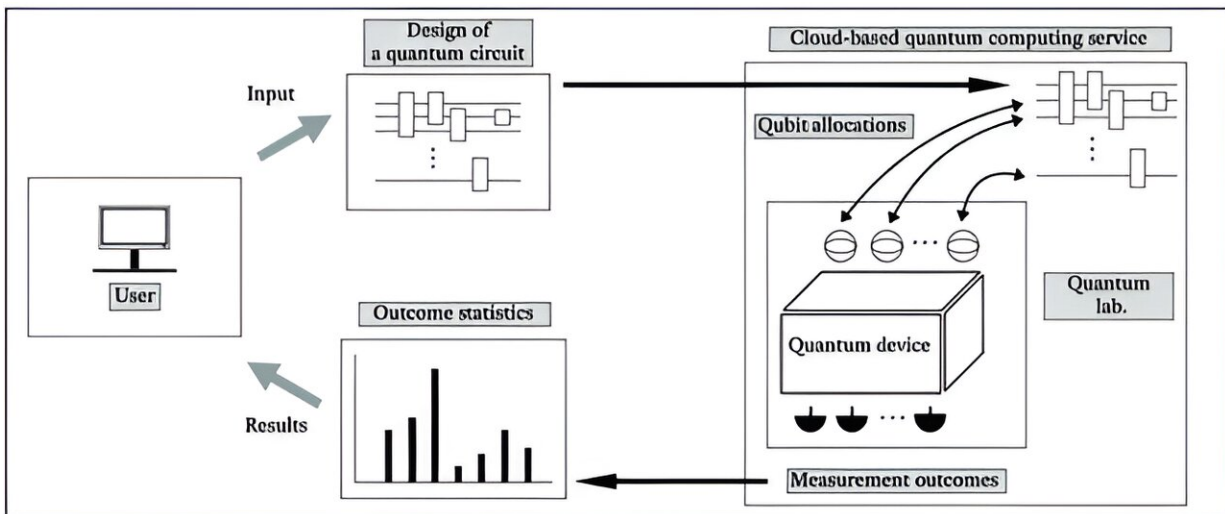


Can cloud-based quantum computing really offer a quantum advantage?

September 22 2023



The input to the service is a user-designed quantum circuit. The service begins with qubit allocation, which relates physical qubits to a designed circuit. An implementation of the circuit is run in the service, and measurement statistics are returned to the user as the outcome. Quantum advantages may be obtained when quantum circuits capable of generating entangled states are realized in the service. Credit: Jiheon Seong and Joonwoo Bae

A quantum machine can drastically speed up certain kinds of computation, but only if two or more quantum bits in the machine are entangled—that is, capable of displaying related behavior despite being separated.

Seeking a way for users of cloud-based quantum computing services to detect qubit [entanglement](#), Jiheon Seong and Joonwoo Bae of the Korea Advanced Institute of Science and Technology developed and tested an entanglement witness circuit. It works to certify entanglement even when the cloud-based service allows only limited control of the machine. Their research was published in *Intelligent Computing*.

Researchers want to build circuits that generate entanglement among qubits. However, until they use a circuit, they do not know whether it is an entanglement-generating circuit or not. A costly procedure called quantum tomography can be performed, or the researcher can use an entanglement witness. The entanglement witness is a mathematical function relating two specific qubits and their states. The value of its output signals whether the states of the qubits are entangled or separable.

Unfortunately, it is not always possible to use an entanglement witness without [direct access](#) to the quantum machine. In a lab setting, and in the IBMQ cloud-based quantum computing service, a researcher can choose which of the machine's hardware qubits to allocate to a circuit. In the IonQ cloud-based quantum computing service, the user does not have this level of control, and thus cannot be sure of getting the appropriate values for computing the output of the entanglement witness function.

A researcher's only input to the IBMQ and IonQ cloud services is a quantum circuit. To address this limitation, Seong and Bae designed special entanglement witness circuits that use the entanglement witness strategy for certifying the presence of entangled qubits. Researchers can use these circuits to detect entanglement using only the measurement statistics output by the service.

They do not need to be able to control qubit allocation. Entanglement witness circuits enable researchers using cloud-based computing to satisfy an "essential requirement" in the process of seeking quantum

advantages.

Moreover, the new entanglement witness circuits are built on a recently developed framework called EW 2.0, which is twice as efficient at detecting entanglement.

Seong and Bae describe entanglement detection for two- and three-[qubit](#) entanglement-generating circuits, outline two schemes for constructing entanglement witness circuits for entanglement-generating [circuits](#) and share results of experiments using the IBMQ and IonQ cloud-based quantum computing services.

More information: Jiheon Seong et al, Detecting Entanglement-Generating Circuits in Cloud-Based Quantum Computing, *Intelligent Computing* (2023). [DOI: 10.34133/icomputing.0051](https://doi.org/10.34133/icomputing.0051)

Provided by Intelligent Computing

Citation: Can cloud-based quantum computing really offer a quantum advantage? (2023, September 22) retrieved 30 April 2024 from <https://phys.org/news/2023-09-cloud-based-quantum-advantage.html>

<p>This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.</p>
--