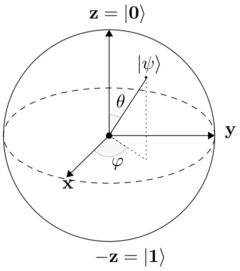
BACHELOR'S THESIS:
SoK: Quantum Memory Management and Optimal Quantum Circuits



Quantum computing uses quantum bits (qubits) that can exist in multiple states simultaneously, leveraging superposition and entanglement to perform complex calculations more efficiently than classical computers. Quantum circuits are the framework for quantum computation, consisting of qubits and quantum gates that manipulate their states, analogous to logic gates in classical circuits. Quantum gates are restricted to implement reversible operations due to the principles of quantum mechanics. In classical computing, many operations are irreversible, like the AND gate which loses information about its inputs. However, quantum operations must preserve information and be invertible. Consequently, quantum circuits are implemented via unitary operations (reversible transformations) to maintain the system's overall quantum state, complicating the design of quantum algorithms and limiting direct implementation of certain classical logic operations.

In 1989, Bennet [Bennett, 1989] showed that any Turing machine that runs in time T and space S can be simulated by a [...] reversible Turing machine in time $\mathcal{O}(T^{1+\epsilon}), \epsilon > 0$ and space $\mathcal{O}(T \log S)$. This allows to give *some* upper bound on the quantum-overhead, and raises the question what the *optimal* or *lowest* quantum-overhead might be.

Topics to cover

- SoK: Review past literature and tools on quantum circuit optimization
- Identify useful metrics
- Extend existing methods (for example Pebbling Games [Meuli et al., 2019]) to find *optimal* solutions

How to reach us?

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It is recommended to have heard the lecture "2400073 — Introduction to Quantum-Computing" and/or have a strong background on linear algebra.

References

[Bennett, 1989] Bennett, C. H. (1989). Time/space trade-offs for reversible computation. *SIAM Journal on Computing*, 18(4):766–776.

[Meuli et al., 2019] Meuli, G., Soeken, M., Roetteler, M., Bjorner, N., and Micheli, G. D. (2019). Reversible pebbling game for quantum memory management.