate email address



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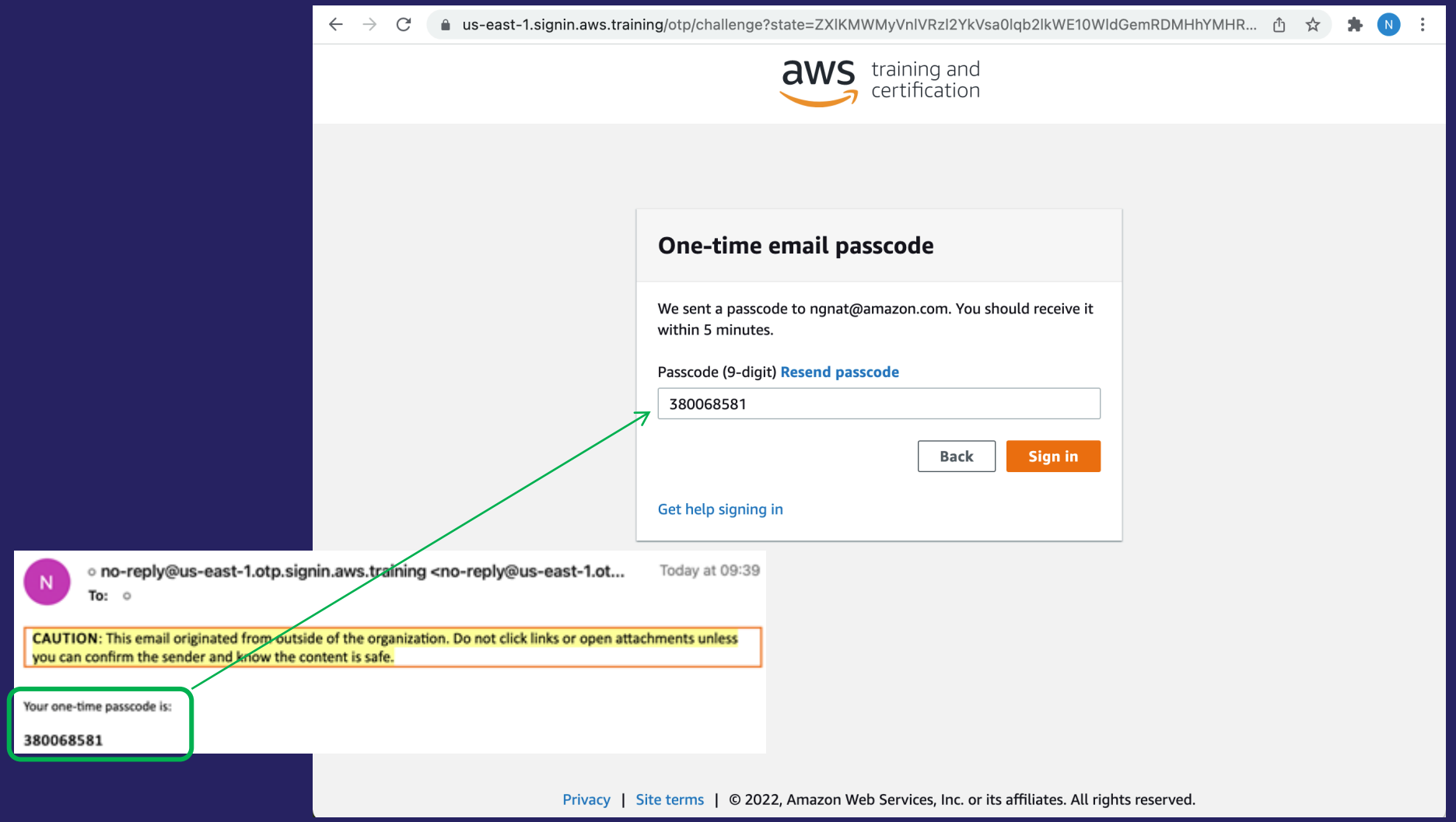

Setup your environment: Event Engine Login

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Learning Objectives

- Understand how Regions work in AWS
- Know how to find account details
- Familiarize with ancillary services
- Activate Amazon Braket
- Create a notebook instance
- Understand the cost structure of Amazon Braket

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Break

We will start again at

15:05 UTC

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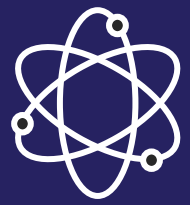
Quantum Computing at AWS



AWS Center for Quantum Computing

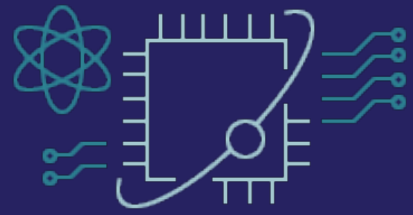
Research and development

Quantum Solutions Lab

State-of-the-art quantum and classical solutions

AWS Partner Network

Community of quantum computing partners

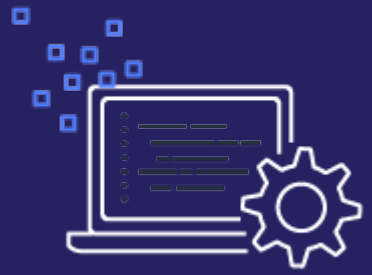


Amazon Braket

Fully managed quantum computing service

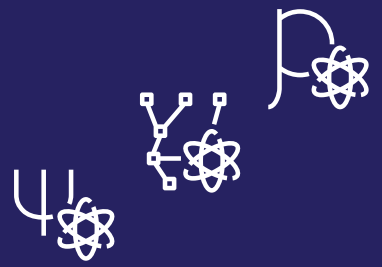
Amazon Braket – the AWS quantum computing service

