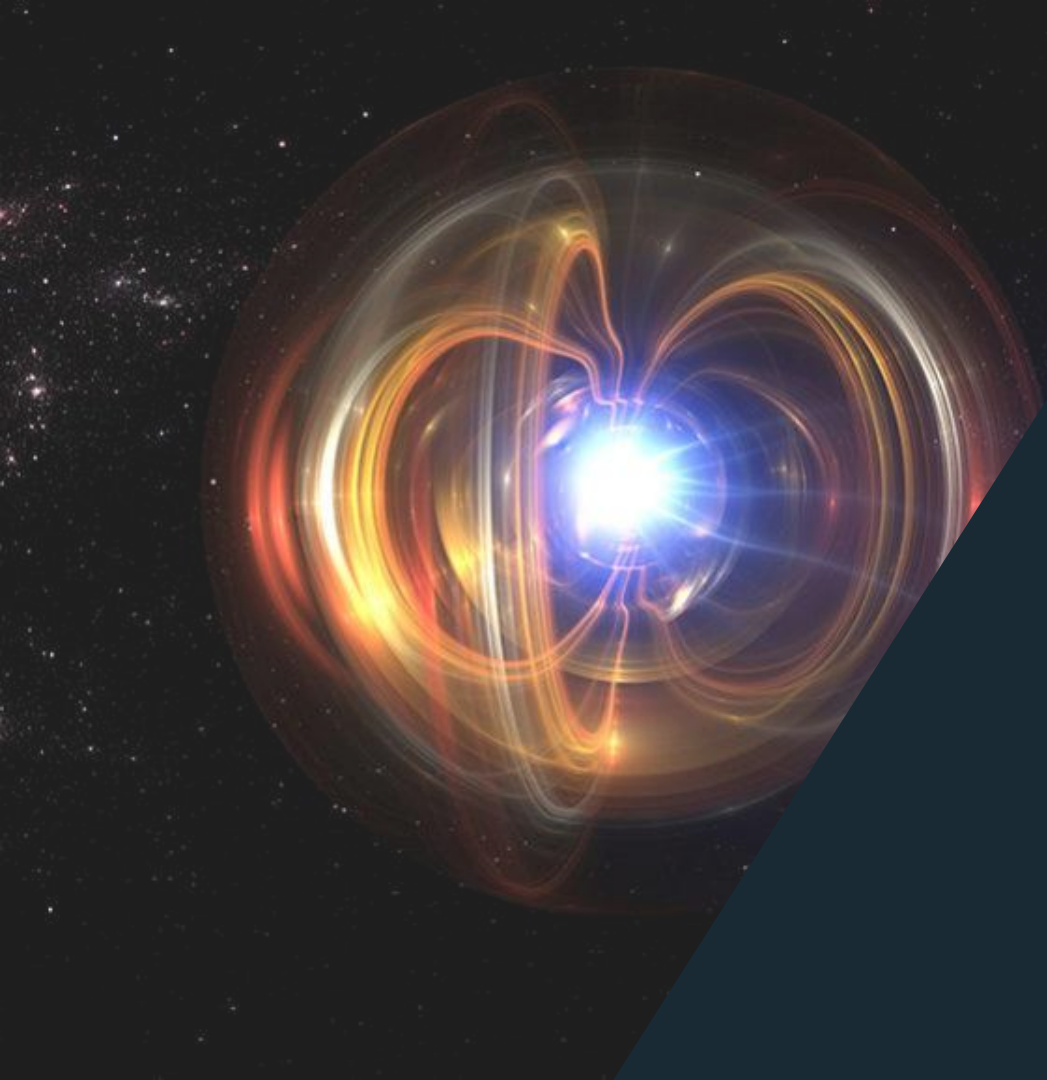


Explore Quantum Teleportation Algorithms with Cloud-based Quantum Computers

Computer Science Capstone with
Professor Marin and Professor Byrnes

Xinyao Han | Yile Xu

PROBLEM STATEMENT

QUANTUM COMPUTING

- Quantum superposition and entanglement.
- Drastically increase computation speed

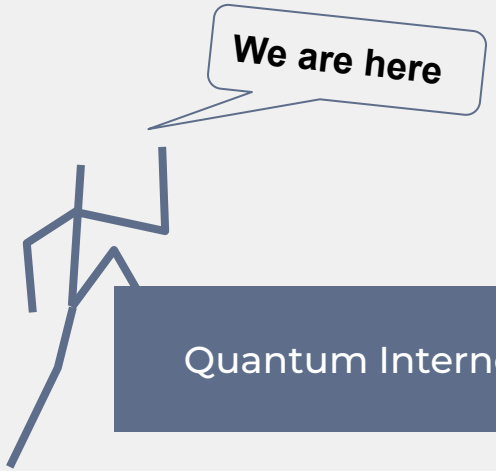
QUANTUM TELEPORTATION

- Quantum state change of two distant entities.
- Transmits long distance information
- Enable **Quantum Internet**

