Benchmarking a Neutral-Atom Quantum Computer

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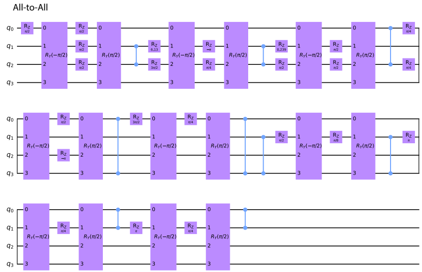
April 2023

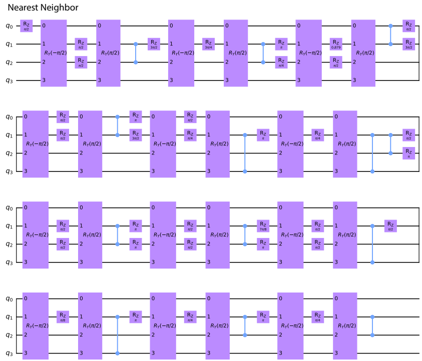
Neutral-Atom Quantum Computing

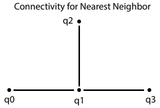
- We use light-matter interactions to rotate and entangle qubits
- Can implement universal gate set of global R_x and R_y gates, local R_z gates, and C_z gates
- R_z gates are implemented with local Stark shifts
- Global R_x and R_y are driven by Rabi oscillation
- Qubits are entangled with Rydberg blockage

Motivation

- Using Rydberg blockage, distant qubits can be entangled easier
- Leads to significant reduction in circuit depth

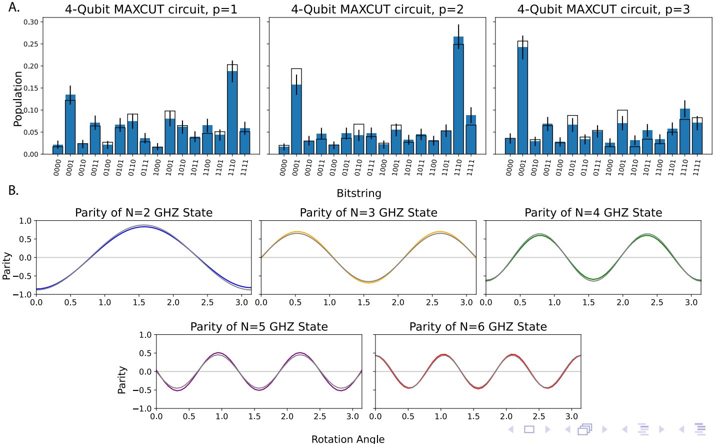






Methods

- Trained noise model trained on previous data
- Average of 99% fidelity between simulated and experimental data of MAXCUT circuits
- Standard deviation of 3.3% between GHZ simulated and experimental fidelities

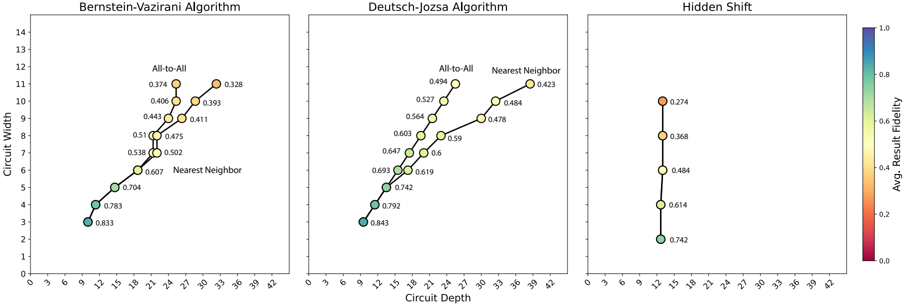


Methods

- Global R_x and R_y gates have $> 99\%$ fidelity on average
- Local R_z gates have 98.4% fidelity on average
- C_z gate is most noisy, with average gate fidelity of 96.9%
- Rydberg blockage excites a state out of the computational basis, so qubits in $|1\rangle$ state have chance of being irreversibly decoherent
- Qubit has $\sim 3\%$ chance of being lost
- Qubits decohere in longer circuits, with $T_2^* = 3.5\text{ms}$
- T_2^* is on order of ~ 100 gates

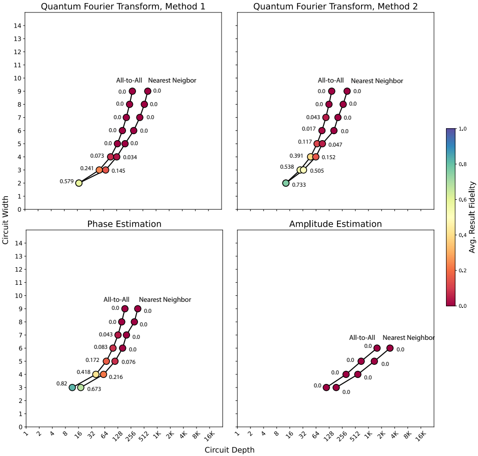
Results

- Bernstein-Vazirani and Deutsch-Jozsa circuits with 5 qubits or less retain $> 70\%$ fidelity
- Hidden Shift circuits with 4 qubits or less retain $> 60\%$ fidelity
- All-to-all connectivity improves fidelity by 3.2% on Bernstein-Vazirani circuits and 5.2% on Deutsch-Jozsa circuits with 7-11 qubits on average



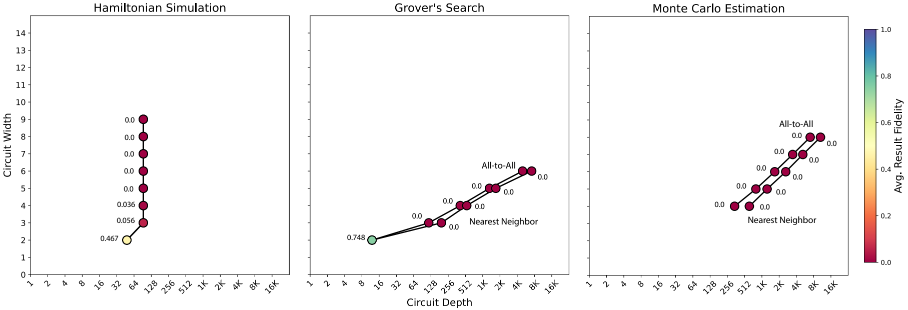
Results

- All-to-all connectivity increases fidelity of 3-5 qubit phase estimation circuits by 14.8% on average
- Increase of 11.4% fidelity on quantum Fourier transform circuits with 3-5 qubits



Results

- Simulation returned low fidelity on most application-focused circuits in the benchmark



Acknowledgements

I would like to acknowledge principal investigator Prof. Mark Saffman and my co-authors Dr. Trent Graham and Cody Poole for supporting my research.