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



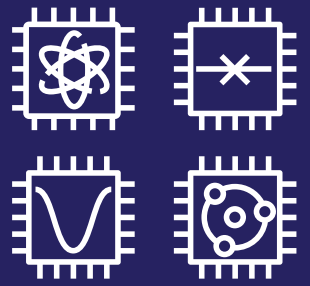
Build

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



Test

- Local simulators for rapid testing
- High-performance simulators



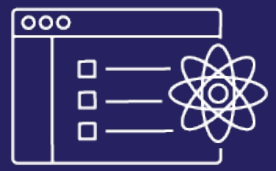
Run

- Access multiple quantum computers
- Combine quantum and classical resources

Analyze

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

Local and managed simulators

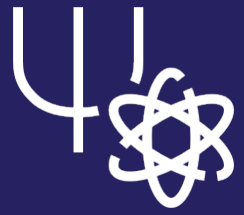


Local simulator

Part of Braket SDK

Fast and convenient prototyping

Number of qubits based on hardware

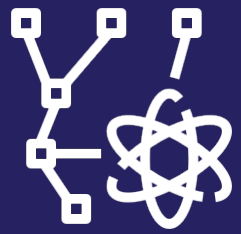


SV1: State Vector simulator

Quantum circuit with up to 34 qubits

Stores the full wave function state

Concurrency: Default 35, max 50

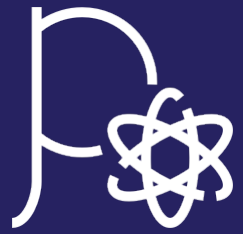


TN1: Tensor Network simulator

Quantum circuit with up to 50 qubits

Encodes quantum circuits into a structured graph

Concurrency: Default 10, max 10



DM1: Density Matrix simulator

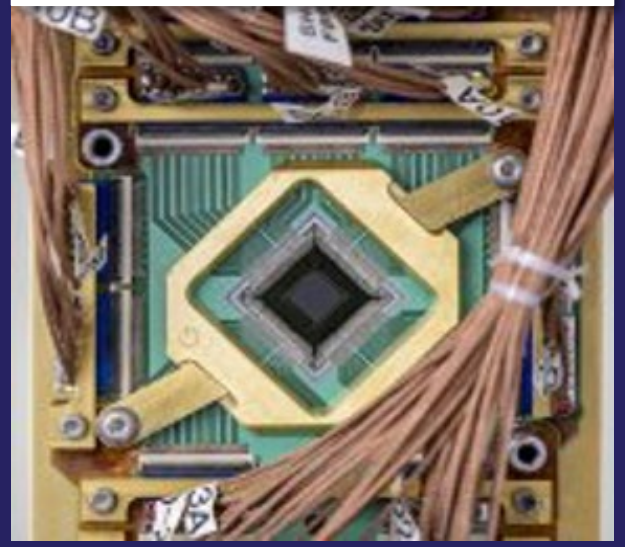
Quantum circuit with up to 17 qubits

Run multiple circuits in parallel with noise simulation

Concurrency: Default 35, max 50

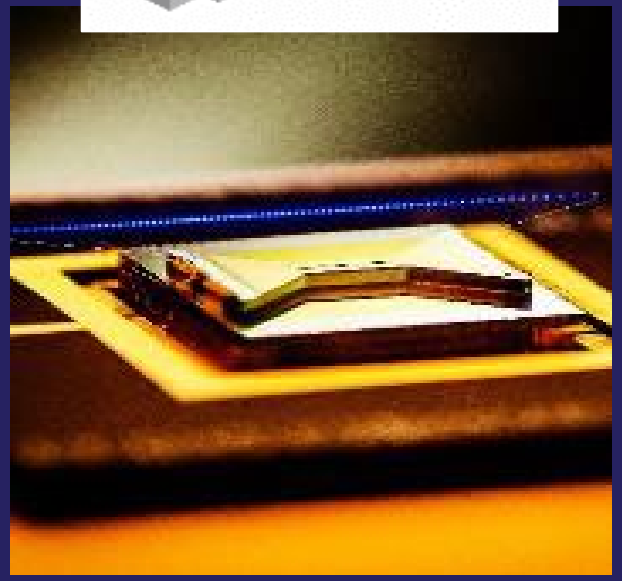
Quantum Computers

D-Wave
The Quantum Computing Company™



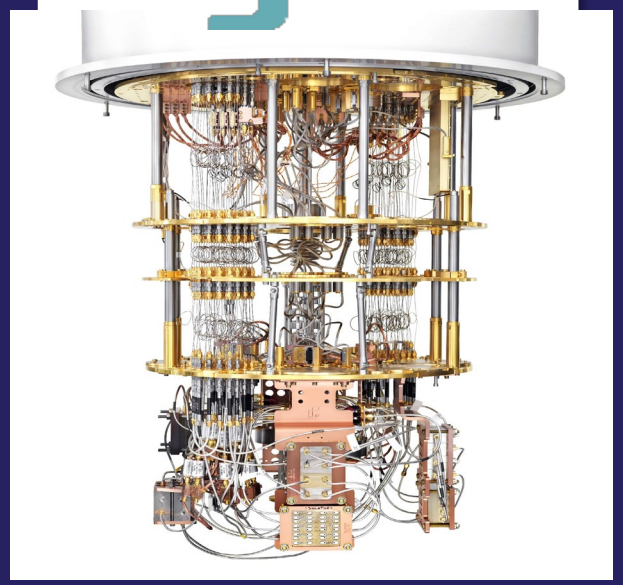
Quantum annealer

IONQ



Trapped ions

rigetti

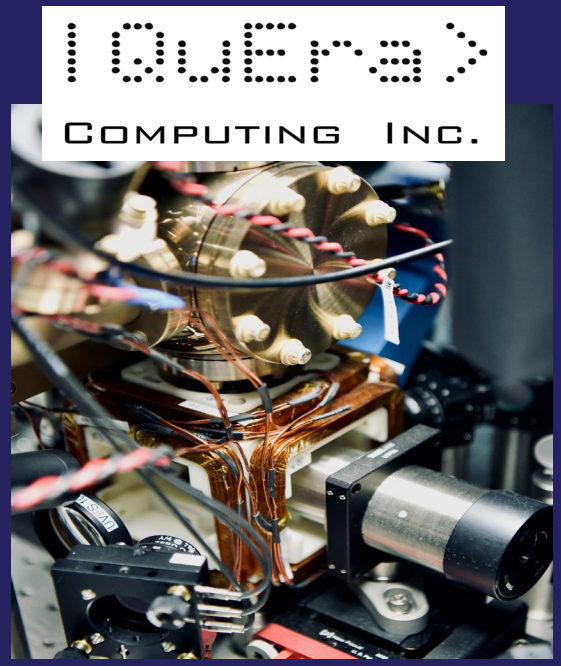


superconducting

New hardware coming to Amazon Braket

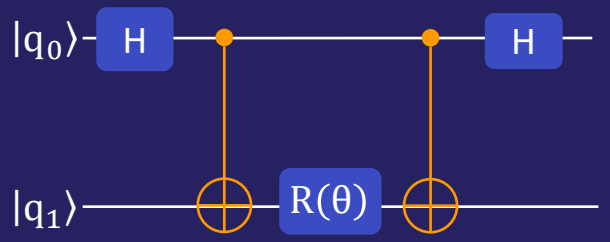
Superconducting

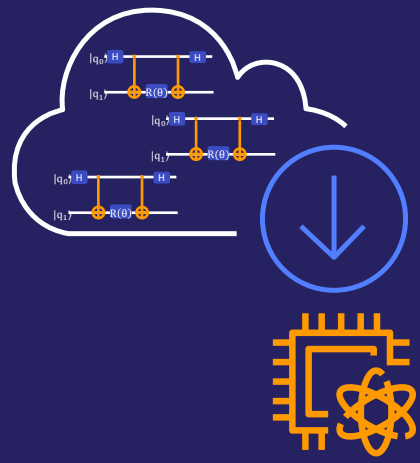
(Now Live)

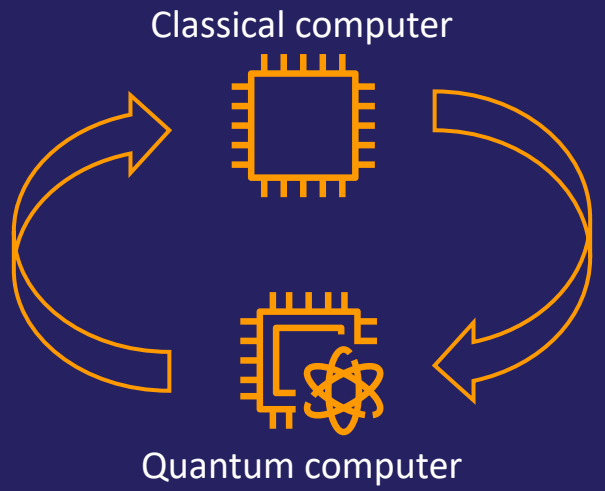


Rydberg atoms

Shots, tasks, and 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

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Learning Objectives

- Device availability and status
- Geographical scope of a QPU
- QPU architecture and design models
- Pick the right simulator for the right job
- Build and run circuits in simulators and QPUs
- Find tasks and interpret results

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Break

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16:35 UTC

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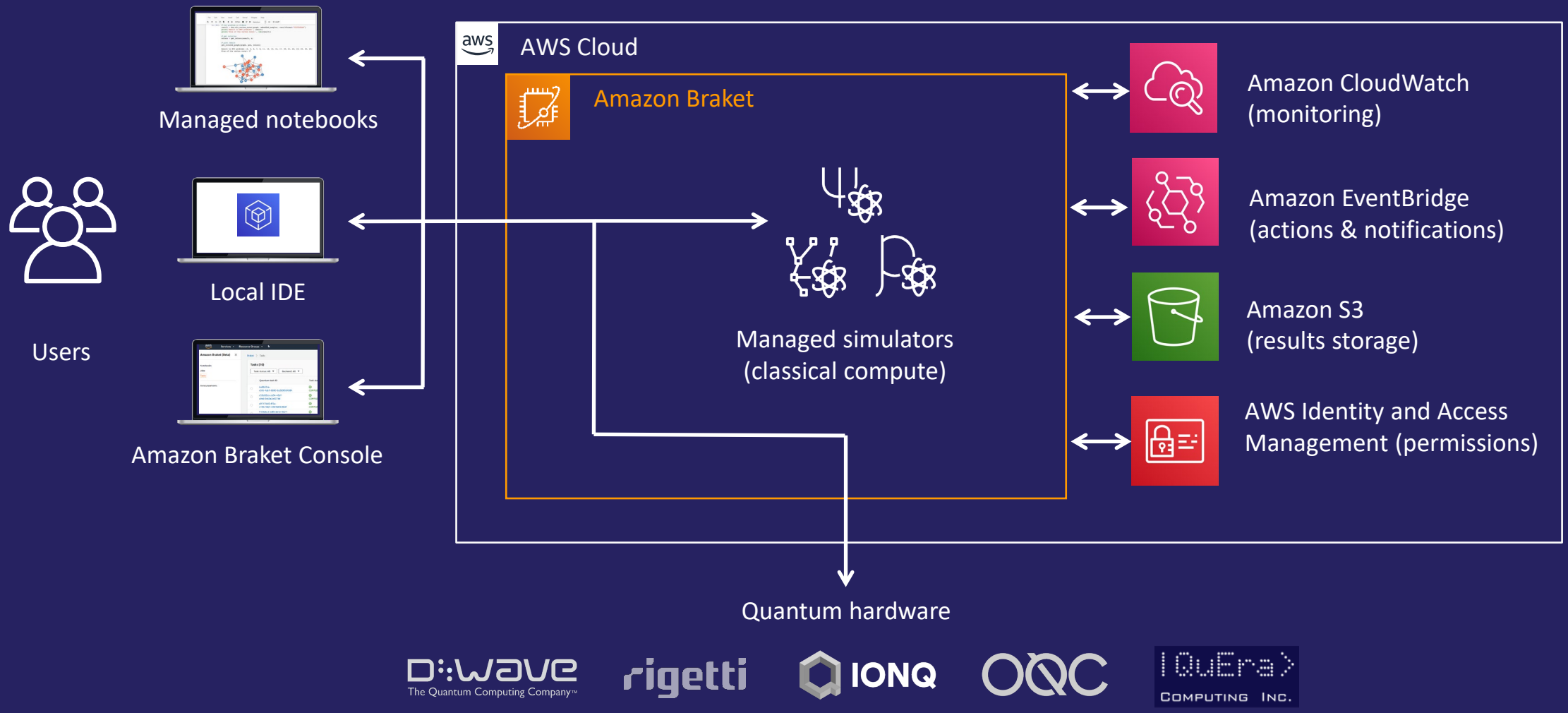
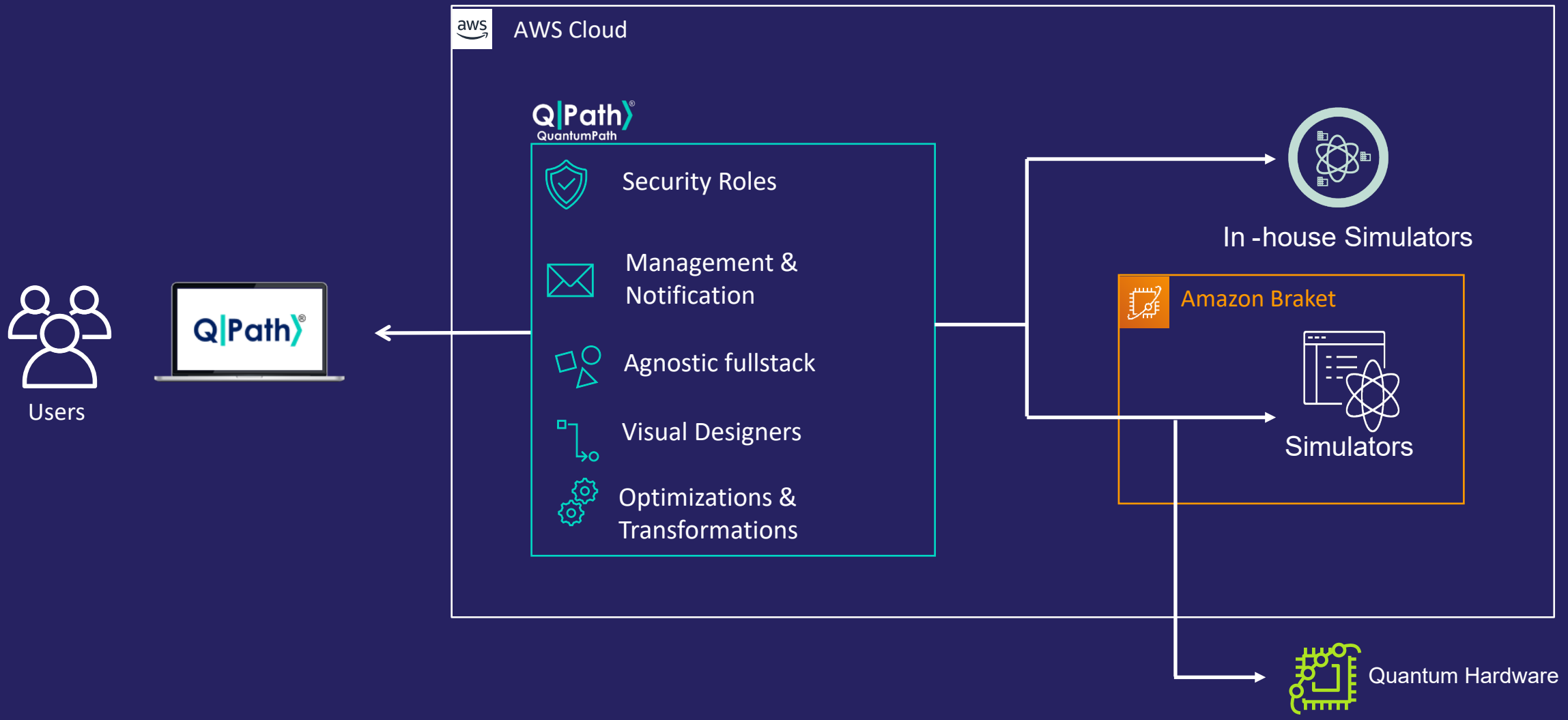
Amazon Braket Architecture



Amazon Braket and QuantumPath®



QuantumPath takes it further

- Explore annealing for optimization problems
- Evaluate gate compatibility across devices
- Explore circuit anatomy

- All of this without having to worry about infrastructure

…while adhering to AWS building practices

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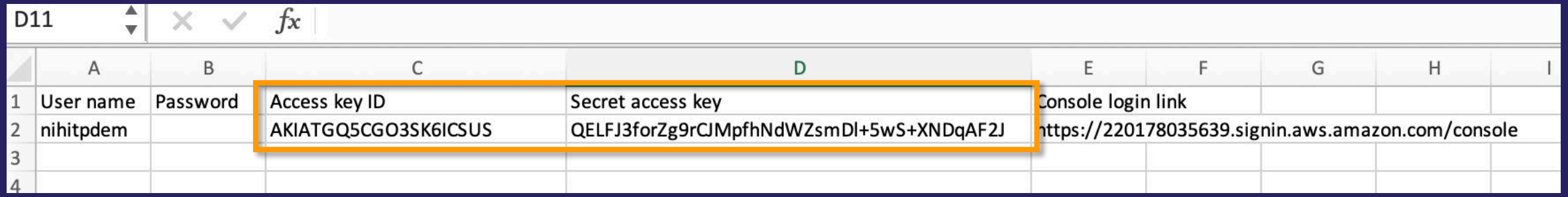
Access QuantumPath®

