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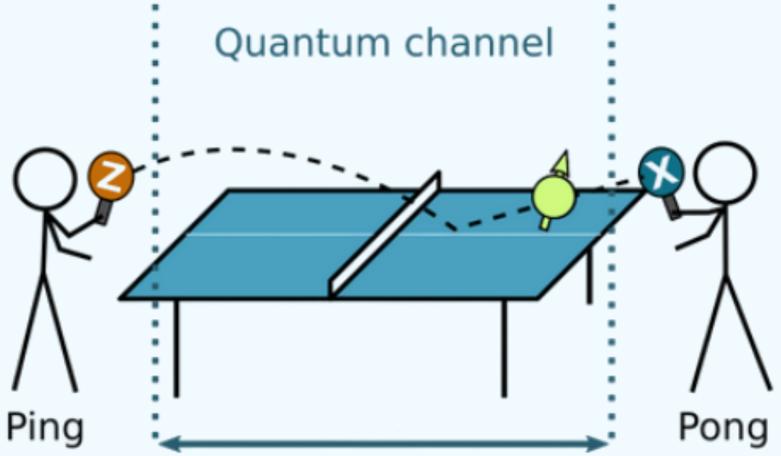
Institute of Digital Technology

Quantum Secure Direct Communication

Ping-Pong Protocol Simulator



Group 4: Quantum Cryptography

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Our team

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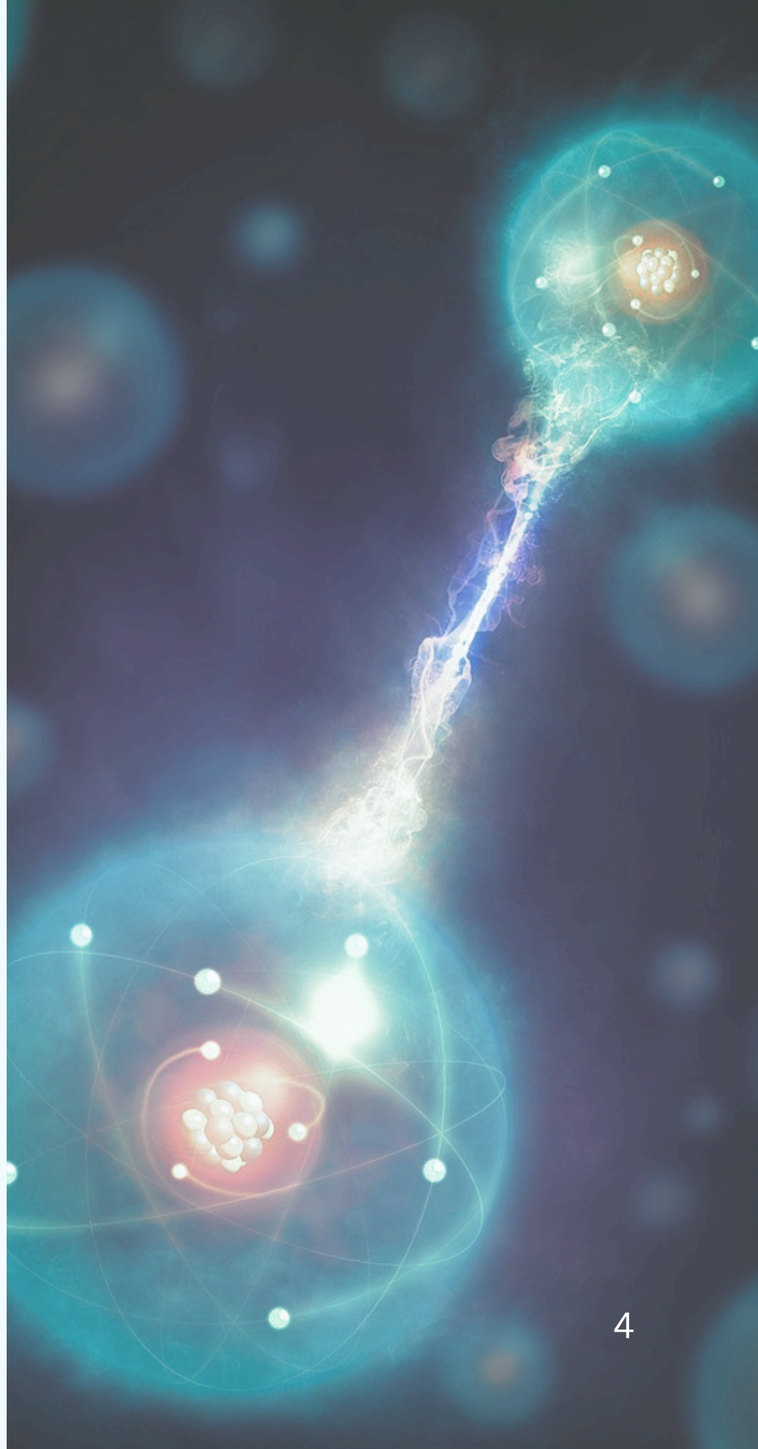
Introduction