DISTRIBUTED SYSTEM PROBLEMS

- Network

PROJECT POSITIONING



Quantum Internet

Analyze the Feasibility of Quantum Internet on Distributed System Problems

Quantum Teleportation

Implement Quantum Teleportation on Single Cloud Quantum Computer

RELATED WORK I

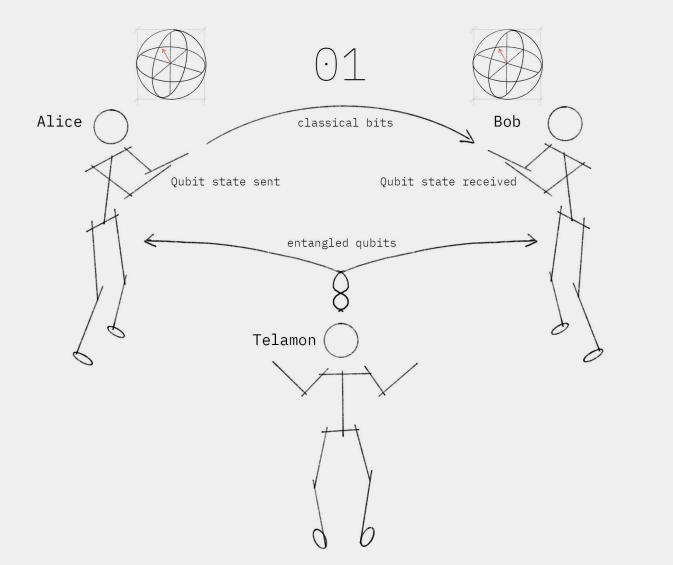
FUNDAMENTAL NETWORK PROBLEMS

- Lower Bonds
- Graph Optimization, Verification Problem

DOES NOT HELP

RELATED WORK II

SUPERLUMINAL TRANSMISSION

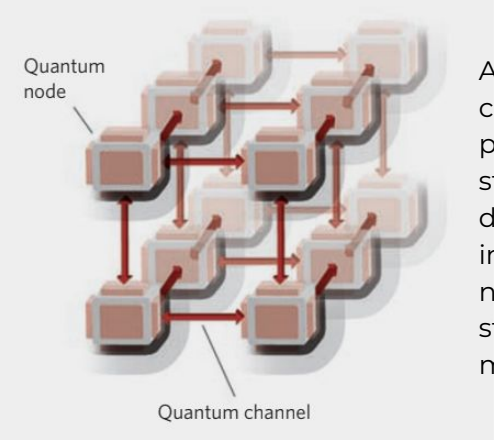


The Quantum Teleportation Protocol

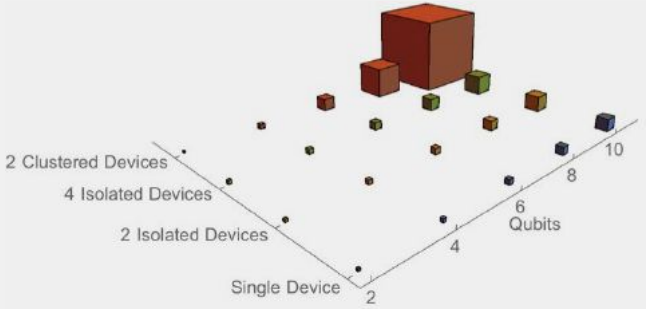
> Quantum teleportation cannot be achieved super-luminally as the transmission of the classical message through the medium is limited to traveling at the speed of light