1. Copy credentials for CLI access



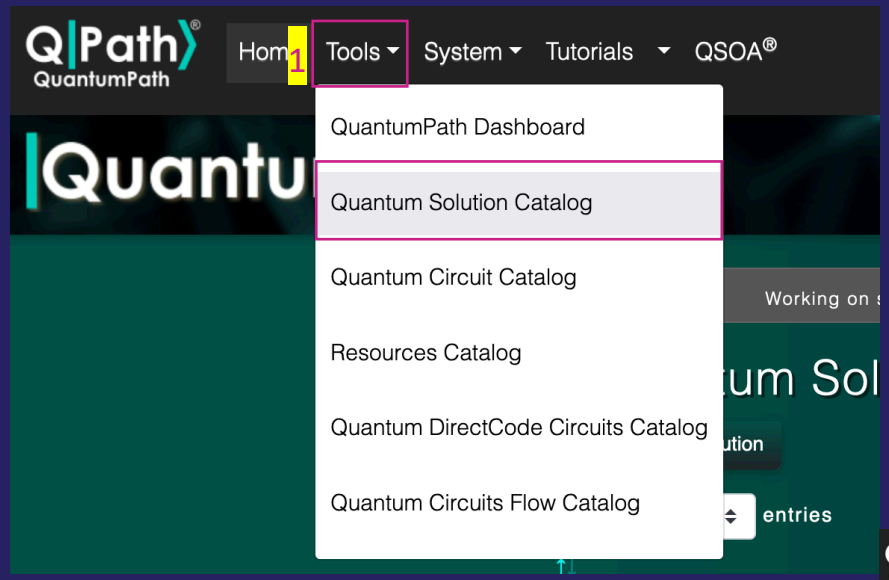
D11

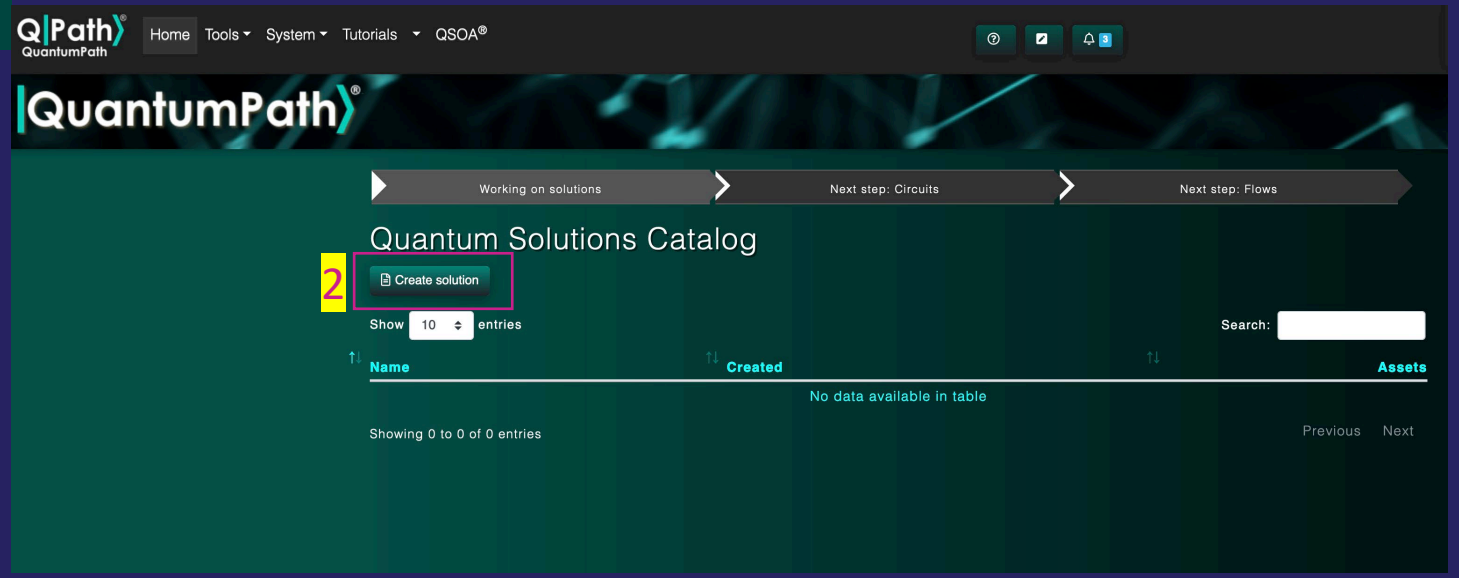
	A	B	C	D	E	F	G	H	I
1	User name	Password	Access key ID	Secret access key	Console login link				
2	nihitpdem		AKIATGQ5CGO3SK6ICSUS	QELFJ3forZg9rCJMpfhNdWZsmDl+5wS+XNDqAF2J	https://220178035639.signin.aws.amazon.com/console				
3									
4									

2. Access QuantumPath®

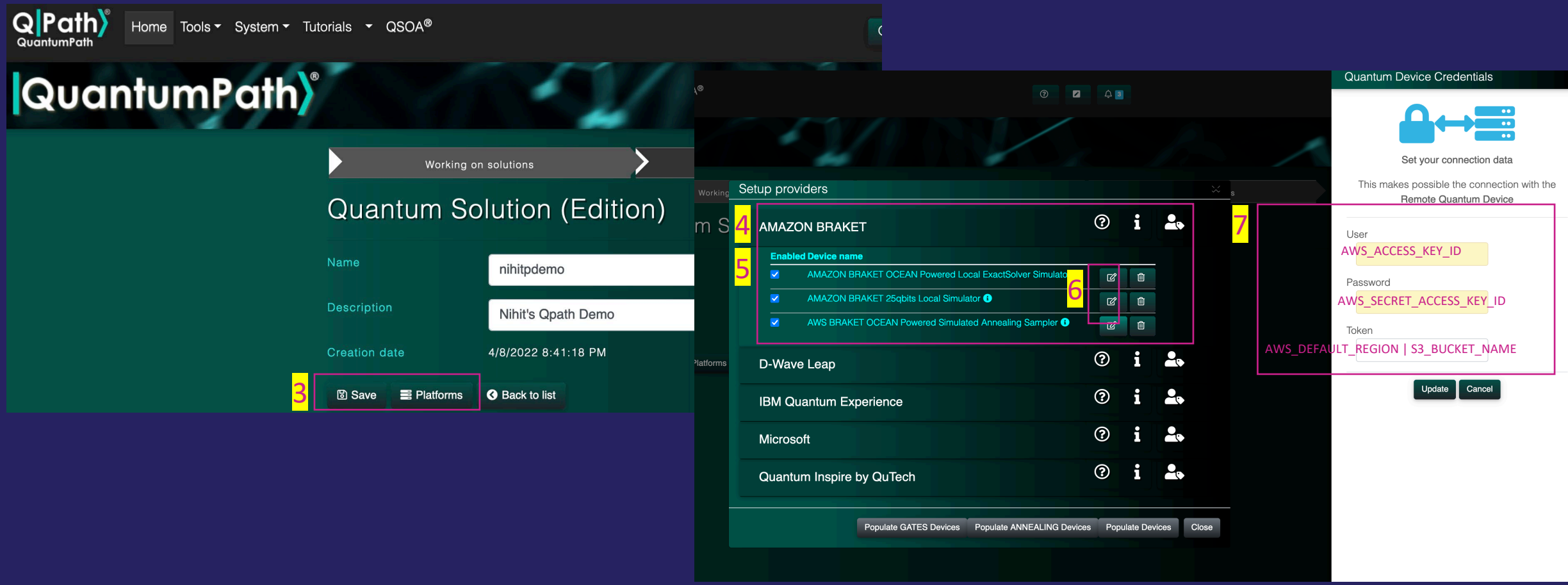
https://core.quantumpath.app/TeamEngagement/TEEnrollmentForm/eyJDb21wYW55TmFtZSI6IkFNQVpPTkFRVUFOVFVNIiwiRW5nYWdlbWVudEtleSI6IkFXU0FRVV8xMTA0MTk3NCJ9

Access QuantumPath®





Access QuantumPath



Q&A & Wrap Up Day 1

Next Steps

Survey

https://survey.immersionday.com/CODE

Follow up

Nihit Pokhrel – nihitp@amazon.com

Juan Moreno – juanmb@amazon.com

aws | aQuantum® Software Engineering

Day 2

Quantum Computing

Introduction to Amazon Braket and QPath®

Your speaker

José Luis Hevia

Software Architect & Software Solutions IT Manager of Alhambra IT. 25+ years of experience in consulting, design of HA-FT Enterprise Multilayer Solutions and technical training, using state of the art technologies. aQuantum Founder & Chief Technology Officer (CTO)

Agenda – Day 2 *(*)*

- ❑ 02:00pm – Summary of Day 1
- ❑ 02:14pm – Creating complete QuantumPath® solutions
- ❑ 02:30pm – Introduction to QuantumPath lifecycle and assets catalog
- ❑ 03:00pm – Demo: Gate-based algorithm development in QuantumPath
- ❑ 03:45pm – Break

- ❑ 04:00pm – Demo: Quantum annealing software development in QuantumPath®
- ❑ 04:30pm – Preparing for Enterprise solutions:
  Hybrid Quantum-Classic architectures with qSOA®
- ❑ 04:50pm – Summary and wrap up

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Q|Path⟩ QuantumPath

Creating complete QuantumPath® solutions

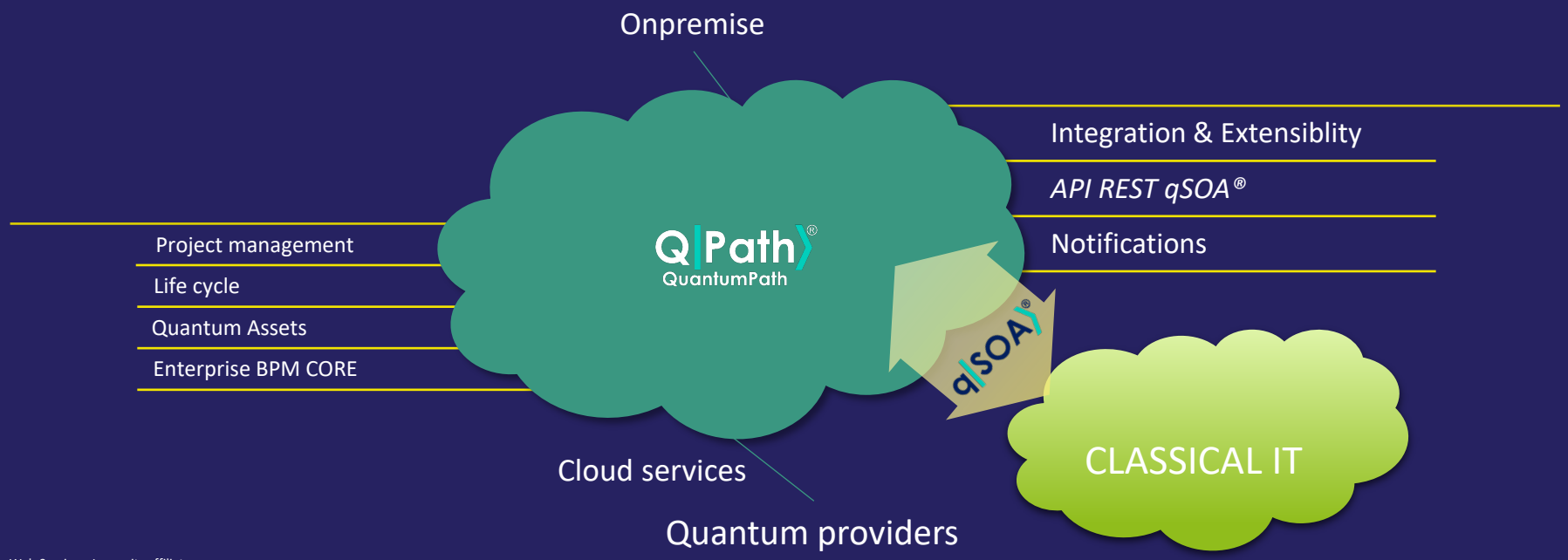
Before knowing what QuantunmPath® is, let's quickly see what we mean by Solution

