DESIGN AND IMPLEMENTATION OF MODERN QUANTUM REPEATERS FOR FUTURE QUANTUM COMMUNICATION TECHNOLOGY AND TELEPORTATION

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Extended Abstract

Introduction

Quantum communication is a new technological paradigm driving the future of information transmission and communication technologies (Bennett et al., 1993). Founded on concepts in fundamental quantum mechanics and applied optics, it has inspired applications such as quantum repeaters that are an integral element in the construction of large-scale quantum networks that build the foundation for a global quantum internet (Gisin & Threw, 2007; Briegel et al., 1998).

The quantum repeater protocol involves a large-scale quantum channel that will get fragmented into multiple small segments (Briegel et al., 1998). The quantum repeaters from each part then distribute entangled states between adjacent nodes. In performing entanglement switching down the chain, the sender and receiver stations get entangled, forming a full large-scale quantum link (Ruihong & Ying, 2019).

This research examines the components and protocols used in a quantum repeater. Numerous components and protocols go into making a fully functioning quantum repeater that can be deployed in the real world away from experimental labs (Gisin & Threw, 2010). That will necessitate a performance analysis based on the various applied protocols. A key protocol of interest for near-term quantum repeaters is entanglement purification. It is essential to ensure entangled states maintain high fidelity throughout the quantum channel.

Results and Discussion

We expect to see in the results improved performance based on the fidelities of the entangled pairs and larger bandwidth with increasing optimisation of the quantum circuit. We anticipate that the results from the simulation will help answer questions regarding the best choice of purification strategy. The results will also address whether the choice of purification protocol affects the impact of the optimisation scheme.

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Methodology

A convenient approach to understanding the quantum repeater infrastructure is emulating it on simulation platforms such as NetSquid and currently available quantum computers such as those from IBM. The environment exposed to superconducting qubits in the IBM quantum computers can ideally emulate the same environment quantum repeaters will be exposed to when in real-world operation (Das et al., 2021).

This research takes a computational approach - involving coding and quantum circuit implementation. Each execution stage and protocol of the quantum repeater gets translated into a modular quantum circuit that can get independently executed on a simulation platform such as IBM Qiskit and NetSquid. The modularity of the code will help test out different purification strategies and protocols for better analysis.

Performance analysis will get done based on the fidelity of the purified Bell pair, the bandwidth of the channel and the stability of the quantum repeater (Krastanov et al., 2019). Optimisation schemes will be applied to the entanglement purification circuits to analyse their performance. Attention will get paid to the limitation imposed by working with finite resources.

Conclusion

This research presents an understanding of the implementation, execution and working of quantum repeaters and all their corresponding protocols, particularly the purification protocols and their optimisation schemes. The results from this implementation should provide a mirror for future approaches to implementing quantum repeaters and challenges existing and those bound to arise.

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