Leibniz Supercomputing Centre

of the Bavarian Academy of Sciences and Humanities

Quantum Computing at LRZ: Status, strategy and outlook

SuperMUC-NG Status and Results Workshop | 10.6.2021 | Luigi Iapichino

Opening | QIC

LRZ Quantum Integration Centre | March 17, 2021

qic.lrz.de

The HPC Innovation/Integration Circle

HPC

Modeling & Simulation (M&S)
Natural World Hypothesis ▸
Equations ▸ Algorithms ▸
Computing ▸ Data ▸ Analysis

AI & Machine Learning

Data ▸ Algorithms
▸ Computing ▸ Pattern Recognition

Big Data

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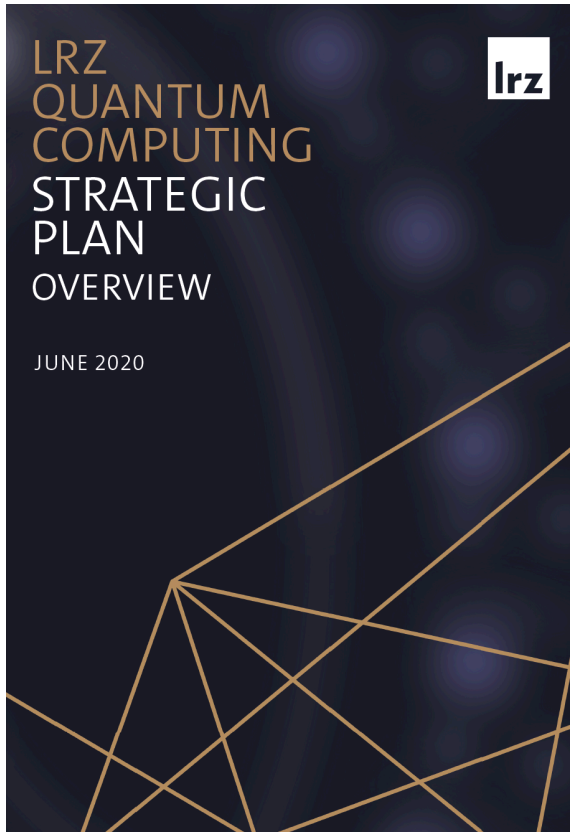
Quantum Computing

Big Data

The LRZ Approach to Quantum Computing



As a User Facility and Service Provider

- Access provider and access manager
- Research consulting and support
- Academic education and training

As a Supercomputing Centre

- System hosting and operation
- HPC-QC integration research
- Technologists training and certification

As part of the Bavarian Quantum Community

- Quantum ecosystem awareness through tech scouting
- User community analysis (surveys, focus/working groups)
- Community networking support

The LRZ Quantum Integration Centre addresses the needs highlighted in our strategic plan

The LRZ strategy in Quantum Computing

On-premise quantum systems

- DaQC project
- R&D
- Hosting systems in the Munich Quantum Valley framework

Practical Quantum Computing services

- Quantum Technology portfolio
- Remote access
- User workflow optimisation

Applied research

High-performance Quantum Computing

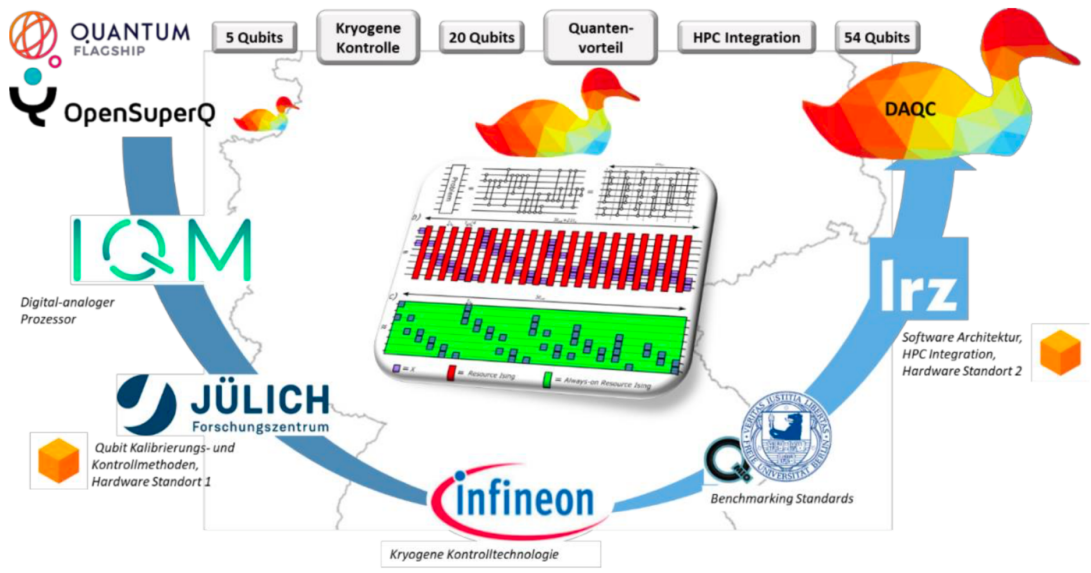
- The Atos QLM system at LRZ
- Software simulators on our HPC systems

