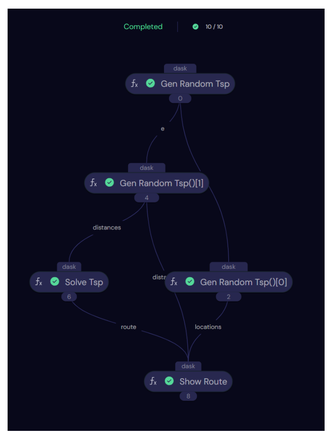
AIST
Create the Future, Collaborate Together

G-QuAT

ABCI-Q Software Environment for Quantum-Classical Hybrid Computing

Quantum-Classical Application Workflow

- Support Covalent and Prefect as workflow orchestration tools on ABCI-Q
- **Covalent**: Provide an end-to-end workflow execution environment
  - A workflow development and execution tool integrated into Open OnDemand (OOD)
  - Plugins for executing tasks on System H and System F
- **Prefect**: Develop a plugin for executing tasks within Singularity containers.



ABCI-Q Software Stack

Applications & Use cases	**Quantum-AI Hybrid Applications**	**Benchmark Tool**
Algorithms & Libraries	**Quantum-AI Libraries:** NEDO QuAILib (Factorization Machine with Annealing, Quluster, Quantum Circuit Knitting, QUDAT), etc	**Quantum Libraries:** OpenFermion, PennyLane, CUDA-QX, etc
Middleware	**Web-Portal Access:** JupyterLab, Open OnDemand	**AI/ML Frameworks:** PyTorch, DeepSpeed, Jax, TensorFlow
		Annealer Frameworks: Amplify SDK, JijZept, PyQUBO
		Quantum Frameworks: Qiskit, Cirq, QURI Parts, CUDA-Q, QIBO
		Quantum Circuit Simulator: cuQuantum, JUQCS, Qulacs, QNI
	SDK: Intel oneAPI, NVIDIA HPC SDK, CUDA Toolkit	**Communication Library:** OpenMPI, NVIDIA HPC-X, UCX
		Packaging Tool: Environment modules, Spack, PyPI
		Storage Tool: BeeOND, s3cmd
	Cloud Access: Qiskit runtime, Amazon Braket hybrid jobs	**Workflow Orchestrator:** Covalent
		Job Scheduler: PBS Professional
		Container Engine: Singularity CE
Hardware	**GPU compute system:** System H	**GPU-based Ising Machines:** Fujitsu DA, Amplify AE, SQBM+, etc
		QPUs: System F (Superconducting), System Q (Neutral Atom), System O (Photonics), etc

Covalent PBS Professional Plugin

Covalent plugin for ABCI-Q System F

Prefect-singularity

QuAILib: Quantum-AI Library Project

- QuAILib is a set of libraries that accelerates the research and development of algorithms combining quantum computers and AI, supporting real-world use cases.
  - SWIFT-FMQA (Black-box Optimization)
  - Qukit-learn (Quantum Machine Learning)
  - QuantumCircuitCutting (Quantum Circuit cutting & knitting)

QuAILib Project Website

SWIFT-FMQC

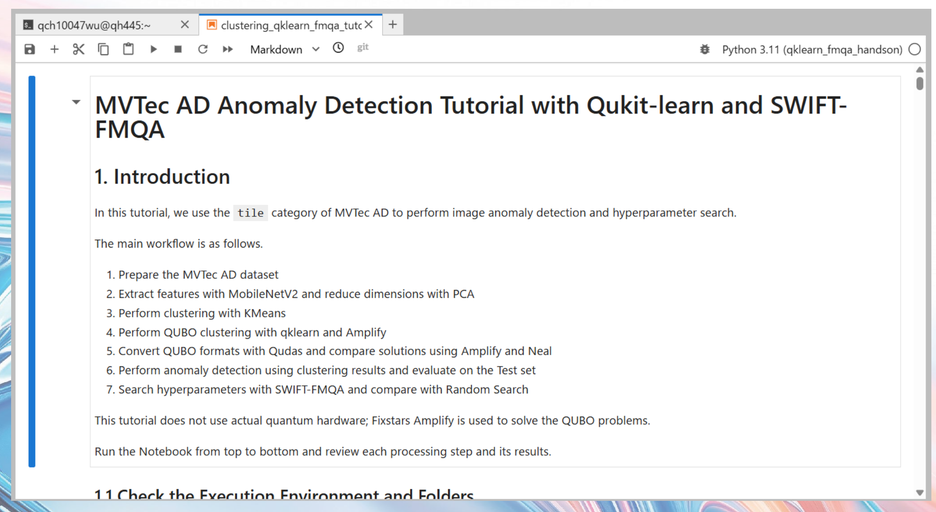
Qukit-learn

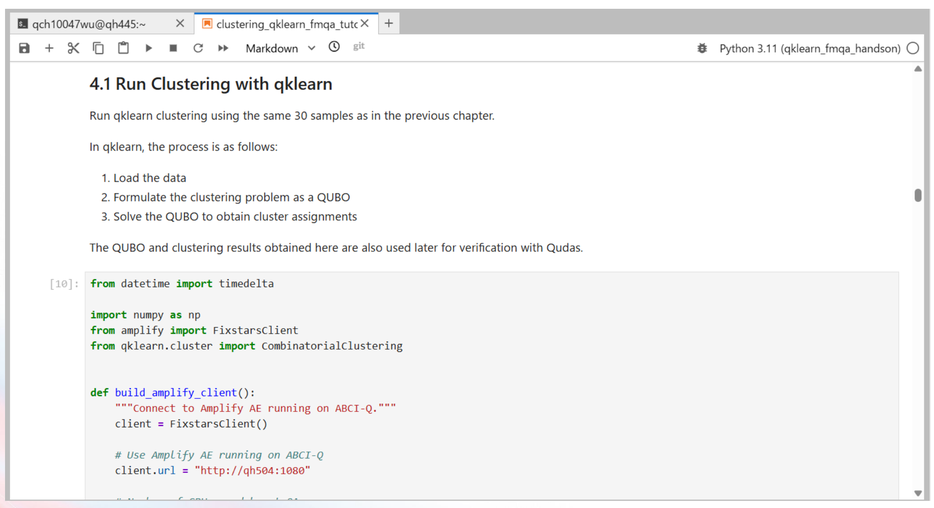
Quantum Circuit Cutting

Tutorials for Quantum-Classical Hybrid Computing

We provide tutorials for developing and validating applications using the QuAILib library. These tutorials offer hands-on learning opportunities through practical examples of quantum–classical hybrid technologies, which can be executed on ABCI-Q.

Tutorial Material Website





AIST SC Website

A part of this work was based on results obtained from “Development of Quantum-Classical Hybrid Use-Case Technologies in Cyber-Physical Development Project” (JPNP23003), commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

QuAILib Quantum-AI Library