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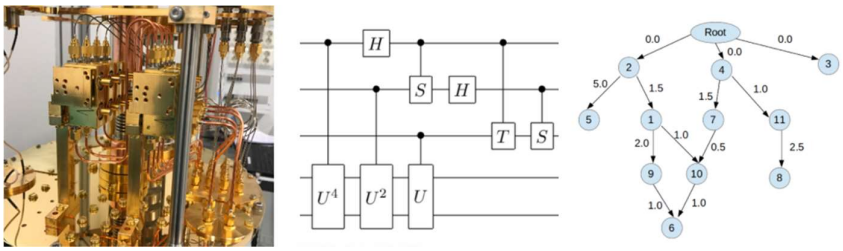
WACQT | Wallenberg Centre for Quantum Technology

Small quantum computers: Help understand their power by building a fast simulator



A quantum device cryostat, a quantum circuit example and a graph visualization.

Background

Quantum computing aims to harness quantum effects to gain speed-ups for a certain class of classically demanding calculations. The technological progress has reached the stage of so called Noisy Intermediate Scale Quantum devices. Simulators and a search for suitable practical applications play a significant part in this progress. However, PC simulators are demanding: the required computational state space grows exponentially with the number of qubits. And while there is in general no escape from this large state space, we can still build simulators which perform at least as fast as possible by analyzing the performance of suitable underlying data structures and operations on them.

Problem description

A research paper [1] has proposed and validated an approach to simulators based on decision diagrams: specifically, in the form of weighted-edge directed acyclic graphs (DAGs). This encoding is particularly beneficial for fast operations on quantum gates. For example, a tensor product of quantum gates, which is typically implemented as a form of matrix multiplication, reduces to a simple concatenation of these DAGs. However, much is left open: how does one implement the DAGs in the quantum simulation domain in the best way and with an eye for parallelization? Does the simulator still perform well when we add noise?

Workflow

In this project you will

1) Decide on an efficient implementation of DAG structures
2) Write your own implementation from scratch and add it to the software at QTL
3) Benchmark the performance of the simulator

Team size

3-6 students

Student background

E, F, TM, D, IT

Literature

[1] Zulehner et al., Advanced Simulation of Quantum Computations, 2019

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