WHY QUANTUM SECURE DIRECT COMMUNICATION?

Every day, our data is **protected by classical encryption** that powerful quantum computers may eventually break. **Quantum Secure Direct Communication (QSDC)** instead uses **quantum effects** like entanglement and measurement disturbance so that any eavesdropper leaves detectable traces.

In this project, we build a **simple web demo** of the **QSDC ping-pong protocol** to show how a quantum channel can send a secret message and reveal Eve, focusing on clear visuals rather than heavy mathematics



Problem Statement

Classical Encryption at risk: Messages are protected by mathematical encryption; with enough computing power (or future quantum computers), these ciphers can be attacked and eventually broken.

Unclear Data Security in practice: It is difficult to see how quantum protocols actually protect messages and detect eavesdropping.

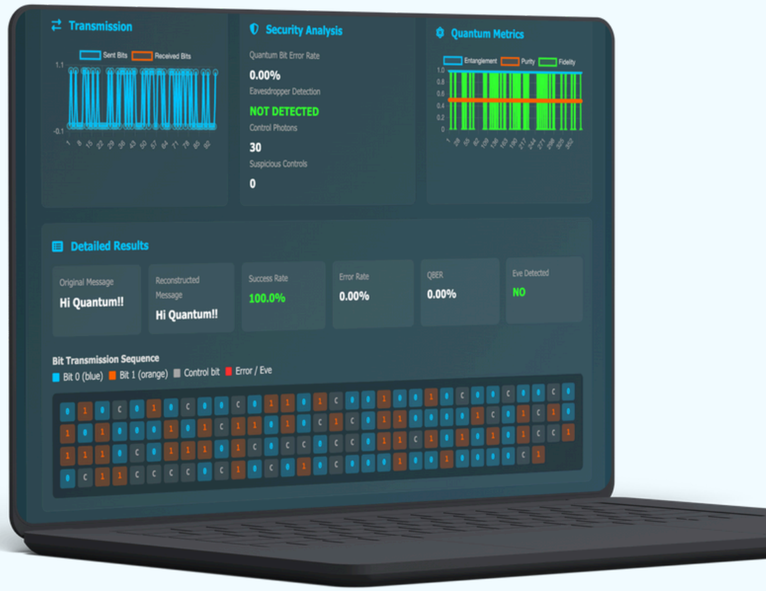
Learning/visualization gap: There is a lack of intuitive, interactive demos for learning QSDC, so students rarely see how protocols like ping-pong actually work in practice.

Objectives

1. **Highlight encryption vulnerabilities:** Show how classical encryption may become insecure with advanced quantum computers, emphasizing the need for new secure communication methods.

2. **Demonstrate secure and clear quantum communication:** Show how QSDC protocols transmit confidential messages while simplifying complex concepts like the Ping-Pong protocol.

3. **Build an interactive demo:** Implement a web-based simulator where users can adjust parameters (message, noise, presence of Eve) and observe the protocol behaviour step by step.



Literature Review

EVOLUTION OF QSDC

Aspect	Key idea	Brief explanation with source
First QSDC protocol (2000)	Entangled EPR blocks	Long and Liu proposed the first QSDC scheme using blocks of entangled EPR pairs and multi-step transmission so the channel is checked for eavesdropping before revealing any useful information [2].
Expansion of protocol families	From entangled blocks to single-photon, GHZ	Later work introduced protocols based on different entangled resources (Bell, GHZ) and single-photon transmission, which broadened QSDC from a single scheme into a family of protocols [2], [3].
Practicality improvements	Memory-free and Continuous-variable QSDC	Surveys describe stages of development: entanglement-based two-step schemes, single-photon and memory-free designs that avoid long-lived quantum storage, and continuous-variable QSDC where information is encoded in field quadratures [2], [3].

