Senior Design Quantum Research paper outline

Abstract

Quantum information systems have emerged as a promising avenue for revolutionizing information processing, offering unparalleled capabilities in terms of data transmission and computation. This paper presents a design framework for a Quantum Information System (QIS) that leverages the concept of a quantum router to enhance the efficiency, security, and scalability of quantum networks. Our proposed quantum router-based QIS architecture addresses the fundamental challenges of quantum communication, quantum computing, and quantum cryptography. We introduce a theoretical model for a quantum router, describe its operating principles, and discuss its potential applications within the context of quantum information processing.

Key contributions of this research include a detailed exploration of the quantum router's ability to efficiently route quantum information based on quantum entanglement and superposition. We demonstrate how this quantum router can facilitate quantum key distribution, quantum teleportation, and quantum gate operations, thereby enabling the seamless integration of quantum devices into a quantum network. Furthermore, our design takes into account the physical requirements of a quantum router, including hardware implementations and the associated technological advancements that will be necessary for its practical realization.

Purpose

Through Iowa State University’s Ames lab, Dr. Durga and Dr. Smith are researchers studying quantum infomration systems. As researchers they need to be able to run numerous quantum algorithms many times over. As one could imagine, hosting numerous quantum computers can be expensive as well as a logistical hassle. For these reasons, we were tasked by them to create a solution to this issue.

Our design is created as a research platform for Quantum inforamtion researchers to be able to run quantum algorithms through a number of quantum computers at the same time and with ease. Because of this, our system needs to be roubust enough to handle any quantum algorithm and also be able to host as many quantum computer nodes as the client needs.

Quantum network

Classical network

Our classical network is a critical part of our design as our quantum information network will require classical information to control the quantum information and starting instructions to the quantum nodes. For our design we used TCP IP sockets as they will allow us to have ample room for us to send instructions and commands between the router and nodes as well as having its own error correction already implemented.

A diagram of a machine

Description automatically generated

Requirements and constraints

Our network must be considered as a physical aspect of the quantum. When we run our simulation, although we don’t use actual quantum bits unless we’re purchasing computation resources from IBM, we should consider the nature of quantum such as quantum entanglement restriction such as distance, since our design must have a simulated quantum network for cluster computing which reflects limitations as much as possible. Also, our network must be available to work as cluster computing, not just for simple communication between different nodes. Although the degree of decentralization can be changed due to the property of our project, it must be working as a network for cluster computing.

As well as functioning, our network must be cost-effective, as using too many Q bits means higher costs for our clients to run our network on IBM quantum computers. Our design goal is to save their research funding as much as possible related quantum networks to fabricate actual quantum nodes.

As our design is originally created for research, our network must be easy to implement when our researchers have all requirements to run our network such as quantum computers for running simulations to make them available to keep focus on Quantum information research.