1. a classic software solution responds to the construction of a product that covers business needs
2. With the appearance of quantum technology, it is necessary to reassess the impact on the development of software solutions
3. Quantum Solution: a software solution responds to the construction of a product that covers business needs, using the advantage of the Quantum Computing

In QuantumPath® we have design from scratch a complete platform, to make eassier the creation of Software Solutions that uses the power of Quantum Computing technologies and integrates them into Classical solutions

QuantumPath® overview

- A complete lifecycle pipeline to create professional quantum software solutions
- From the creation of the quantum algorithm through its development, testing and implementation, to its deployment and reuse
- Support of different types of quantum hardware: gate-based, quantum annealing, etc.
- qSOA®, to integrate classical and quantum through open, robust and transparent protocols



QuantumPath® overview

An agnostic platform that allows circuit definition & QUBO formulation through an intuitive code-free interaction

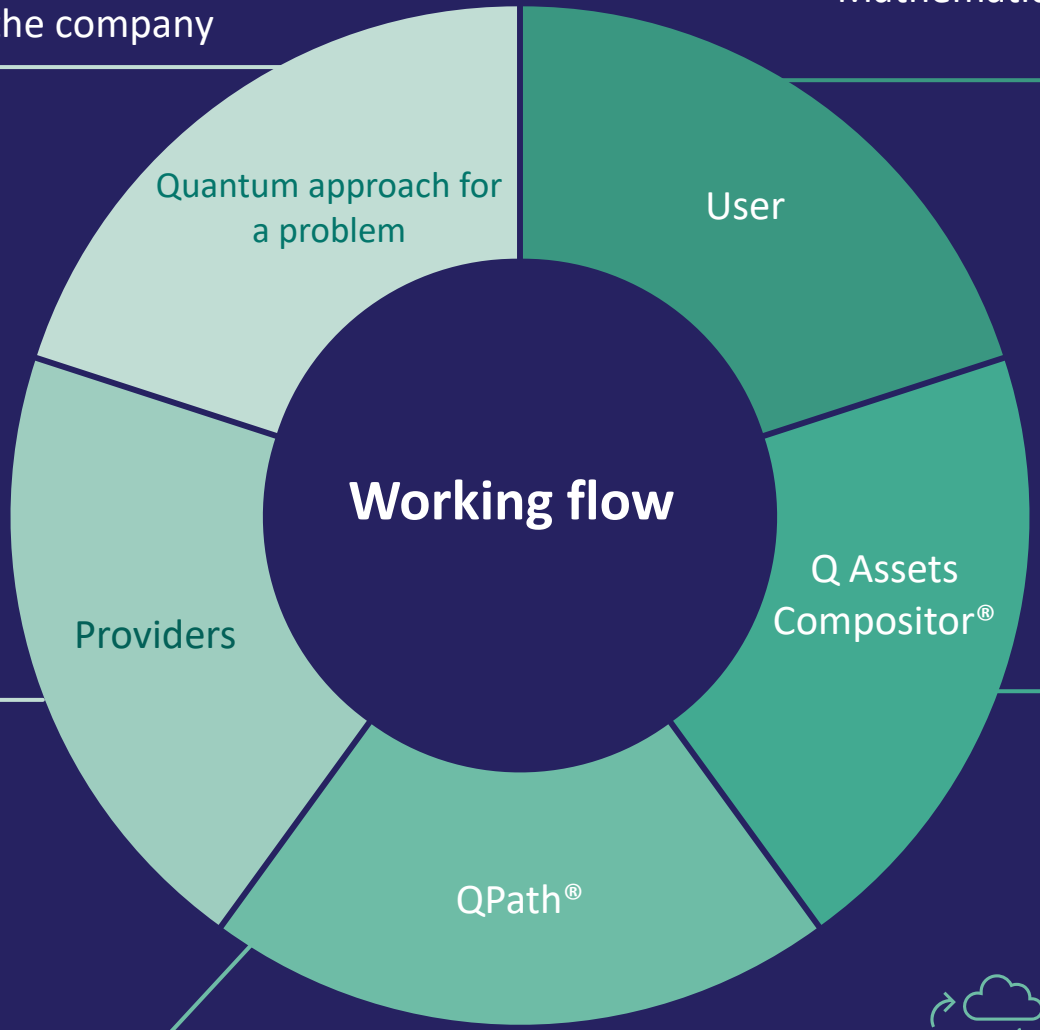
1. Identify a problem that need to be solved using Quantum Power
2. Determine gates, variables, or interactions and constraints, including quadratic and linear terms
3. Create the circuit or Map into QUBO formulation

Q Assets Compositor® to create the circuit or formulate the QUBO matrix for you, connects with the quantum computer providers servers and retrieves the result

QuantumPath® overview

A complex problem is set by the company

Mathematical formulation of the problem using a set of quantum assets and tools



Providers retrieves and stores the results into QuantumPath® unified, so it's more easy reuse them for analysis and democratization

The compositors creates the CIRCUIT or QUBO in an easier way

QPath® translates from the GUI into code and connects with providers

QuantumPath® overview

Pipelines

Graphical — An easier implementation of the circuit and the QUBO matrix

Q|assets compositor for annealing

Pseudocode — An intermediate level of abstraction

Q|Path QuantumPath

Direct Code — Programming level lovers who enjoy the provider SDKs

python Q# qASM

Q|Path QuantumPath

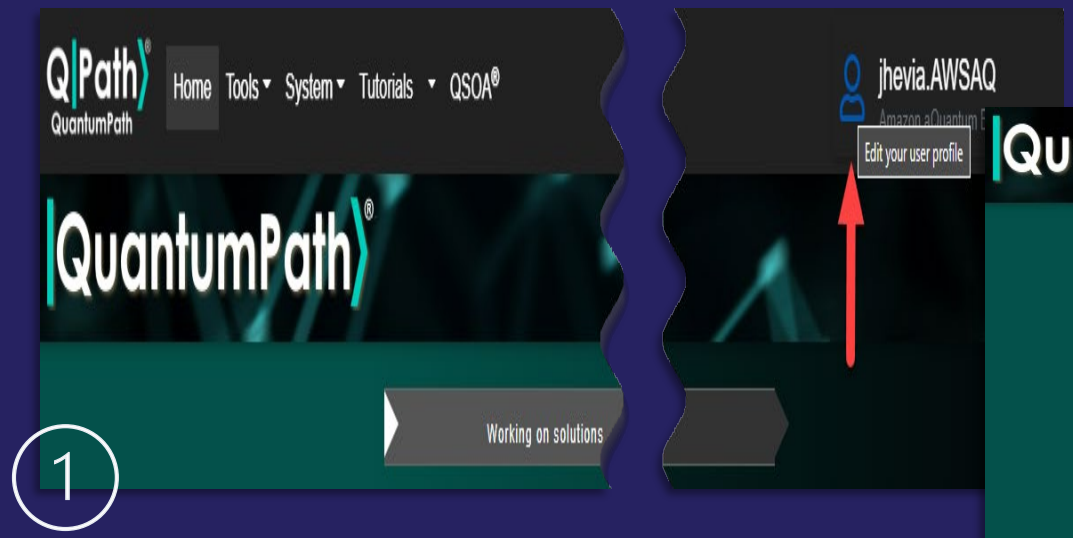
Creating Complete QuantumPath® Solutions

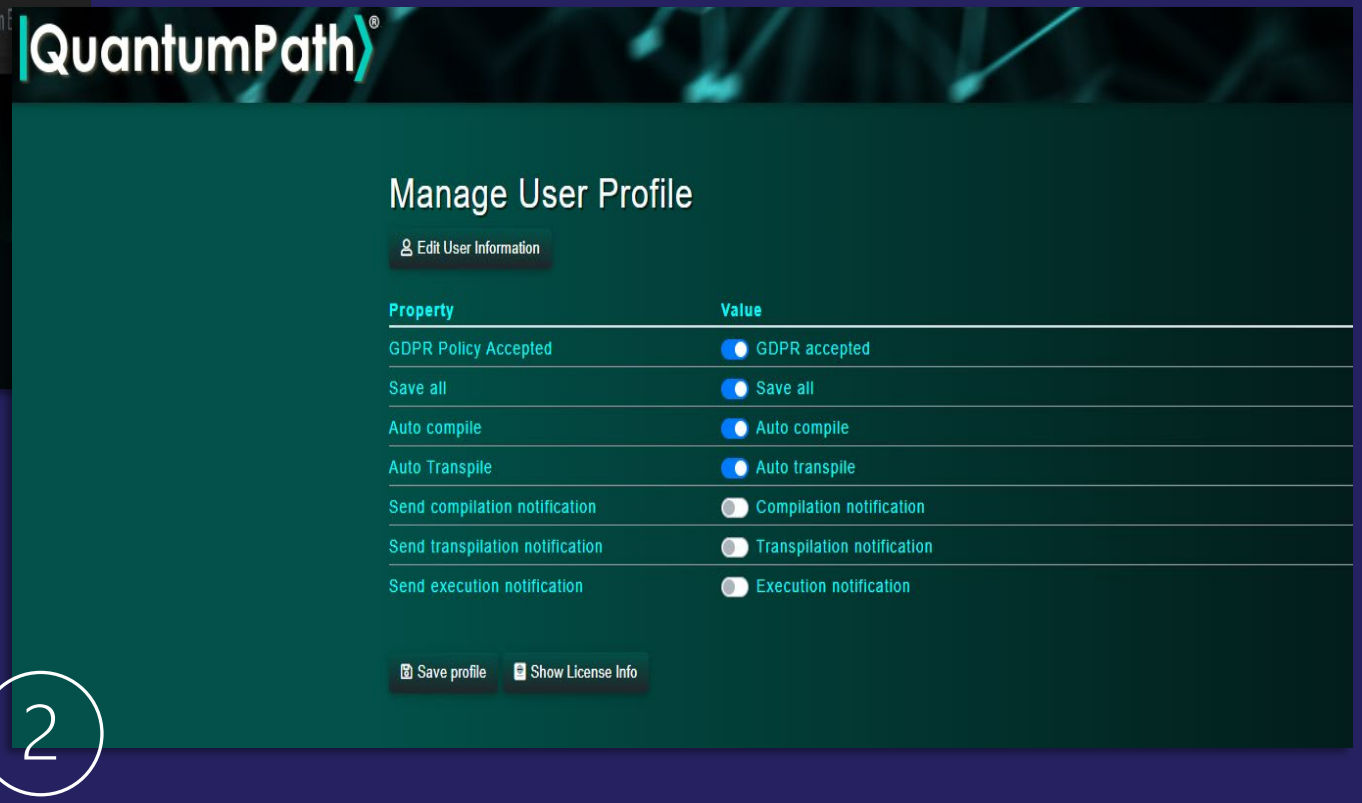
1. Analize the type of problem to solve determines technology
2. Create a QPath Solution cover the project definition and it’s technology requirements
3. Maintain the QPU providers and select based on different criteria
4. Create the quantum assets, try them, analyze results through lifecycle
5. Publish the ready to production flows and integrate them in classical IT systems

