Q-Link Technical Whitepaper

Quantum-Secure Communication Infrastructure for the Post-Quantum Era

Abstract

Q-Link is a quantum communication platform designed to deliver provably secure data transmission using quantum key distribution (QKD) and entanglement-based technologies. This whitepaper details the technical architecture, security model, and implementation roadmap for Q-Link.

Introduction

Classical cryptographic systems rely on computational assumptions that are vulnerable to future quantum computers. Q-Link addresses this challenge by leveraging the fundamental laws of quantum mechanics to secure communications.

Quantum Communication Fundamentals

Quantum communication uses quantum states of photons to transmit information. Any measurement or interception alters these states, making eavesdropping detectable. QKD enables two parties to generate shared secret keys without transmitting the keys themselves.

Quantum Key Distribution Architecture

Q-Link implements prepare-and-measure and entanglement-based QKD protocols. Single-photon sources encode quantum states, while photon detectors measure them to generate shared secret keys.

Entanglement-Based Networks

Entanglement allows correlated quantum states across long distances. Q-Link uses entangled photon pairs to enable secure communication and quantum internet compatibility.

Hybrid Classical–Quantum Integration

Quantum channels generate encryption keys, while classical channels transmit encrypted data. Q-Link integrates with existing fiber and satellite infrastructure.

Satellite and Free-Space QKD

Free-space and satellite QKD overcome fiber distance limitations, enabling intercontinental quantum-secure communication.

Security Model

Security is information-theoretic. Eavesdropping introduces detectable disturbances. Error correction and privacy amplification strengthen key integrity.

Network Management

A quantum network controller manages key distribution, synchronization, routing, and monitoring.

Scalability and Performance

Trusted nodes and future quantum repeaters enable scalable deployments while preserving security.

Regulatory Considerations

Q-Link aligns with telecom regulations, national security standards, and post-quantum cryptography initiatives.

Roadmap

Phase 1: enterprise pilots. Phase 2: city-scale networks. Phase 3: satellite integration. Phase 4: global quantum networking.

Conclusion

Q-Link establishes a foundational communication layer for the quantum era, ensuring long-term digital trust.