August 28, 2024
Fujitsu Limited
Osaka University

Fujitsu and Osaka University accelerate progress toward practical quantum computing by significantly increasing computing scale through error impact reduction in quantum computing architecture

New technologies establish method to run practical quantum algorithms faster than current classical computers with fewer qubits

Kawasaki and Osaka, August 28, 2024 – Fujitsu Limited and the Center for Quantum Information and Quantum Biology at Osaka University (QIQB) today announced the joint development of two new technologies for the space-time efficient analog rotation quantum computing architecture (*1) that will accelerate the realization of practical quantum computing.

Fujitsu and QIQB have leveraged these new technologies, one that improves phase angle accuracy during phase rotation (*2) and one that automatically generates efficient qubit operation procedures, to show that it is theoretically possible for a quantum computer to perform a calculation that would take a classical computer five years, in only ten hours. The two organizations found that the calculation, a material energy estimate, would be possible using only 60,000 qubits, significantly less than the amount typically thought to be required (*3) for fault-tolerant quantum computation (FTQC) (*4) to surpass the calculation speed of classical computers.

These results demonstrate for the first time how quantum advantage, i.e., quantum computers being able to solve problems faster than current classical computers, can be achieved in the early-FTQC era (*5), which is expected to arrive around 2030. Quantum computing is expected to accelerate technological innovations in various fields, including enabling a larger-scale analysis of the Hubbard model (*6) for developing high temperature superconductors (*7), which may improve the efficiency of electrical infrastructure, as well as lead to innovations in material development and drug discovery.

The generation of efficient qubit operation procedures was achieved through the development of a quantum circuit generator. This system introduces a streamlined the process for converting logic gates, which are the fundamental operations of quantum computing, into physical gates, which operate the qubits. The system is also equipped with acceleration technology that minimizes computing time by dynamically changing the operational procedures of the qubits.

The two organizations initially announced the quantum computing architecture on March 23, 2023(*8), but there were obstacles to practical applications including insufficient accuracy in phase rotation and the lack of an established physical gating procedure, a method of operating qubits suitable for specific calculation problems. These new technologies address these obstacles.

Through their continued joint quantum computing initiatives, Fujitsu and QIQB aim to contribute to solving societal issues, addressing decarbonization and reducing the cost of new material development.

Acknowledgements
This research was supported by the following grants: Japan Science and Technology Agency (JST); the Program on Open Innovation Platforms for Industry-academia Co-creation (COI-NEXT), "Quantum Software Research Hub" (JPMJPF2014); JST Moonshot Goal 6 "Realization of a fault-tolerant universal quantum computer that will revolutionize economy, industry, and security by 2050", R&D project "Research and Development of Theory and Software for Fault-tolerant Quantum Computers" (JPMJMS2061); and Japanese Ministry of Education, Culture, Sports, Science and Technology's Quantum Leap Flagship Program (MEXT Q-LEAP) "Development of quantum software by intelligent quantum system design and its applications" (JPMXS0120319794).

Notes

(*1) Space-time efficient analog rotation quantum computing architecture:
A quantum computing architecture that can significantly reduce the number of physical qubits needed for arbitrary phase rotation, An essential step in achieving practical quantum computing.

(*2) Phase rotation:
An operation in which the arbitrary phase angle of a qubit rotates. An essential element in unlocking the true power of quantum computing.

(*3) One million qubits
The estimated number of qubits required to solve the FeMoco (enzyme active center) energy estimation problem with an error rate of 0.1% (source cited: Reiher, *et. al.*, PNAS, 114 (29) 7555-7560 (2017)).

(*4) Fault-tolerant quantum computation (FTQC):
Fault-tolerant quantum computation achieved through the correction of quantum errors.

(*5) Early-FTQC era:
An era in which quantum computers work with only a maximum of 100,000 physical qubits and FTQC is considered to be impossible to achieve.

(*6) Hubbard model:
A theoretical model for calculating material properties. It is used to describe strongly correlated electron systems, including in high-temperature superconductivity.

(*7) High temperature superconductor:
A material that exhibits a phenomenon which causes it to have zero electrical resistance when it reaches a temperature above the boiling point of liquid nitrogen.

(*8) Fujitsu and Osaka University develop new quantum computing architecture, accelerating progress toward practical application of quantum computers
https://www.fujitsu.com/global/about/resources/news/press-releases/2023/0323-01.html

Related Links

- Center for Quantum Information and Quantum Biology https://qiqb.osaka-u.ac.jp/en/
- Fujitsu Quantum
  https://www.fujitsu.com/global/about/research/technology/quantum/index.html
- Fujitsu and Osaka University Deepen Collaborative Research and Development for Fault-Tolerant Quantum Computers
  https://www.fujitsu.com/global/about/resources/news/press-releases/2021/1001-01.html

About the Center for Quantum Information and Quantum Biology at Osaka University
The Center for Quantum Information and Quantum Biology consists of six research groups: Quantum Computing, Transdisciplinary Quantum Science, Quantum Information Devices, Quantum Communication and Security, Quantum Sensing, and Quantum Biology. QIQB promotes transdisciplinary research between each of these research groups and with other academic fields. The Center is an international research hub for quantum innovation by actively promoting international academic exchange and collaboration across borders. QIQB seeks to play a key role in nurturing future quantum leaders and specialists through education and training. For more information: https://qiqb.osaka-u.ac.jp/en/

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About Osaka University
Osaka University was founded in 1931 as one of Japan's imperial universities through strong demand from political and business circles in Osaka, as well as the people of Osaka City and Prefecture. The spiritual roots of Osaka University can be found in Kaitokudo and Tekijuku, educational institutions of the Edo period. After its merger with Osaka University of Foreign Studies in 2007, Osaka University became a comprehensive university with its own School of Foreign Studies. Boasting 11 undergraduate schools, 15 graduate schools, and 6 affiliated research institutes excelling in the fields of the humanities and social sciences, medicine, dentistry, pharmacy, science, and engineering, Osaka University is one of Japan's premier comprehensive research universities.
Osaka University will celebrate the 100th anniversary of its founding in 2031.
We will contribute to the creation of a society where each member feels worth living through co-creation with diverse stakeholders to solve local and global challenges in accordance with the university's motto of "Live Locally, Grow Globally."

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