Hands On Workshop
Prepare QuantumPath Solution

Prepare the Environment

- Setup your profile options to make better the experience…



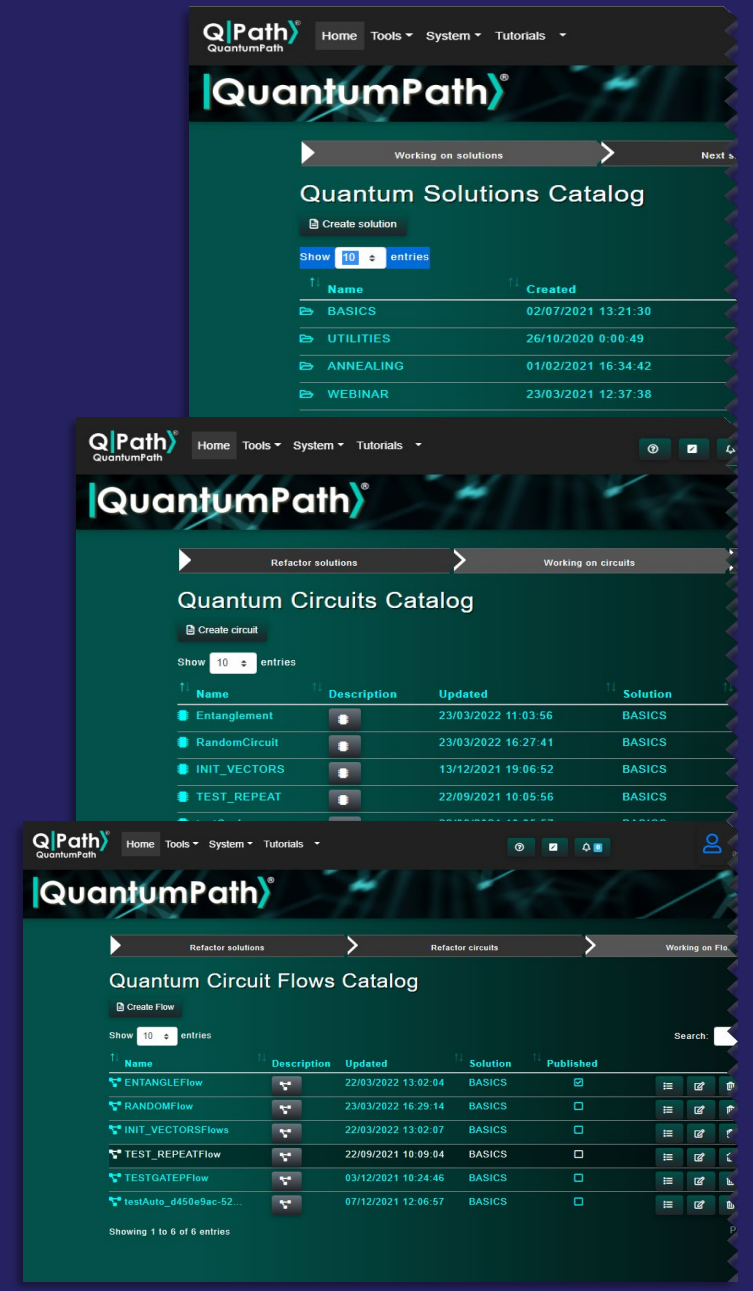


Learning Objectives

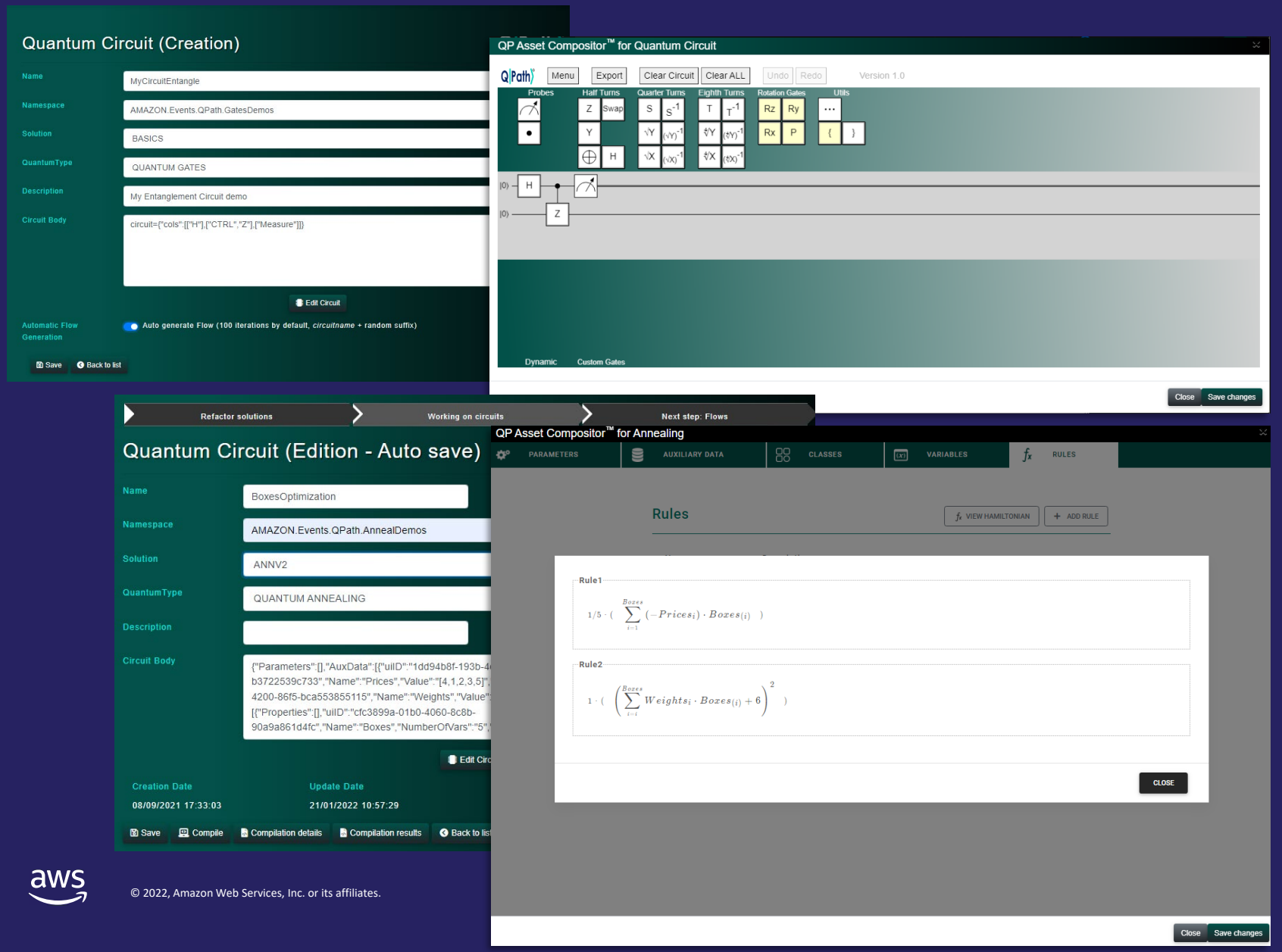
- Know lifecycle and assets catalog
- Develop gate-based algorithm development
- Formulate and implement graphically an annealing problem
- Understand the integration between quantum and classical systems

QuantumPath® lifecycle and assets catalog

1. The solution is the “box” inside you store the assets that compose a quantum application
2. The Circuit Assets are the atomic pieces that let the user the creation of the pieces of the quantum program puzzle, that can be GATES “pieces” or “Annealing” pieces.
3. The Flows Assets are the “main” routines that put the Circuits on the run, orchestrating their execution and conditions
4. The Assets pass through compilation and transpilations pipelines to validate the quantum application pieces
5. At the end, you execute and experiment with the results
6. And decide what flows can be executed from the outside business Use case

