QCStack: Between Classical Clusters and Quantum Computing

Quantum computing is still a big promise, but at the latest since the first quantum computer went into operation in Germany in June 2021, the future technology has moved a bit into the present. Dr. Valeria Bartsch heads the "Next Generation Computing – Quantum Computing" team and talks in this interview about the current state of research.

What is the state of research In Quantum Computing?

Compared to classical computing, quantum computing is still at the beginning of its development. In principle, we are at the same stage as the first classical computers in the 1950s. We lack an invention similar to that of the transistor, which revolutionized computers and provided a hardware platform on which all further developments are based. We put a lot of work into research and testing. Therefore, we expect a rapid improvement of the hardware, the algorithms and the software stack to deliver on the promise of quantum computing. We want German industry to be ready as soon as the benefits of quantum computing can be implemented in reality. Coming from high-performance computing, we are looking in particular at the software

stack and the integration between classical clusters and quantum computers. We are building an abstraction layer-an interface between the hardware and the application-that every quantum computer needs. As yet, this interface must be implemented individually for each quantum technology and variant. We would like to generalize this step. We are financially supported by the German Federal Ministry of Education and Research (BMBF). The ministry has set up a special funding program for quantum technology. We are leading the project QCStack project and, together with our partners build a suitable middleware.

What does that mean exactly?

The middleware ensures the exchange of data between application programs that work under different operating systems or in heterogeneous networks. In our case these are software stacks, i.e. software packages that build on each other software packages with the task of supporting the execution of a common application. To understand this, it is helpful to compare with an orchestra: The instruments must be tuned, i.e. calibrated, in order for the interaction to work. The music is arranged according to the composition of the orchestra. Likewise, the algorithms are calibrated to run on a particular quantum system. In the orchestra, the conductor gives the instruments the cue, the qubits get their "go" from a scheduler.

This sounds like a big task. Is the Fraunhofer ITWM working alone on QCStack?

The project is a joint effort – we focus on the compiler that translates quantum algorithms to real quantum systems. The "Dahlem Center for Complex Quantum Systems" at Freie Universität Berlin is developing methods for the optimal control of quantum systems and working on their application. Qruise GmbH, a spin-off of Forschungszentrum Jülich, then deals with the commissioning of the software and (re)calibration. At the end of the project – probably in January 2025 – we want to present the first functional iteration of the software; both the core software and the algorithms it contains must then have achieved MVP (Minimal Viable Product) status. This means that our product must be so good that it is of interesting for companies.

Qubits are the smallest computing units in quantum computing.

Fraunhofer operates "IBM Quantum System One"

Since June 2021 quantum computing is possible in Europe: Together with IBM Fraunhofer operates the quantum computer "IBM Quantum System One" under EU data protection guidelines. It is available to companies and research organizations to develop and test application-related quantum algorithms and build up know-how.

www.itwm.fraunhofer.de/QCStack_en

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