Abstract

This thesis work discusses the design, realization, characterization and operation of a two-qubit processor implemented using capacitively coupled tunable superconducting qubits of the Transmon type. Each qubit can be manipulated and read out individually using a non-destructive single-shot readout. In addition, a universal-two qubit gate can be implemented using the interaction between the qubits.

The processor implements therefore all basic building blocks of a universal two-qubit quantum processor. Using it, we implement the universal $\sqrt{i}$*SWAP two-qubit quantum gate. We characterize the gate operation* by quantum process tomography and obtain a gate fidelity of 90 %. We use this gate to create entangled two-qubit Bell states and perform a test of the CHSH Bell inequality, observing a violation of the classical boundary by 22 standard deviations after correcting for readout errors.

Using the implemented two-qubit gate, we run the so-called Grover search algorithm: For two-qubits, this algorithm finds among four elements **x** $\in$ ***{00, 01, 10, 11}*** *the one* element ***y*** *that solves a search problem encoded by a function* **f** *for which* ***f(y) = 1*** and ***f(x*** $\neq$ ***y) = 0***. *Our implementation obtains the correct answer to the search* problem after a single evaluation of the search function ***f(x)*** *with a success probability* between **52 %** and **67 %**, therefore outperforming classical algorithms that are bound to a success probability of **25 %**. This constitutes hence a proof-of-concept of the quantum speed-up for superconducting quantum processors.

Finally, we propose a scalable architecture for a superconducting quantum processor that can potentially overcome the scalability issues faced by today's superconducting qubit architectures.

2012 Demonstrating Quantum Speed-Up With a Two-Transmon Processor A. Dewes

Demonstrating Quantum Speed-Up with a Two-Transmon Quantum Processor

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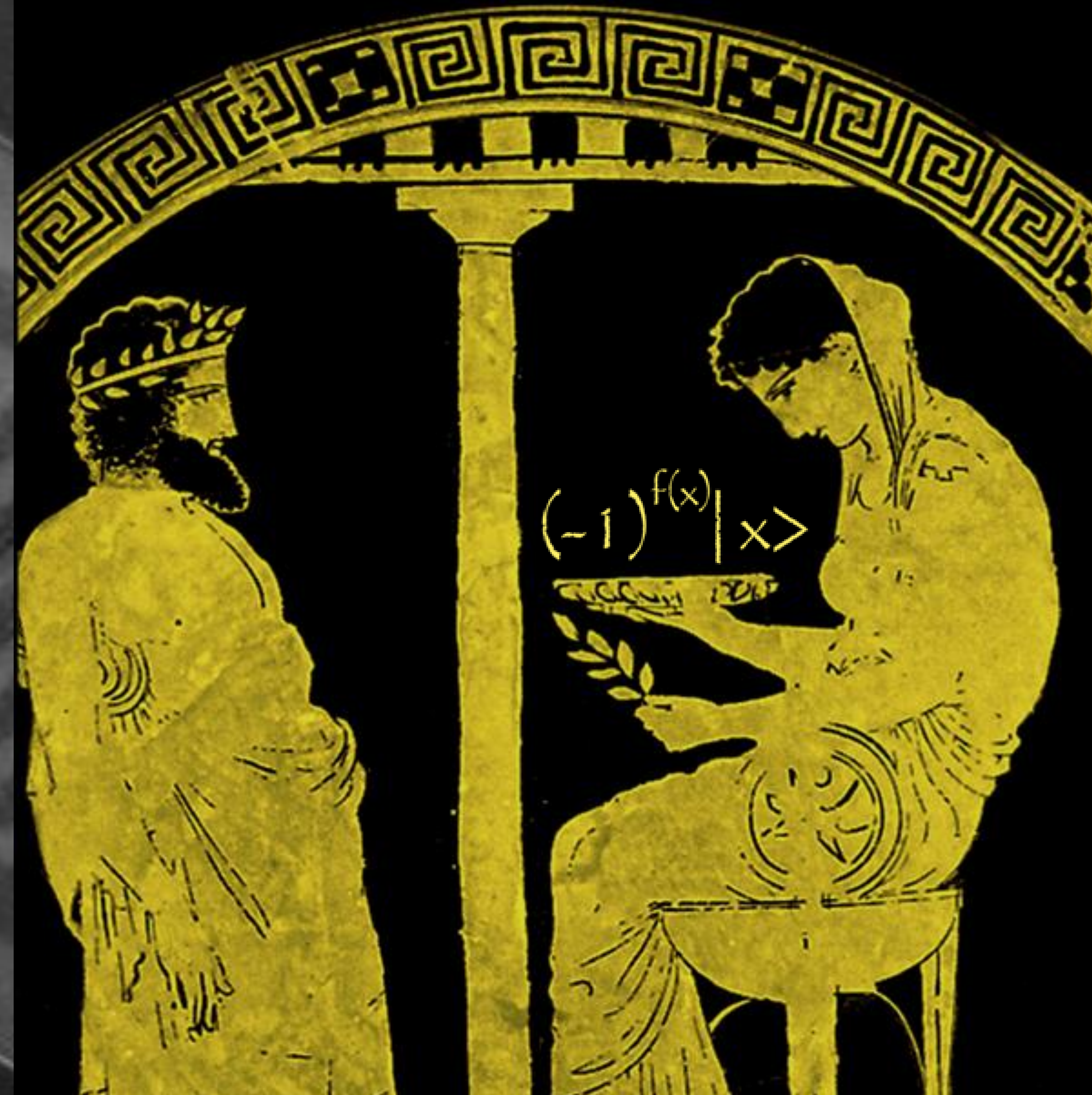

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