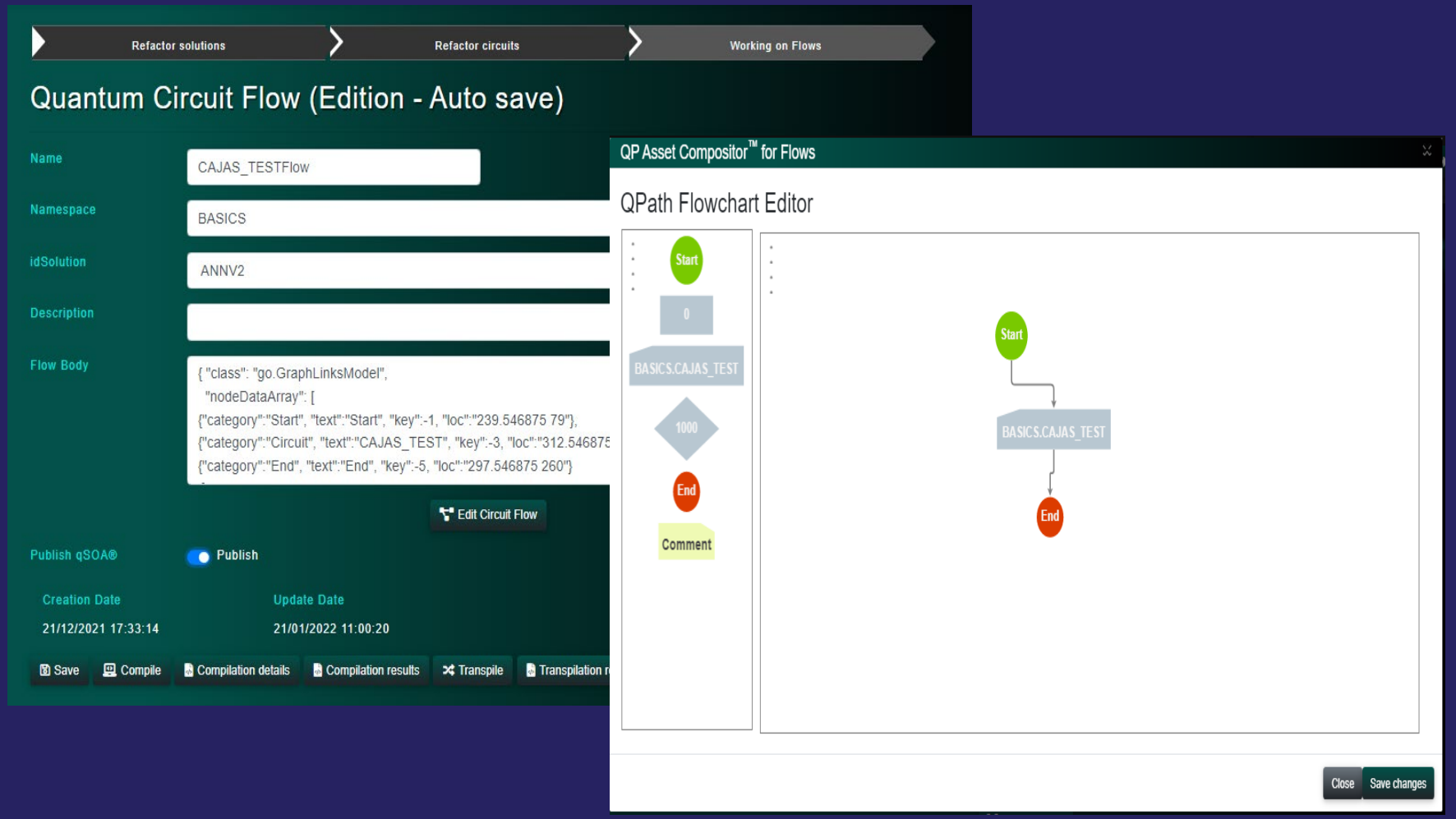


QuantumPath® lifecycle and assets catalog



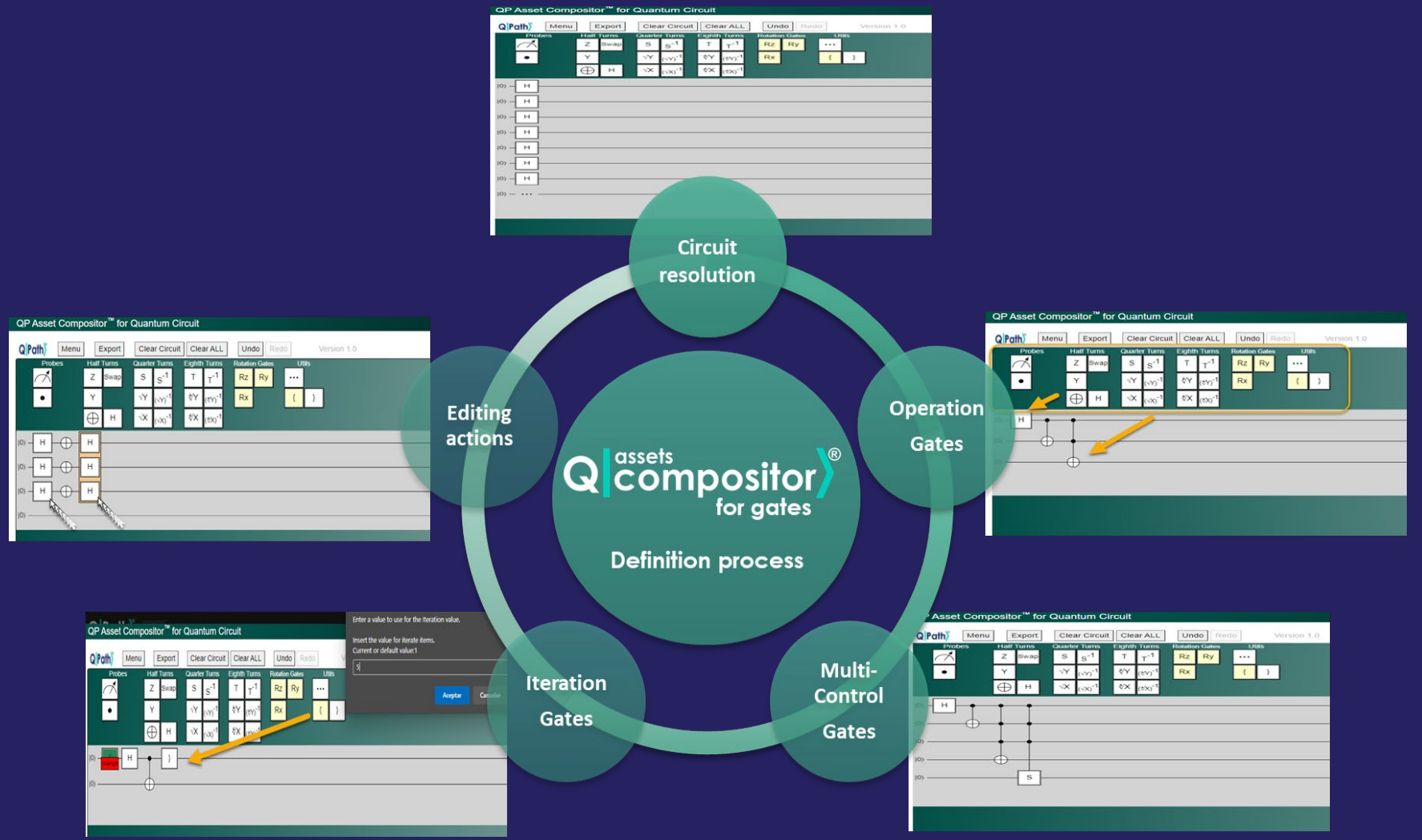
1. CRUD uses cases
2. Metadata Edition
3. Visual designers
4. Actions over Assets

QuantumPath® lifecycle and assets catalog



1. Drag'n'Drop features
2. Namespaces for Taxonomies
3. Multiple Shapes
4. Profile flags to automate tasks
5. High level and low level metadata

Gate-based algorithm development in QuantumPath®



1. Unlimited qubit scale
2. Full Agnostic gates
3. Editing helper actions
4. Operations over circuit
5. Agnostic multiControl gates
6. Rotation Pauli Gates

Q|Path QuantumPath

Hands On Workshop:
Gate-based algorithm development

Break

We will start again at

16:00

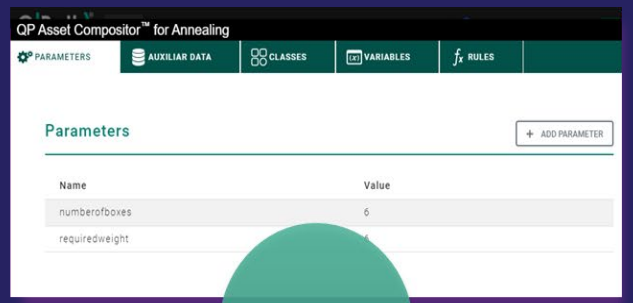
Agenda – Day 2 *(*)*

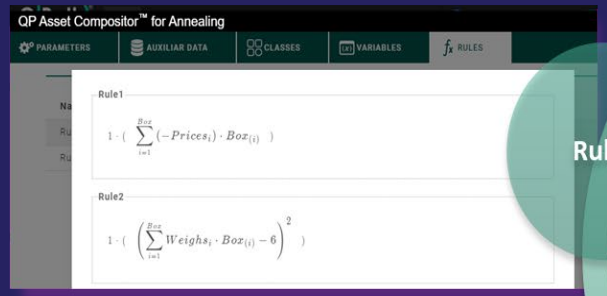
- ❑ 02:00 pm - Creating complete QuantumPath® solutions
- ❑ 02:30 pm - Introduction to QuantumPath lifecycle and assets catalog
- ❑ 03:00 pm - Demo: Gate-based algorithm development in QuantumPath
- ❑ 03:45 pm - Break

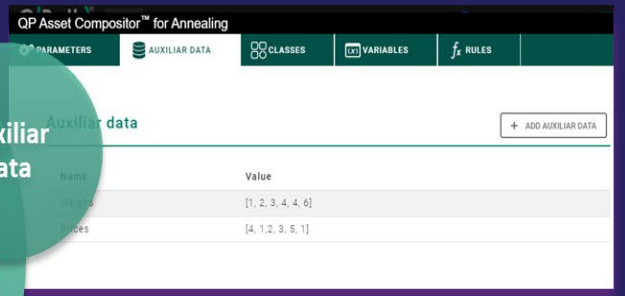
- ❑ 04:00 pm – Demo: Quantum annealing software development in QuantumPath®
- ❑ 04:30 pm – Preparing for Enterprise solutions:
  Hybrid Quantum-Classic architectures with qSOA®
- ❑ 04:50 pm – Summary and wrap up

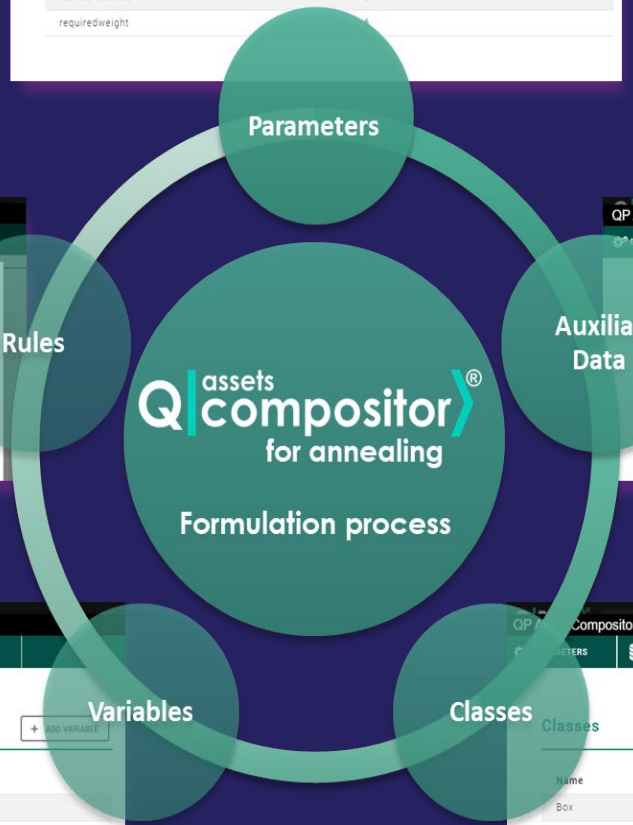
(*) All times are in UTC

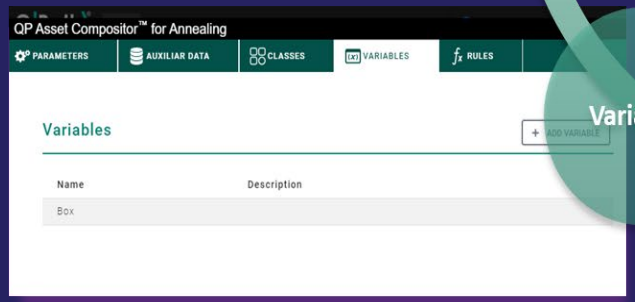
Quantum annealing software development in QuantumPath®

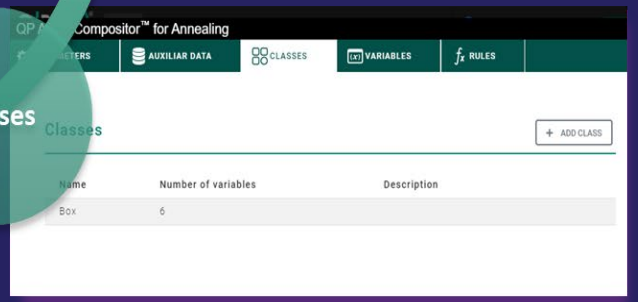












1. Agnostic Hamiltonian QUBO
2. Parameters, Auxiliar and Data
3. Classes and Variables
4. Visual rules design
5. Formulas and model validation
6. Hamiltonian representation

Q|Path⟩ QuantumPath

Hands On Workshop: Quantum Annealing software development in Qpath®

The knapsack problem

What is the set of items in the knapsack that weighs roughly 6 Kg and maximizes the total worth?