Quantum user community and education

- The Bavarian Quantum Computing eXchange (BQCX)
- Alignment with the research community

Digital-analogue Quantum Computer (DAQC)

BMBF-funded project, 02/2021-01/2025



- Development of a test system up to 54 qubits, potentially scalable to $O(10^3)$
- Integration into the HPC environment
- Procurement of a cryostat and setup of lab space in preparation

HPC simulation tools for Quantum Computing

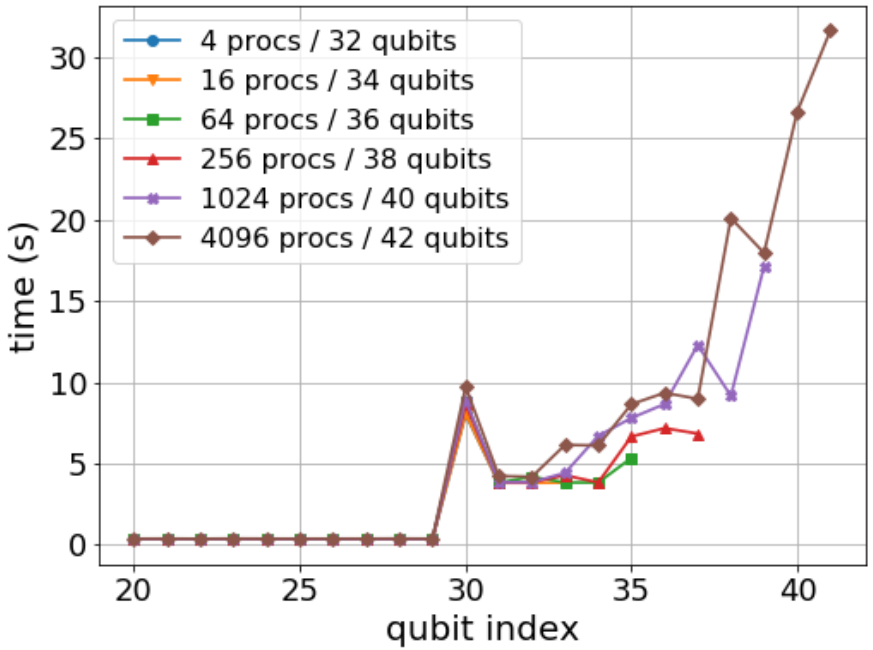
- Current quantum hardware still too experimental to enable reliable tests for algorithm development
- Simulation as asset for researchers to prepare applications for upcoming architectures
- Constraints on algorithm complexity and memory footprint make it an HPC challenge

- Hardware simulators: Special-purpose systems optimised for running quantum algorithms
- Software simulators: Applications for executing quantum algorithms on high-end traditional HPC system
- Software emulators: Applications for studying the behaviours of quantum hardware on a traditional HPC system

HPC simulation tools for Quantum Computing

The Intel® Quantum Simulator (Intel-QS) is a simulator of quantum circuits on HPC systems

- First runs and scaling on SuperMUC-NG
- Optimization and development project: Collaboration between LRZ and Intel
- Tutorials at ISC19 (Intel booth) and HPCS19 on Intel-QS, more planned at LRZ



Weak scaling of Intel-QS up to 2000 nodes on SuperMUC-NG.
Guerreschi et al., ArXiv: 2001.10554

The Atos Quantum Learning Machine (QLM) at LRZ

- Hardware simulator with a complete end-to-end software environment
- The software environment fully compatible with the most used development platforms (Qiskit, Cirq, Rigetti, ProjectQ) and can simulate noise on current quantum systems
- Preliminary work to make the system available to our users
- Press release and public announcement in March
- 2-day workshop with Atos for first wave of users on May, 4-5
- Development of synergies with other building blocks of our QC strategy