RELATED WORK III

DISTRIBUTED COMPUTATION POWER

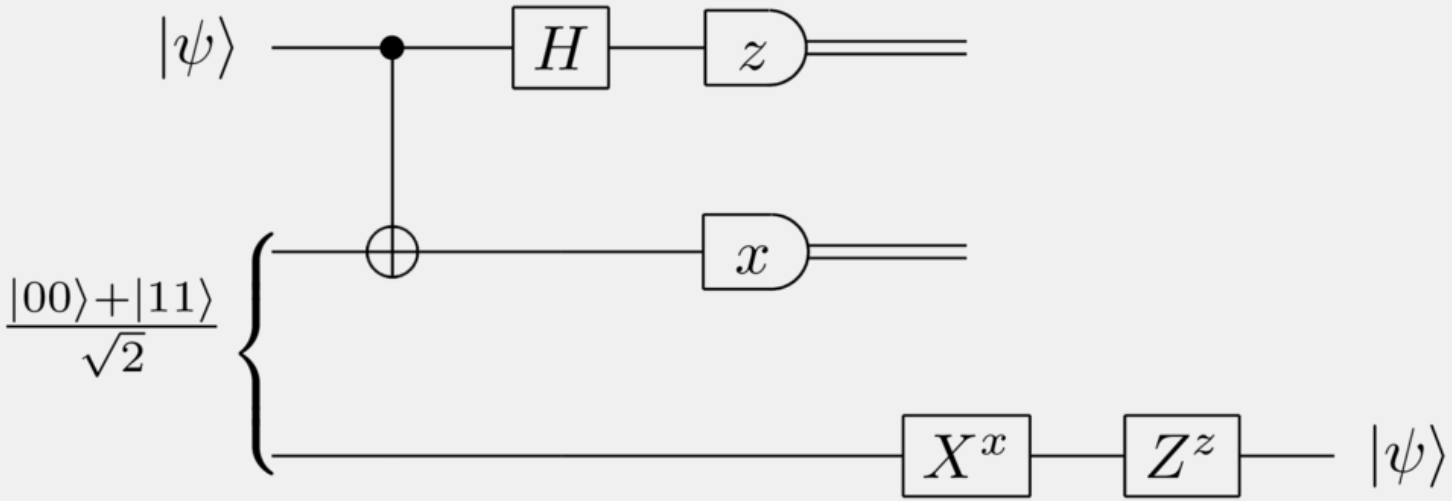


A notional quantum network composed of quantum nodes for processing and storing quantum states and quantum channels for distributing quantum information. Alternatively, such a network can be viewed as a strongly correlated many-particle system.



Quantum cloud computing speed-up: The volume of the cube represents the computation power.

QUANTUM TELEPORTATION



Circuit diagram for the quantum teleportation algorithm.

EVAL METHOD - FIDELITY

$$F(\rho, \sigma) = \left(\operatorname{tr} \sqrt{\sqrt{\rho}\sigma\sqrt{\rho}} \right)^2$$

for density operators

FIDELITY OF QUANTUM STATES

- Density operators represent quantum states
- A measure of the "closeness" of two quantum states

SOLUTION

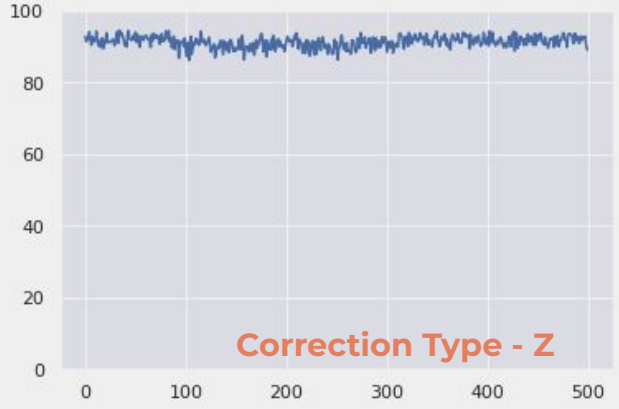
FIDELITY MEASURE

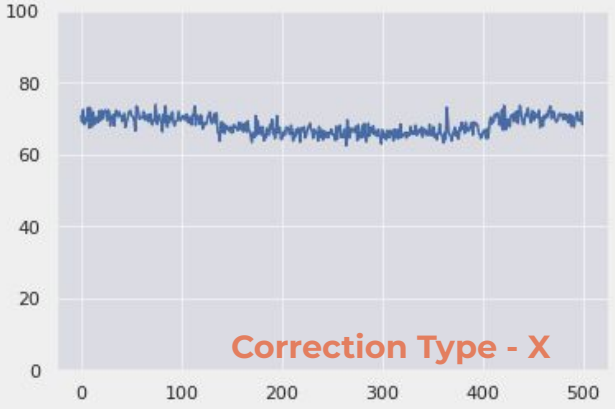
Perform a rotation on the basis of the state that is teleported and find if the teleported state after state preparation is reversed to be |0>

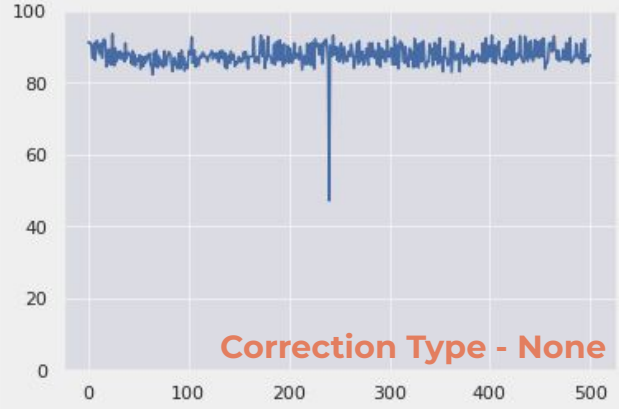
4 CORRECTION TYPES

Implement different versions of circuits to ensure all the corrections are applied properly. Calculate the mean and the std, plotted the fidelity of all these circuits separately.

RESULTS AND DISCUSSION







CONTRIBUTION AND FUTURE WORK

CONTRIBUTION

- We benchmark the performance of the IBM quantum processor using on-chip quantum teleportation with post selection.
- We build 3 qubits quantum teleportation algorithms on IBM quantum processor with our own state preparation and applied 4 different corrections.
- We simulate the performance of quantum teleportation using simulator and implement teleportation on quantum computer.
- We systematically test the performance using fidelity and analyze the results.

FUTURE WORK

- Generalized version of circuits
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