RULES

$$x_i = \begin{cases} 1 & \text{if item i is in the box knapsack} \\ 0 & \text{otherwise} \end{cases}$$

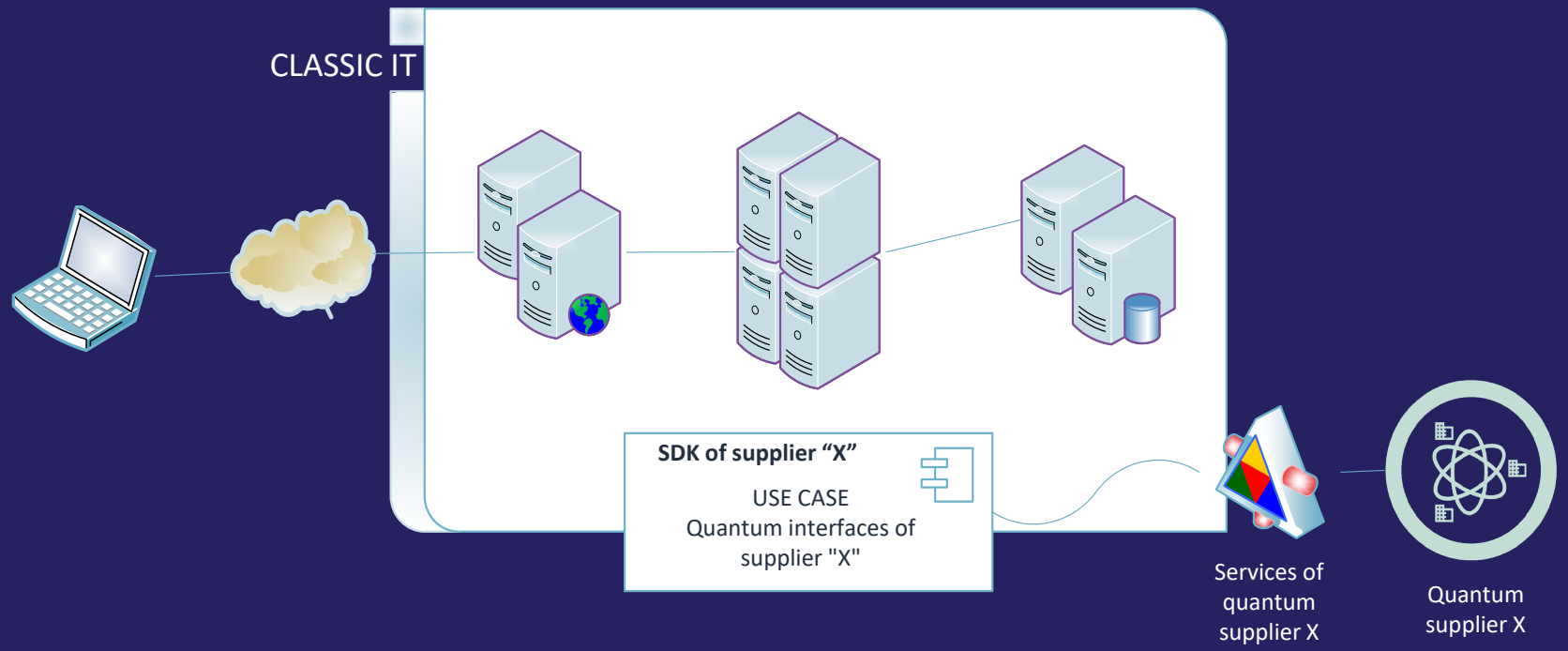
$$\text{price} = \sum_i V_i x_i, \quad V_i \text{ price of item } i$$

$$\left(\sum_i P_i x_i - 6\right)^2 = 0, \quad P_i \text{ weight of item } i$$

OPTIMIZATION $\min -\sum_i V_i x_i + \lambda \left(\sum_i P_i x_i - 6\right)^2$

Hybrid Quantum-Classic Architectures with qSOA®

How hybrid integration is usually approached in the current model...

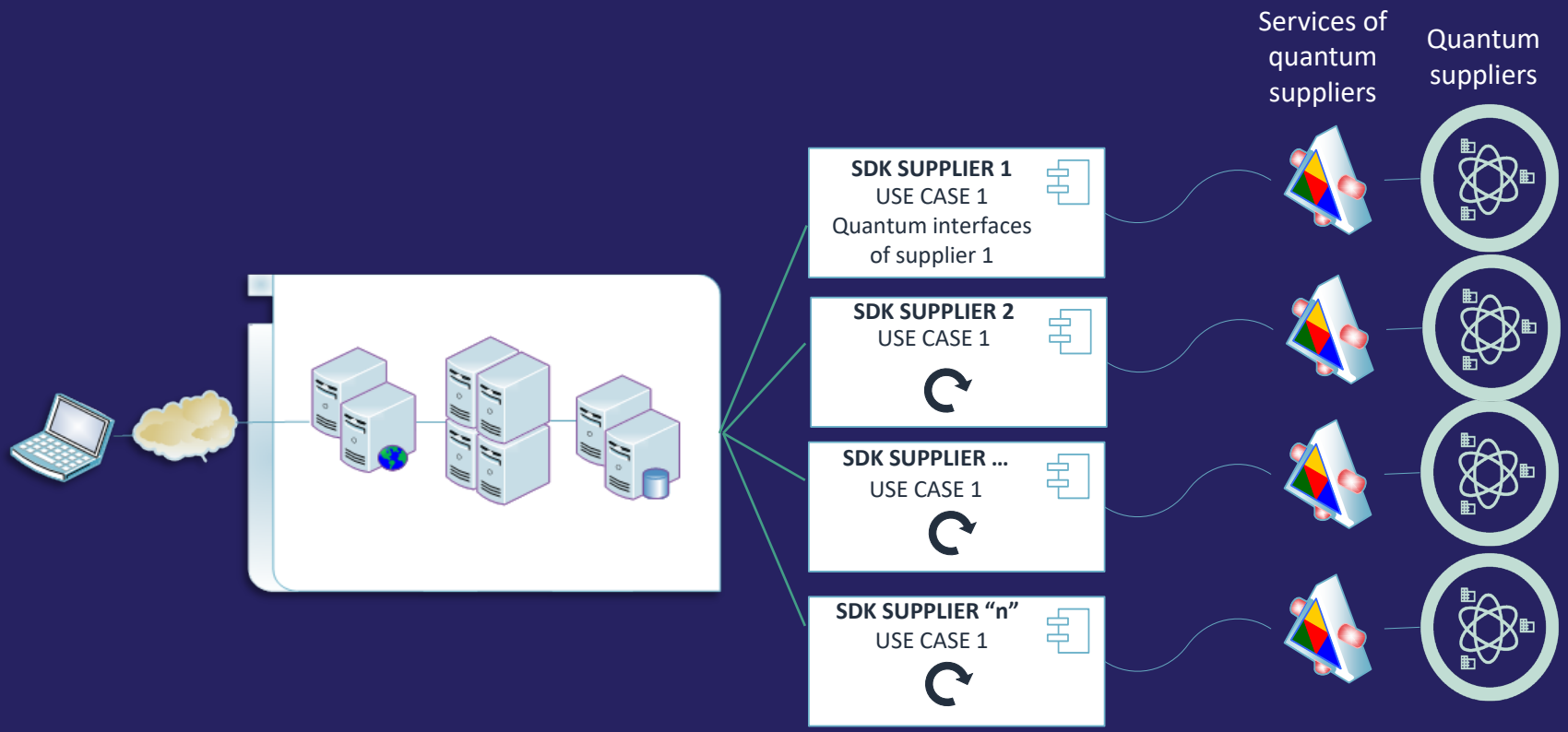


Hybrid Quantum-Classic Architectures with qSOA®

...and as most suppliers actually state...

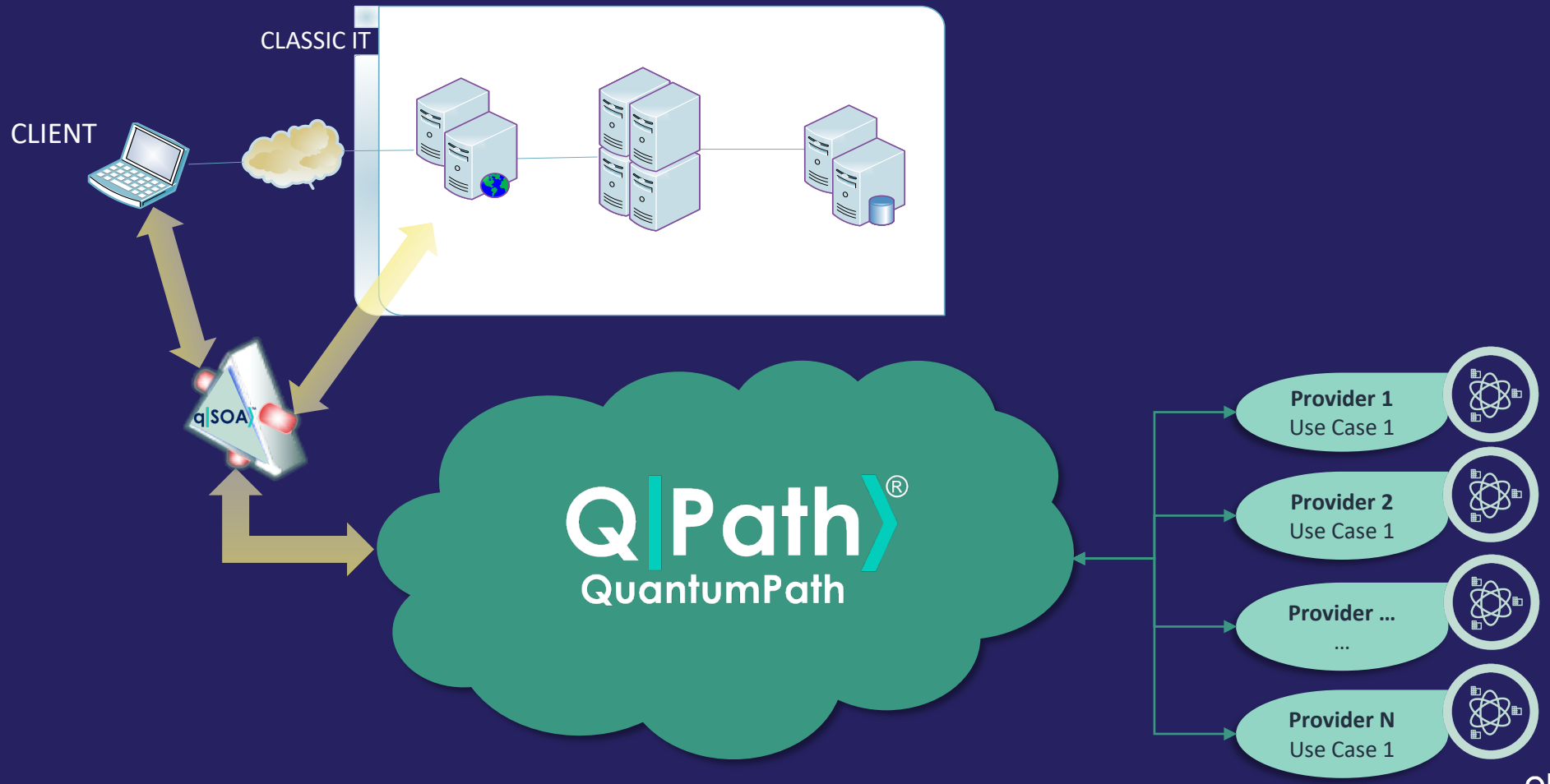
"The fine print"...

- For each use case, one code component
- For each technology, a version of the code component is required
- Each component is specific to a manufacturer's SDK
- Each manufacturer has its requirements and specifications



Hybrid Quantum-Classic Architectures with qSOA®

...and how it is approached with the help of QuantumPath® qSOA® REST API...



Hybrid Quantum-Classic Architectures with qSOA®

qSOA®

A high-level service architecture that makes the classical part independent from the quantum part, fully oriented to business requirements.

1. Clear and standardized connection points
2. Manufacturer agnostic
3. Direct access to quantum business use cases
4. Democratize the Quantum resources reusing your timelapsed stored results

QPath®'s qSOA® architecture, metalanguages, APIs and *ConnectionPoints* simplify the development of quantum algorithms and apps in the context of hybrid information systems.

