Quantum Computing Providers

Which quantum computing systems and services are there?

Meetup of Quantum Computing Vienna

Systems and Services

- Probably, you do not want to start with purchasing a quantum computer and setting it up in your data center (capital expense).

- You can test algorithms with simulators and then run them on quantum computers provided as cloud services (operating expense).

Disclaimer

- The quantum computing providers on the following pages are sorted alphabetically to not rank them.

- There are others beyond this list.

- The statements are my personal observations at the time of writing and do not evaluate the providers or their products.

Alpine Quantum Technologies (AQT)

- AQT provides a web service based on REST and JSON.

- Their instruction set architecture consists of five gates.
    - X, Y, and Z rotate around the x-, y-, and z-axis, respectively (1-qubit)
    - R rotates around an arbitrary axis (1-qubit)
    - MS entangles via Mølmer-Sørensen (2-qubit)
    - https://www.aqt.eu/aqt-gate-definitions/

- There is one quantum system available for partners.

Amazon

- Bracket is a cloud service providing access to quantum computers of other providers.

- Beyond that it provides tools for quantum software development phases build, test, run, and analyze.

- The quantum computers and services can be utilized via the Braket API.

Google

- Google provides three processor architectures: Sycamore, Bristlecone, and Foxtail

- Sycamore provides the following instructions.

  - 1-qubit: Phased XZ, Virtual Z, and Physical Z

  - 2-qubit: Sycamore, Root iSwap, and CZ

- Cirq is an open-source Python programming framework.

- Quantum processors are available for partners only.

IBM Q

- Qiskit is a Python programming framework.

- Their instruction set architecture consists of four physical gates.

  - U1 Rotate around z-axis (1-qubit phase shift)

  - U2 Rotate around x- and z-axis (1-qubit)

  - U3 Rotate around x-, y-, and z-axis (1-qubit)

  - CX Entangle via controlled NOT (2-qubit)

- There are 21 available systems. https://quantum-computing.ibm.com/services/resources

IonQ

- builds quantum computers based on ion traps and provides them as cloud services.

- They measure quantum processing capacity as number of Algorithmic Qubits instead of Quantum Volume.

- Three systems are available to customers and partners.

- They are provided via three cloud providers, and four languages and software development kits.

Microsoft

- Azure Quantum is a cloud service and provides quantum computing via the hardware of other companies. https://azure.microsoft.com/en-us/products/quantum/

- Microsoft researches topological quantum computers.

- The Quantum Development Toolkit provides the Q# programming language, libraries for industrial applications, and more. https://azure.microsoft.com/en-us/resources/development-kit/quantum-computing/

QC Ware

- provides consulting, algorithms, and access to quantum computers of other providers.

- Forge is their development environment and kit designed for both, data scientists and quantum engineers, and based on Jupyter and Python.

- They publish prices per hour of quantum computing time based on the physical backend.

Oxford Quantum Circuits (OQC)

- builds superconducting quantum computers based on their Coaxmon three-dimensional and scalable qubits.

- Quantum Computing as a Service (QCaaS) makes their quantum computers commercially available in the cloud.

- The service is available to strategic partners and customers via Amazon Braket.

- OQC is committed to the OpenQASM roadmap, but there is no public documentation.

Quantinuum

- Tket is a Python programming framework.

- The H1 systems provide the following native gates.
    - 1-qubit U1q(theta, phi)
    - 1-qubit Rz(lambda)
    - 2-qubit ZZ

- Two systems are available to customers.
  https://www.quantinuum.com/products/h1

Rigetti

- Quantum Cloud Services provide the API. Quil(-T) is the programming language. Forest is the SDK and supports pyQuil, Qiskit, Cirq, and QASM.

- Their native gates are

  - 1-qubit RX and RZ rotate around the x- and z-axis

  - 2-qubit CPHASE, CZ and XY

- Two systems are available to customers. https://qcs.rigetti.com/qpus

Onward from Here

- Dominic Walliman made this video in early 2022 about who has which quantum computers
  https://youtu.be/gcbMKt079l8

- You can try some of the quantum software development kits and probably run your algorithms on actual quantum computers.