

Distributed implementations of hybrid HPC and quantum computing: case NordlQuEst

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The integration of high-performance computing (HPC) resources with quantum computers (QC) is underway. The driving force is the need for accelerating discovery in a variety of fields of science, research, and innovation: sufficiently powerful computational modelling can aid in solving many of the grand-challenges facing society.

HPC and QC resources can either be co-located at the same premises, or geographically distributed [1]. Here, we consider the distributed approach, using the Nordic-Estonian Quantum Computing e-Infrastructure Quest (NordlQuEst) as an example. NordlQuEst is a collaboration between five countries supported by the Nordic e-Infrastructure Collaboration (NeIC) initiative [2]. In the project, several HPC resources are connected with several QC resources under a common platform. The main HPC platform is provided by the leadership class, pan-European LUMI pre-exascale supercomputer infrastructure, physically located in Finland [3]. In addition, the Norwegian eX3 experimental supercomputer testbed [4] provides classical resources. Initially, LUMI is integrated with the Chalmers/Wallenberg Centre for Quantum Computing (WACQT) QAL9000 quantum computer in Sweden, and the Finnish Quantum Computer (FQC), operated by VTT Technical Research Centre of Finland. The synergies of pooling both talent and hardware are discussed, and speculations on the future of HPC+QC are provided.

The importance of international collaboration for establishing best practices in an emerging field is underlined. In order to extract maximal utility from the quantum computers of the future, we need to set up the machinery for operating them well in advance. This includes enabling quantum software development by seeding the change of thought necessary for approaching a given problem from a completely new angle; one that is amenable to quantum computation.

[1] M.P. Johansson, E. Krishnasamy, N. Meyer, and C. Piechurski, “Quantum Computing – A European Perspective”, *PRACE Technical Report* (2021).

<https://doi.org/10.5281/zenodo.5547407>

[2] M. Johansson and G. Wendin, “The Quest for a Nordic Quantum Computing Ecosystem”, *ERCIM News* **128** (2022). <https://ercim-news.ercim.eu/en128/special/the-quest-for-a-nordic-quantum-computing-ecosystem>

[3] <https://www.lumi-supercomputer.eu/>

[4] <https://www.ex3.simula.no/>