Hybrid Quantum-Classic Architectures with qSOA®

The company poses a complex problem

The team generates products from the problem using a set of quantum assets and tools

Classical Systems can dynamically create or refactor assets through business rules

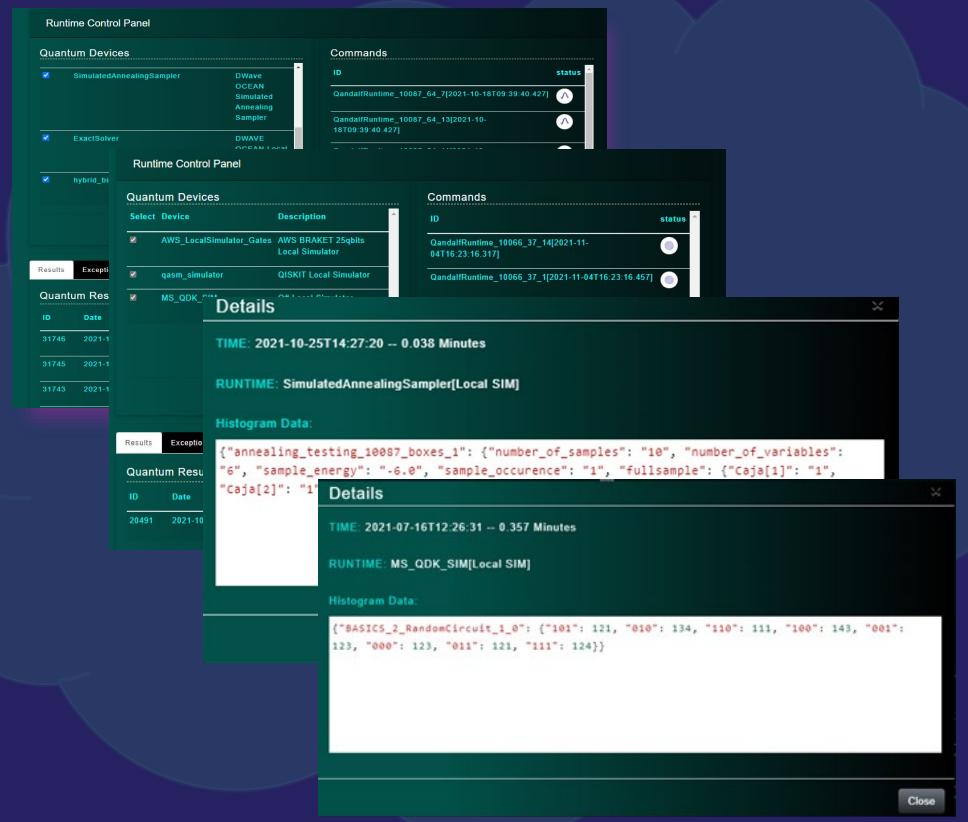
Publish use case flows

Classical IT calls quantum use cases

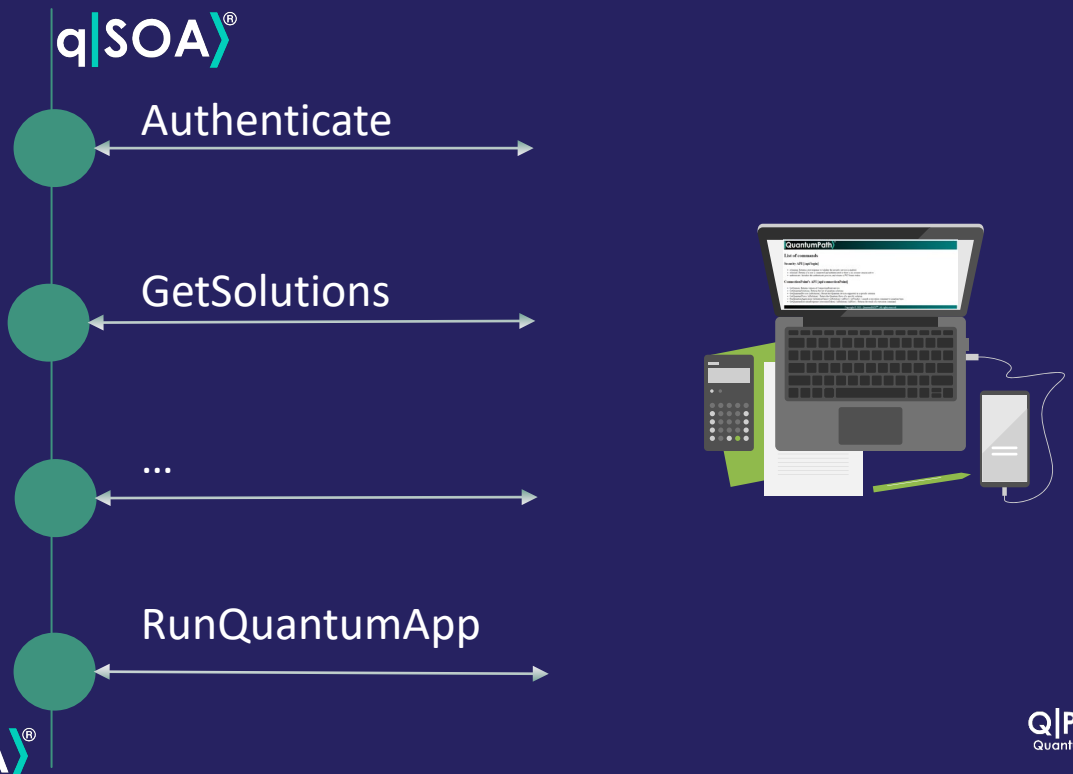
Persistent Results, traceability and telemetry

Hybrid Quantum-Classic Architectures with qSOA®

Run unchanged against your favorite instances on your vendors' quantum computers ...

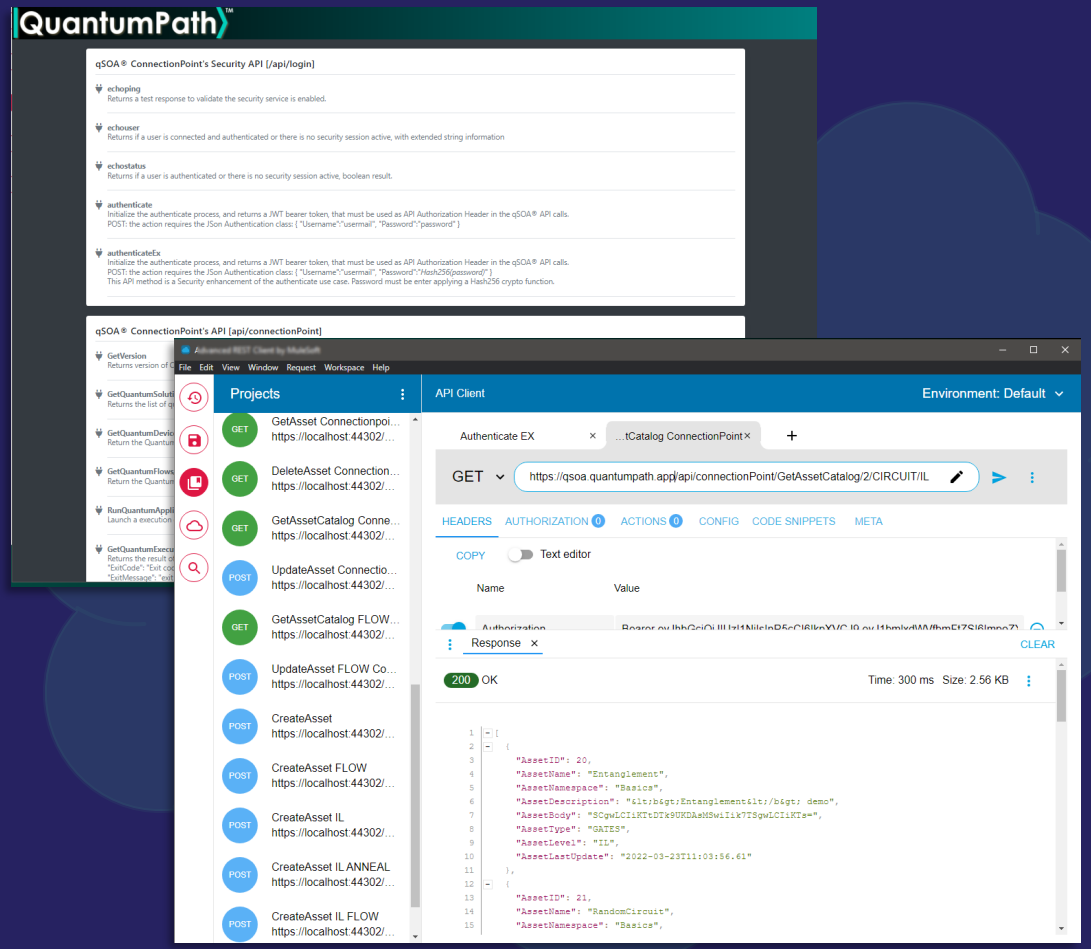


...reading standardized results

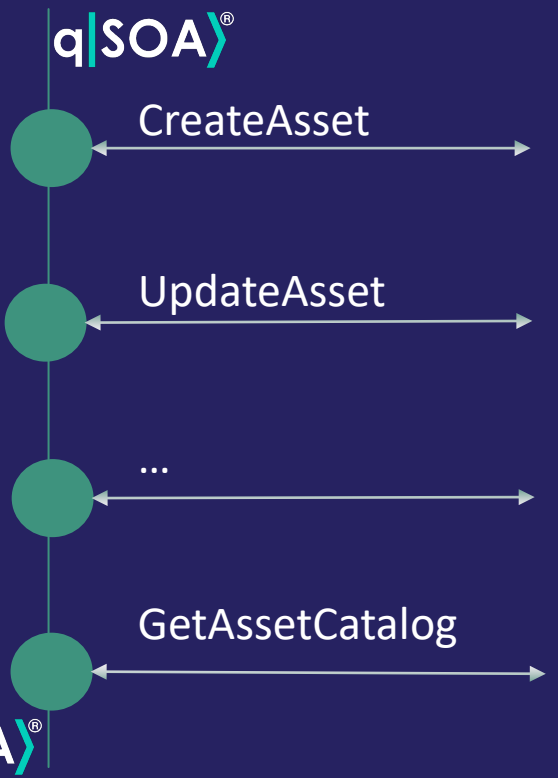


Hybrid Quantum-Classic Architectures with qSOA®

Dynamically create and manage the Quantum Assets Lifecycle…



… Using Visual level Language or QP Intermediate Language. Compose your "strings"…



Hybrid Quantum-Classic Architectures with qSOA®

Quantum software development platform for the hybrid solution ecosystem

Hybrid Quantum-Classic Architectures with qSOA®

Simple Windows Application through .NET Client QPath® SDK

Python Jupyter client through QPath® PY client SDK

BUSSINES CASE: NAVISION signature key

BUSSINES CASE CRM: Technicians calendar optimization

BUSSINESS CASE: QHealth Project

CAIXA FINTECH PoC: Finnancial portfolio

Hands On Workshop: qSOA® demos

Taking it further

- Explore the Quantum Application development
  - Connecting solutions to multiple QPU (like amazing Bracket resources)
  - Explore gate-based circuits using QuantumPath®
  - Explore the advantages of Q Assets Compositor® for annealing
  - Execute experiments in multiple QPU and analyze results and telemetry

- Analyze qSOA® benefits
  - Through .NET & Python SDK integrate quantum software into your classical IT
  - Execute your quantum uses cases or thirdy-party ones
  - Create dynamic assets based on business rules and explore them into the UI

Q&A & Wrap Up Day 2

Next Steps

Survey

https://www.aquantum.es/workshop-amazon-qpath-form/

Follow up

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