Integrated Quantum Repeater Network System Using Both E2E and HBH Teleportations

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1. Introduction

In quantum repeater networks, a qubit made out of a quantum system such as a quantum computer can be transferred from one network node to another one by a process called quantum teleportation if the two nodes are entangled. In this paper, to reduce the qubit transmission delay, we propose an integrated quantum repeater network system that utilizes both an end-to-end (E2E) teleportation [1] and hop-by-hop (HBH) teleportations. We investigate the proposed system with simulation.

2. Problem with the E2E Teleportation Method

In typical quantum repeater networks utilizing the E2E teleportation, a source node can teleport a qubit to a destination one by an E2E quantum entanglement shared between the nodes located far away from each other. Such an E2E entanglement is generated by an entanglement swapping performing a bell measurement in every transit node on the route between the source and destination nodes. The bell measurement is also required for the quantum teleportation, and hence, the E2E method needs to maintain multiple quantum entanglements for a long time. This will increase the qubit transmission delay in the quantum repeater network.

3. Proposed Network System

In our proposed system, an HBH teleportations method without an entanglement swapping is utilized to reduce the qubit transmission delay together with the E2E teleportation. Here, we include a destination node as a hop, and thus, the teleportation between adjacent nodes is called one-hop teleportation. As shown in Fig. 1, how to use quantum entanglements is different for the HBH and E2E teleportations. In the case of the HBH transmissions, a qubit is transferred from the node 1 to 2 and stored at the quantum memory. Thereafter, the qubit is transferred from the node 2 to 3. If an E2E entanglement is already available between the node 1 and 3, the two-hops teleportation is preferentially performed through the E2E teleportation.

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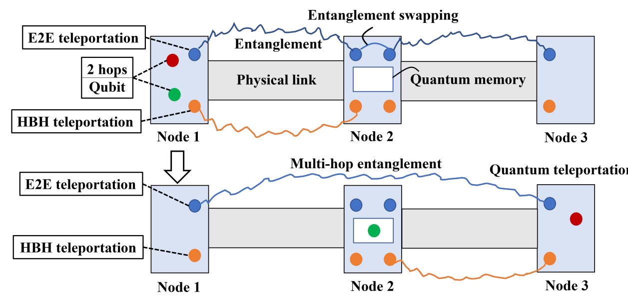

Fig. 1 Proposed integrated quantum network system.

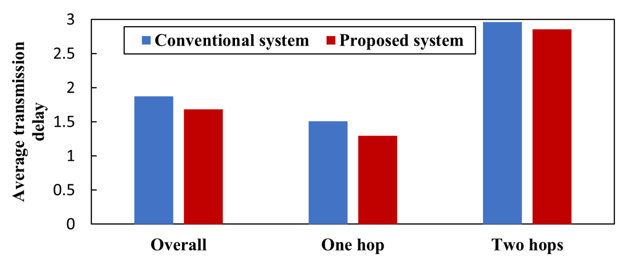

Fig. 2 Proposed integrated quantum network system.

4. Numerical Examples

Figure 2 shows the simulation results of our proposed system in terms of average qubit transmission delay, compared to a conventional system where only E2E teleportation is used. In this evaluation, the entanglement generation time and the swapping time were set to 0.5 and 0.7, respectively. The quantum teleportation time was 0.5 and 1.0 for one-hop and two-hops, respectively. Requests for two-hops qubit transmission arrived at node 1 based on a Poisson process with a rate of 0.325, and one-hop requests arrived at the nodes 1 and 2 with rates of 0.325 and 0.65, respectively. From this figure, we find that our proposed system reduced the average transmission time. This is because our proposed system utilizes quantum entanglement resources effectively.

5. Conclusion

In this paper, we proposed an integrated quantum repeater network system. Simulation results showed that the proposed system can reduce the qubit transmission delay.

References

[1] R.V. Meter, "Quantum Networking and Internetworking," *IEEE Network*, vol. 26, no. 4, pp. 59–64, July/Aug. 2012.