System arrived at LRZ

November 26, 2020

Quantum user community and education

The Bavarian Quantum Computing eXchange (BQCX)

Founded in July 2019

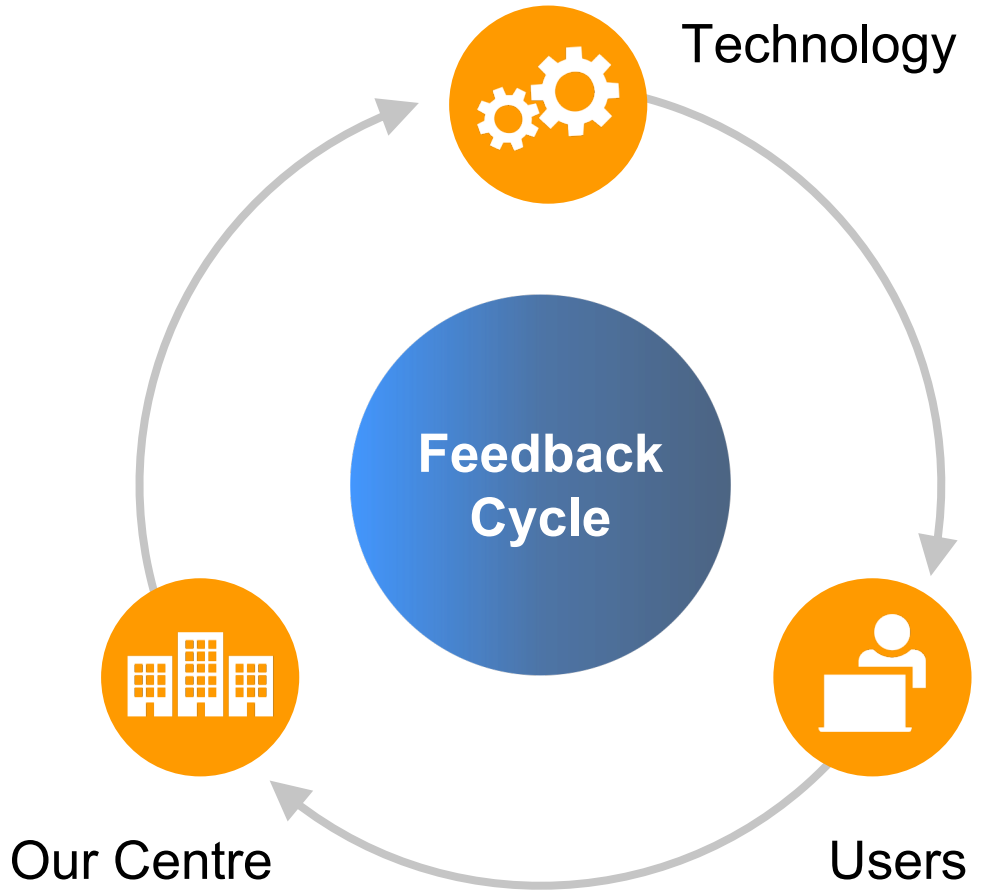
Bringing together and understanding the different community components

Provide a monthly forum for presentations of field experts and companies

Opportunity of visibility and networking for community members

Community alignment

- Survey of user needs (special focus: educators)
- Market surveys and tech scouting
- Focus groups
- Following / anticipating the user requests, within the LRZ role of science enabler
- Connecting with the ecosystem and its funding opportunities



Community involvement and research projects

- The **Munich Quantum Valley** is an alliance of the BadW, the FhG, the MPG, LMU and TUM to create a local unique centre for quantum science and technologies.
- The BMBF-funded **DAQC** project has been described earlier.
- The Bavarian Competence Centre for Quantum Security and Data Science (**BayQS**) is a project involving the FhG, LMU, TUM and LRZ.
- The PRACE-WP8 project **QuantEx** is a collaboration between ICHEC and LRZ for the development of a quantum simulator in Julia on novel HPC architectures.
- Finally, we are partnering with **Intel Labs** for a performance characterisation and development of the Intel Quantum Simulator.

Input for Q&A session

Which kind of quantum computing technology are you currently using?

Which kind of quantum computing technology would you like to use?

By your estimation, how large will your quantum resource needs be in the next 2-3 years?

What are your biggest challenges in using quantum computing?

What could make your user experience with quantum computing better?