Investigating Crosstalk Errors in Quantum Circuits: A Qiskit Framework Study

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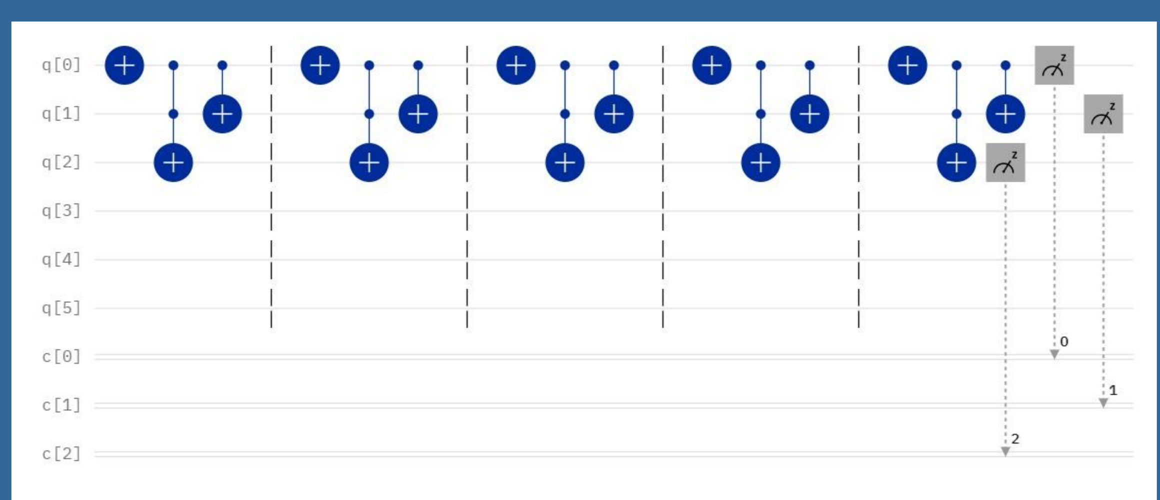
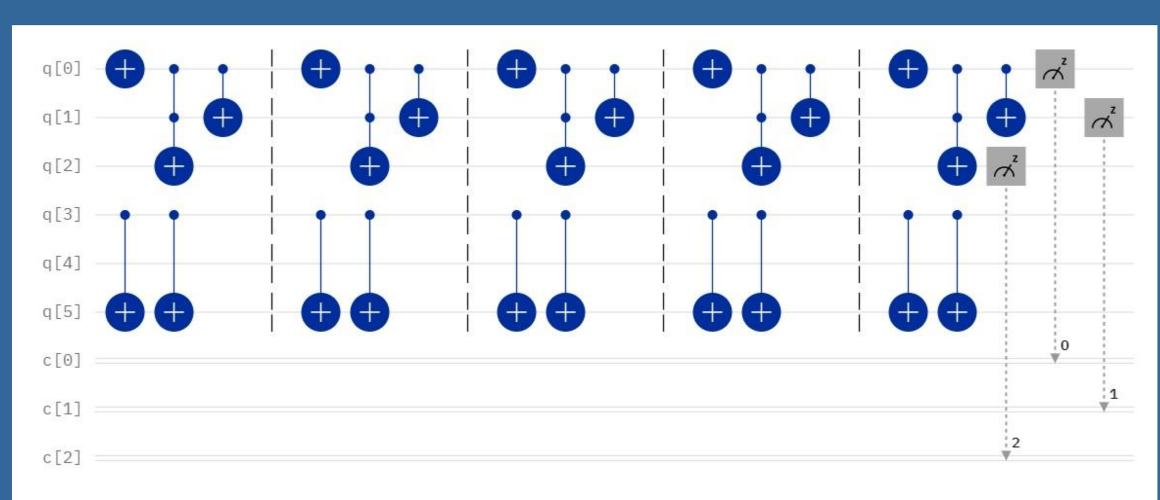
Introduction

- Using IBM Quantum Lab, investigate crosstalk errors in a 5-qubit quantum computer (IBM Lagos).
- The objective of this experiment is to reproduce it and investigate the impact of crosstalk error rates with one error type on quantum circuit outcomes.
- The goal is to emphasize the significance of crosstalk reduction methods in quantum computing systems.





Method

- Build Circuits: we used the IBM Qiskit framework to build quantum circuits.
- The non-crosstalk model is represented by crosstalk-free circuits.
- Qubits in the circuits were correctly mapped to apply the non-crosstalk concept.
- Crosstalk Model: To simulate crosstalk issues, a crosstalk model was introduced. duplicated the same circuits, but this time, to account for the crosstalk model, added two CNOT gates.
- Interactions between qubits are represented by the additional CNOT gates.
- Comparative Analysis: The circuit results for the crosstalk and non-crosstalk models were compared.
- Observed the effects of crosstalk faults on the performance and behavior of quantum circuits.
- Before starting the circuits, we made an estimation of the measurement result.
- In the context of quantum computing, "count" refers to the process of obtaining multiple different outputs from a quantum circuit and then tallying the number of times the correct answer is observed, reflecting the probabilistic nature of quantum measurements.

Results

On IBM Lagos (Real Quantum Computer):

- Ten jobs were sent with crosstalk and non-crosstalk problems.
- Due to a long line, the findings took around two days to arrive.
- The average number of counts obtained was 0.5615 for non-crosstalk and 0.581 for crosstalk.
- There is no discernible difference in crosstalk and non-crosstalk counts.
- Crosstalk counts were unexpectedly higher than non-crosstalk counts.
- IBM's optimization strategy for executing quantum circuits avoided potential sources of crosstalk, resulting in similar outcomes in both cases.

On fakeLagosV2 (Simulator):

- On the IBM quantum computer, simulations were run to preview the findings.
- Counts obtained on average: 0.646 for crosstalk and 0.655 for non-crosstalk.
- There is a minor difference between crosstalk and non-crosstalk numbers.
- In contrast to the real quantum computer, the simulator had more non-crosstalk counts than crosstalk counts.
- Because of the decreased noise in the simulator, simulated findings beat real quantum computer results.

Conclusion

Due to IBM's successful gate optimizations, which reduced probable causes of crosstalk, the experiment on IBM Lagos, a real quantum computer, revealed no significant difference between crosstalk and non-crosstalk findings. The simulator, fakeLagosV2, on the other hand, surpassed the real quantum computer findings due to reduced noise levels, showing the relevance of noise reduction in attaining more accurate quantum computing outputs.

Reference

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