Literature Review

QSDC AND PROTOCOL CONCEPT

QSDC Idea

Send the message itself using quantum states, not just a key.

Roles

Bob (sender/decoder), Alice (encoder), Eve (eavesdropper).

Ping-Pong Protocol

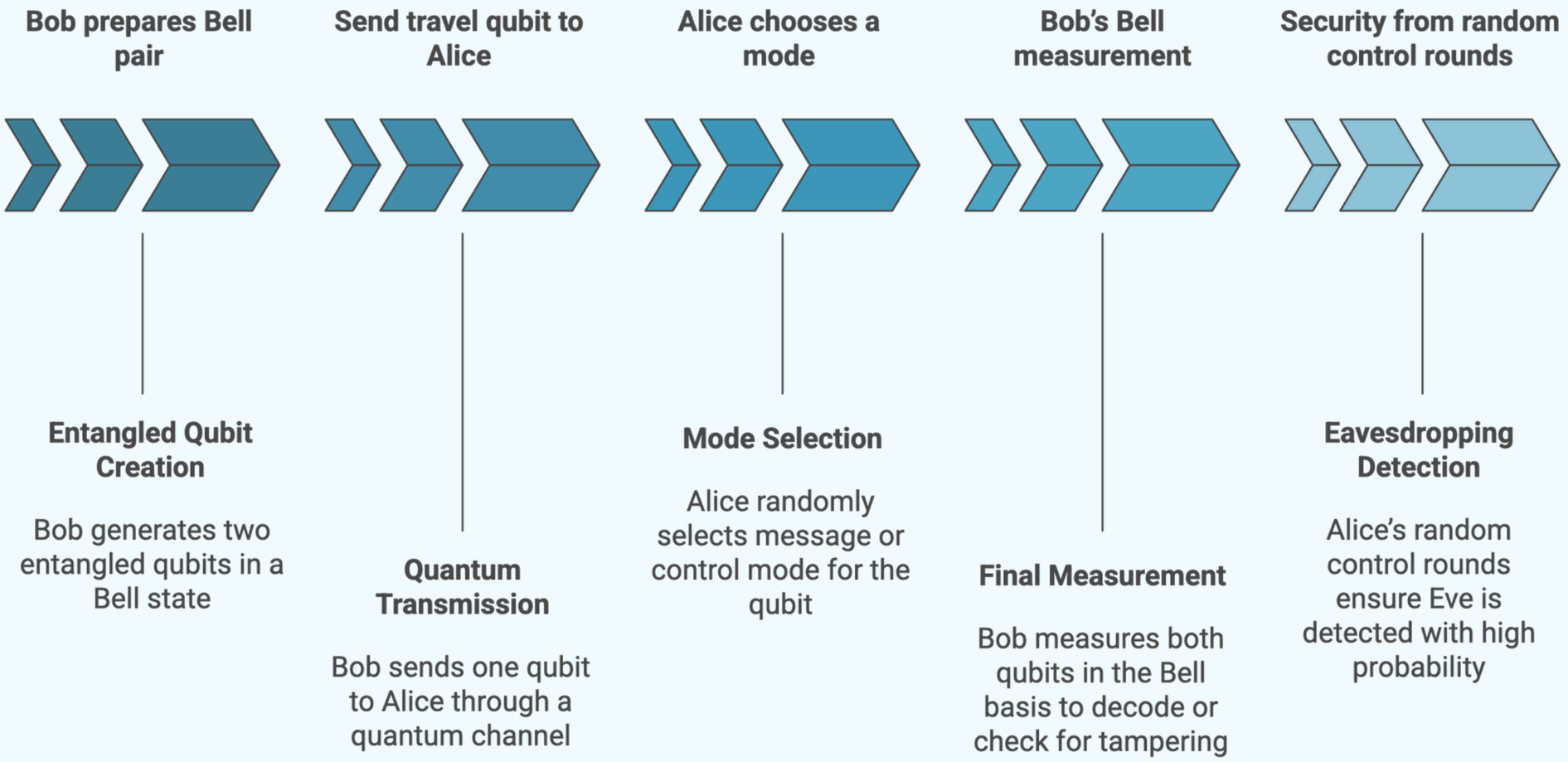
One of the first and simplest QSDC schemes using entangled Bell pairs.

Ping-Pong Name

A single qubit travels Bob → Alice → Bob, like a ball in a game.

