Compilation and Circuit Cutting

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Circuit cutting can be used to decompose quantum circuits by cutting qubit wires [PHO+2020] or gates [MF+2021, PS+2023, UHS+2023]. However, the method suffers from an exponential sampling overhead in the number of gates or wires cut. If all gates connecting a given partitioning of the qubits are cut the quantum circuit can be executed on smaller quantum computers. However, if the cutting this is done in a naive way, the sampling overhead can explode, making the process highly inefficient.

In this thesis, the task is to investigate circuit and gate identities [IMM+2022, NRS+2018] to identify strategies to rewrite the circuits. The goal is to reduce the number of gates connecting the partitions or combine gates in a way to allow more efficient cutting, to minimize the overall sampling overhead.

References:

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Machine-Learning-Assisted Partitioning of Quantum Circuits for Circuit Cutting

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Quantum circuit cutting is a method to decompose quantum circuits by cutting qubit wires [PHO+2020] or gates [MF+2021, PS+2023, UHS+2023] into subsets of quantum circuits with a reduced number of qubits. Thereby, quantum circuit cutting enables both the reduction of hardware requirements for the execution of quantum algorithms, as well as specialized forms of distributed and parallelized quantum computing. It suffers, however, from an exponential sampling overhead in the number of gates or wires cut.

For practical use of quantum circuit cutting, it is therefore of utmost importance to partition the corresponding quantum circuits prior to cutting, such that the number of gates or wires connecting the partitions is minimized. Here, a partitioning refers to a grouping of the qubits involved in the quantum circuit. As machine learning (ML) methods have proven to be able to provide very efficient solutions to certain problems, here we want to leverage ML as a means to provide efficient and scalable solutions to this particular partitioning problem. We will partially rely on recent work [PER+2024, PMD+2024] that has used ML for distributed quantum computing.

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