Background Information

IBM Research at CeBIT 2017: Quantum Computing

We live in a world where classical physics defines our experiences and our intuition - and ultimately how we process information. However, nature at the atomic level is governed by a different set of rules known as quantum mechanics. It is beyond the reach of classical computers to solve problems that exist in nature in which quantum mechanics plays a role, for example, understanding how molecules behave.

Quantum computers can execute quantum algorithms which are based on the surprising principles of quantum mechanics. They have the potential to solve certain problems that are impossible to solve on today's supercomputers: from better drugs and stronger cryptography to new facets of artificial intelligence or helping design new, exotic materials.

IBM is the leader in this emerging field. On March 6, the company announced an industry-first initiative to build commercially available universal quantum computing systems. "IBM Q" quantum systems and services will be delivered via the IBM Cloud platform.

Already today users can run experiments on a quantum processor available within the IBM Quantum Experience on the IBM Cloud. A user guide gives an easy-to-understand introduction to the fascinating quantum world providing many examples in how to program the quantum computer. More complex quantum algorithms can be programmed and executed in real time on the IBM Quantum processor by the usage of the quantum assembly language QASM 2.0 as well as a Python SDK, both of which have been recently released by IBM.

Even more, APIs (Application Program Interface) for the IBM Quantum Experience will enable developers and programmers to begin building interfaces between its existing five quantum bit (qubit) cloud-based quantum computer and classical computers, without needing a deep background in quantum physics.

IBM is the first company to commit to building universal quantum computing systems that will provide the capability to explore a new realm of computational power beyond today's classical computers impacting many aspects of society

When universal quantum computers become a reality, they will be exponentially better at analyzing data as a complement to classical computers' machine learning and advanced analytics capabilities. We want our clients to start exploring business use cases so they are ready with business applications when fully fault-tolerant universal quantum computers become a reality.

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At CeBIT, we are showing some components necessary to run a quantum installation and describe the achievement of IBM Research as well as the path going forward.

What is Quantum Computing?

Today's computers use binary digits (bits) to do calculations and process information based on a simple principle: bits exist in a state of either 1 or 0. Quantum computing has bits too, but instead of ones and zeros, its quantum bits (qubits) can represent 1, 0 - or both at once - a phenomenon known as superposition. Superposition can allow two qubits to behave in ways that cannot be explained by the individual components. This is called entanglement, an effect which is unknown in the classical world.

IBM employs superconducting qubits that are made with superconducting metals on a silicon chip and can be designed and manufactured using standard silicon fabrication techniques.

Qubits are very fragile and can quickly lose their quantum information when interacting with matter, electromagnetic radiation, sound, or changes in temperature. Therefore, quantum systems are stored under vacuum in very cold places such as cryostats at a temperature of about -273°C. When qubits lose their quantum information, they are no longer in superposition or capable of entanglement - means, they can no longer represent a one, a zero, or both at once. The process of qubits losing their information is called quantum errors or decoherence. The short period when qubits are in superposition and capable of entanglement, is called coherence time; longer coherence time means more power to solve problems.

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