Literature Review

STEP-BY-STEP WORKFLOW OF PING-PONG PROTOCOL



Technologies

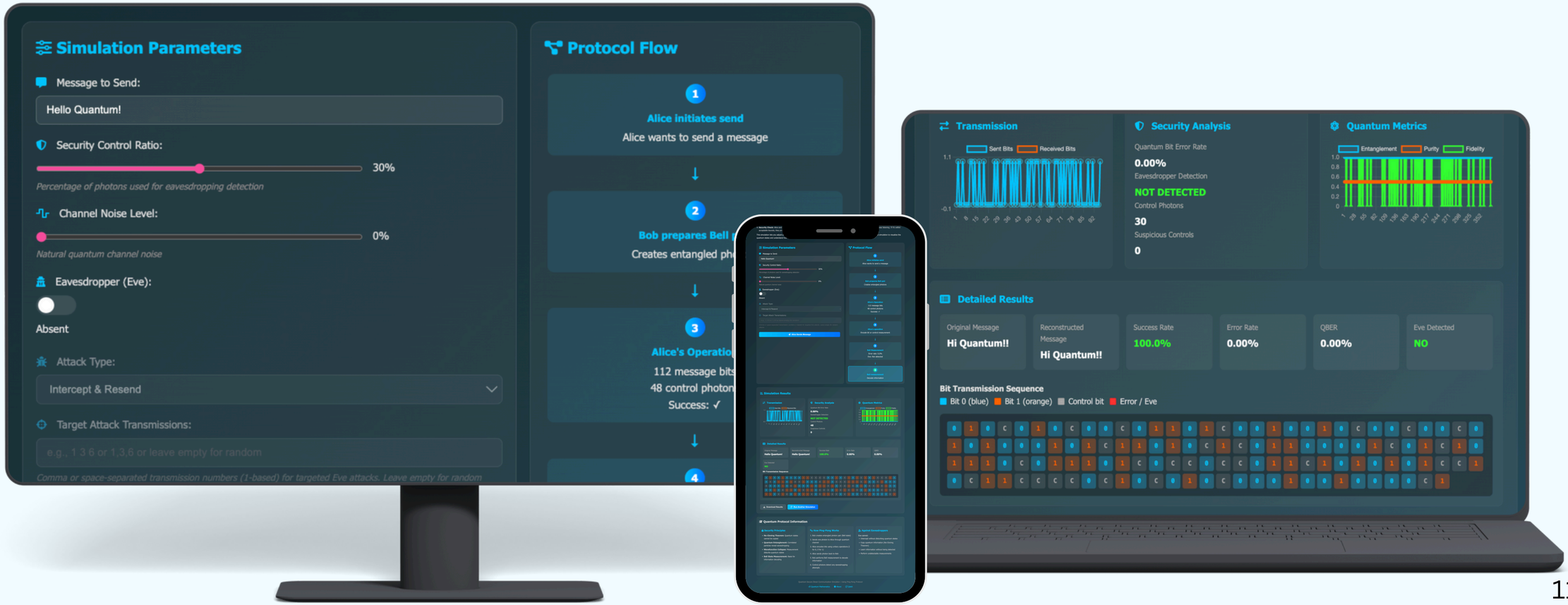
Language

Frameworks

Libraries

Result

FULL PROTOTYPE OF THE QSDC PING-PONG PROTOCAL WEB SIMULATION



Future Works

1. Visualization of the Quantum state to show case the state of the protocal
2. Implement more advance simulation of the project and add test for user to learn
3. Deployment for educational purpose

Web Demo

References

[1] "Quantum Secure Direct Communication (QSDC) Definition„" SolveForce, 21 January 2023. [Online]. Available: https://solveforce.com/2023/01/21/quantum-secure-direct-communication-qsdc-definition/. [Accessed 17 December 2025].

[2] X.-T. S. a. G.-L. L. D. Pan, "Free-Space Quantum Secure Direct Communication: Basics, Progress, and Outlook„" Advanced devices & instrumentation, 21 January 2023. [Online]. Available: https://spj.science.org/doi/10.34133/adi.0004.

[3] J. Dong, J. Teng and S. Wang, "Multiparty Controlled Quantum Secure Direct Communication of d-Dimensional Using GHZ State," 2008 Second International Symposium on Intelligent Information Technology Application, 2008. [Online]. Available: https://ieeexplore.ieee.org/document/4740058.

Thank You So Much!

Q&A