

# First successful simulation of 50 qubit quantum computer, setting a new world record

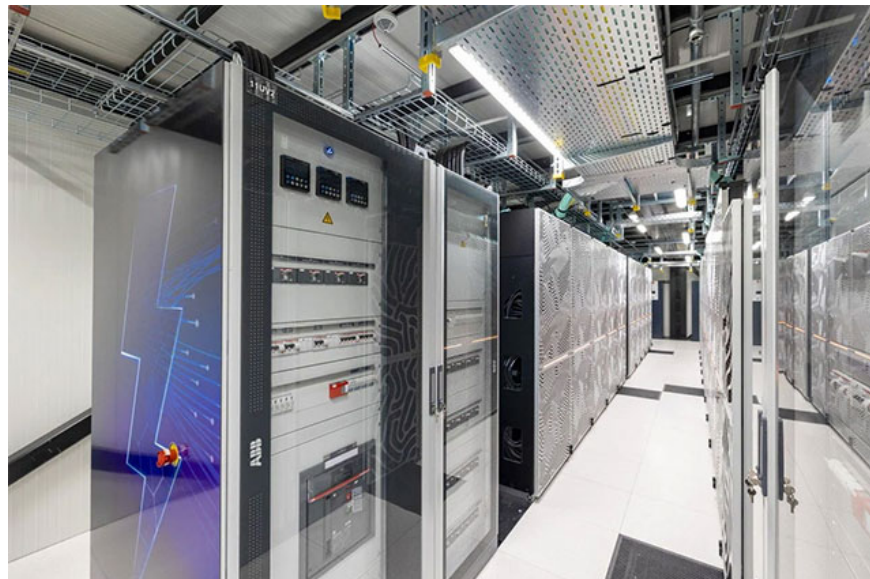
The JUPITER supercomputer set a record by simulating 50 qubits, surpassing the previous mark of 48 qubits. The achievement was based on CPU–GPU hybrid memory technology and optimized JUQCS-50 software.

**The JUPITER supercomputer has just set a major milestone by simulating 50 qubits. This achievement comes from major improvements in memory and data compression techniques.**

A research team from the Jülich Supercomputing Center, in collaboration with NVIDIA experts, has successfully recreated for the first time a 50-qubit universal quantum computer on the JUPITER system — Europe's first exascale supercomputer, which has been operational since September at Forschungszentrum Jülich.

Previously, the 48 qubit record was set by Jülich in 2019 on Japan's K supercomputer. The new achievement affirms the superior power of JUPITER, while opening a powerful experimental platform to verify and develop future quantum algorithms.

Quantum computer simulations play a big role in the development of quantum technology. They help scientists verify experimental results and test new algorithms when real-world quantum hardware is not yet advanced enough to run those problems. Typical examples include VQE (Variational Quantum Eigensolver) used for molecular and material analysis, or QAOA (Quantum Approximate Optimization Algorithm) used in logistics optimization, finance, and AI.



## Challenges beyond the limits of traditional supercomputers

Recreating a quantum computer on a classical system is a Herculean task. Each additional qubit increases the number of quantum states that need to be described exponentially. At 50 qubits, the system requires about **2 petabytes of memory** —that's two million gigabytes.

*' Only the world's largest supercomputers can achieve this level, ' said Professor Kristel Michielsens, Director of the Jülich Supercomputing Center. ' This shows the increasingly close connection between HPC (high-performance computing) and quantum research. '*

Each quantum operation, such as manipulating a logic gate, affects more than **2 quadrillion** complex number values. These values must be precisely synchronized across thousands of computing nodes to accurately reproduce the behavior of a real quantum processor.

## Breakthrough thanks to new generation memory technology

The record was achieved thanks to the tightly coupled CPU–GPU architecture in JUPITER's NVIDIA GH200 Superchip processors. This design allows data exceeding GPU capacity to be temporarily transferred to CPU memory without significantly reducing performance.

To take advantage of this hybrid memory system, the NVIDIA Application Lab and Jülich teams have upgraded the JUQCS simulation software. The new version — **JUQCS-50** — is capable of performing quantum operations efficiently even if some of the data must be stored on the CPU.

They also added byte-code compression that reduces memory requirements by more than eight times, along with dynamic algorithms that continuously optimize data exchange between more than 16,000 GH200 Superchips.

*' With JUQCS-50, we can simulate universal quantum computers with high precision and solve questions that no real quantum system has yet tackled, ' said Professor Hans De Raedt, lead author of the study (now in preprint form).*

## Towards open quantum infrastructure for the research community

JUQCS-50 will be made available to research institutes and businesses through JUNIQ — Jülich's integrated quantum computing infrastructure. The tool will serve as both a research platform and a performance testbed for future supercomputers.

The project was developed within the framework of the JUPITER Research and Early Access Program (JUREAP). *' The early collaboration between Jülich and NVIDIA experts during the construction phase of JUPITER allowed for hardware-software co-design from the beginning, an important step in fully exploiting the power of this exascale system, ' said Dr. Andreas Herten, project member.*

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