Contribution ID: **23** Type: **not specified**

Optimizing Quantum Network Performance: Performance Evaluation of Quantum Dijkstra's Algorithm

Quantum communication methods are highly sensitive to variations in protocol parameters, which can affect their effectiveness. This study explores the performance of quantum communication protocols using online quantum computing platforms such as Quirk, Qiskit-IBM-Q, Rigetti Forest, and D-Wave. Despite the promising advancements over classical teleportation, many protocols fall short of their anticipated benefits. We propose a routing scheme to enhance fidelity in quantum networks by focusing on positive quantum channel capacity. The proposed Channel Selection (CS) algorithm, combined with the K-shortest path technique, is designed to optimize fidelity rates for source-destination pairs. This paper presents a detailed implementation of Quantum Dijkstra's Algorithm within a quantum circuit model, utilizing quantum gates and the IBM Qiskit framework to find the shortest path in a graph. We assess various quantum error channels, such as amplitude damping, phase flips, and bit-flip errors, to identify optimal quantum error correction methods. Through performance analyses, we evaluate the impact of noise levels, channel capacities, and the number of source-destination pairs on throughput, fidelity, and memory utilization. Our results demonstrate that the CS algorithm outperforms traditional methods like Q-PATH and Greedy by maintaining higher fidelity and throughput, optimizing memory usage, and effectively managing noise. This study highlights the advantages of the CS algorithm in enhancing quantum communication networks and its potential for practical implementation in noisy environments.

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