RESEARCH NOTE

IBM QUANTUM QISKIT 1.0 RELEASE

STEVE McDOWELL, CHIEF ANALYST
MAY 17, 2024

CONTEXT

IBM released significant enhancements to Qiskit, its widely used quantum software platform. These enhancements show its evolution from a software development kit launched in 2017 into a comprehensive software stack.

BACKGROUND: WHAT IS QISKIT?

Qiskit is IBM's open-source quantum computing software development kit (SDK), which helps users develop and run quantum computing programs. It allows researchers, developers, and enthusiasts to explore quantum algorithms and experiments, leveraging IBM's quantum processors.

Qiskit is structured around three main components:

1. **Qiskit Terra**: This is the framework's foundation, where users can create, compile, and run quantum circuits on both simulators and real quantum machines. Terra provides the tools needed to design quantum circuits from the ground up and optimize them for the specific topology of IBM's quantum processors.

2. **Qiskit Aer**: Aer simulates quantum circuits and includes noise models that mimic the conditions of real quantum hardware, allowing users to test and validate quantum algorithms under realistic conditions before running them on actual quantum machines.

3. **Qiskit Ignis**: Ignis provides quantum hardware calibration and error mitigation. It provides tools to improve the results from noisy quantum experiments, which is critical in the current era of noisy intermediate-scale quantum (NISQ) technology.

Through Qiskit, IBM supports a growing ecosystem of developers, researchers, and industries in exploring the potential of quantum computing and advancing the discovery of quantum advantage.

QISKIT 1.0 ENHANCEMENTS

QisKit 1.0 introduces a vast number of enhancements:

1. **Stable SDK**: Qiskit 1.0 offers a stable release suitable for building, optimizing, and visualizing quantum circuits. This version solidifies Qiskit's capabilities, making it more robust for research and practical quantum computing applications.
2. **AI-powered Optimization**: The Qiskit Transpiler Service, embedded with AI capabilities, allows for optimizing quantum circuits specifically for quantum hardware. This AI-driven optimization helps reduce circuit depth and improve the overall efficiency of quantum computations.
3. **Simplified Execution Modes**: The Qiskit Runtime Service is enhanced to include simplified execution modes for performant execution on quantum hardware. This streamlines the process and enhances the execution speed of quantum circuits.
4. **Qiskit Code Assistant**: Powered by IBM's WatsonX-based generative AI models, the Qiskit Code Assistant aids developers in automating the development of quantum code. This tool uses generative AI to facilitate code creation, reducing the barrier for new users and speeding up the development process for experienced users.
5. **Qiskit Serverless**: This open-source tool enables the execution of quantum-centric supercomputing workloads across quantum hardware and classical computing clusters. It seamlessly integrates quantum and classical resources, enhancing users' computational capabilities.
6. **Performance Improvements**: The enhancements in Qiskit SDK 1.0 significantly optimize quantum circuits. The new version can optimize circuits for quantum hardware 39 times faster than previous versions, with a considerable reduction in memory usage and overhead.

Qiskit 1.0 marks a mature phase in quantum computing software development, providing users with a comprehensive toolkit to address complex problems through quantum solutions.

COMPETITIVE ENVIRONMENT

Several platforms and tools compete with IBM's Qiskit in the quantum computing ecosystem. These tools vary in focus and specialization, from quantum algorithm development to hardware control and quantum circuit simulation.

Here are some of the main competitors to IBM's Qiskit:

1. **Google Cirq**: Developed by Google, Cirq is an open-source framework that allows users to write, manipulate, and optimize quantum circuits to run on Google's quantum processors and simulators. It is designed to be flexible and extensible, similar to Qiskit, but is tailored more specifically to Google's quantum computing initiatives.

2. **Rigetti Forest**: This includes PyQuil, a Python library for quantum programming using Quil (Quantum Instruction Language), and the Forest SDK, which provides tools and services to simulate and execute programs on Rigetti's quantum computers. Rigetti focuses on integrating quantum computers into existing classical computing workflows.

3. **Microsoft Quantum Development Kit**: This kit includes Q#, a programming language developed specifically for quantum computing. It is part of Microsoft's comprehensive approach to quantum computing that integrates with its Azure cloud services. It also provides tools for running quantum simulations on classical hardware.

4. **Amazon Braket**: Amazon Braket is a fully managed service that provides a development environment to build, test, and run quantum algorithms. It supports different quantum hardware technologies, including those from D-Wave, IonQ, and Rigetti, providing users with various platforms.

5. **D-Wave Leap**: Focused on quantum annealing, D-Wave provides the Leap platform, which offers access to its quantum annealers. Quantum annealing is particularly suited for optimization problems, and D-Wave's platform is unique compared to gate-based quantum computing platforms like Qiskit.

6. **Strawberry Fields and PennyLane by Xanadu** are Python-based frameworks for quantum machine learning, photonic quantum computing, and quantum chemistry. Xanadu's approach centers around quantum photonic processors, which use light particles for quantum computation.

Each platform brings unique capabilities and focuses to the quantum computing field, catering to different aspects of quantum research and development.

ANALYSIS

The first stable release of Qiskit SDK v1.0 is a critical development showing maturity in IBM's quantum software tools, moving from experimental phases to more reliable and robust offerings. The stability of the SDK can help foster broader adoption and possibly increase the user base beyond the current 550,000 individuals and entities.

Integrating AI to optimize quantum circuits is another strategic enhancement that sets IBM apart from competitors. By leveraging AI in the Qiskit Transpiler Service, IBM pushes the efficiency of quantum computations to new heights. This AI-driven optimization is crucial as it addresses one of the fundamental challenges in quantum computing: the efficient execution of quantum circuits, essential for achieving quantum advantage, where quantum solutions surpass the capabilities of classical computing solutions for practical problems.

Moreover, the simplification provided by the new execution modes in the Qiskit Runtime Service and the introduction of Qiskit Code Assistant powered by generative AI models lower the barriers to entry for new users and enhance productivity for seasoned quantum developers. This makes quantum computing more accessible to a broader audience.

Another notable addition is the Qiskit Serverless component. By facilitating the execution of quantum-centric supercomputing workloads across diverse computing environments, IBM addresses the critical scalability and resource optimization challenges as quantum computing moves towards more commercial applications.

From a strategic perspective, the updates enhance the functionality and appeal of IBM's quantum offerings and showcase the company's ongoing commitment to innovation and leadership in the quantum space. As enterprises begin to evaluate the potential of quantum computing for their specific needs more seriously, IBM's enriched toolkit and demonstrated performance improvements position it as a preferred partner in exploring quantum solutions.

As the quantum computing community strives to achieve quantum advantage, Qiskit is an essential tool. It enables scientists, researchers, and industries to unlock new computational capabilities and explore complex problem-solving scenarios that were once beyond reach.