Paper ID: 82876
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IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Interactive Presentations - IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (IP)

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# QUANTUM ERROR CORRECTION FOR QUANTUM SATELLITE-BASED NETWORKS

**Abstract**

As quantum computers with thousands of logical quantum bits approach reality, there is a growing demand for enhanced security communication protocols. This heightened need for security stems from Shor's algorithm, which enables the factorization of primes in logarithmic time complexity, significantly improving from the exponential time complexity associated with the best classical algorithms. The acceleration in factorization plays a crucial role in compromising widely used public-key cryptosystems, such as the RSA scheme. The RSA scheme holds significant importance in classical Internet security and is employed by various entities, ranging from banks to virtual private networks. The utilization of quantum communication not only facilitates secure key exchange, underpinned by the principles of physics, but also establishes a medium for quantum computers to exchange non-classical information.

Quantum key distribution (QKD) creates secure keys from quantum information shared between parties. However, facilitating secure communication to our already existing internet is just the beginning. With the advancement of quantum networks, it will be possible to exchange quantum information between quantum computers all around the globe. This new quantum internet will enable many new technologies, like blind quantum computation, distributed quantum computing, or high-sensitivity sensing.

Our research focuses on satellite-based free-space channels for their extensive coverage and dynamicity in links. Using satellites as intermediary nodes brings free-space-based quantum communication to its extremes. The idea of quantum satellite nodes is not novel to this work. The first quantum communication satellite, Micius, was launched in 2016 by China. The European EuroQCI initiative plans to have a space segment with its prototype, Eagle-1.

Quantum error correction codes (QECC), as their classical counterpart, can increase the resilience of a quantum channel against different types of errors and noises. Satellite systems have very different channel noise rates for different parts of the network. There are even differences between uplink and downlink attenuation. This heterogeneity in the system's error channels means various error corrections would be needed. Our work explores multiple types of QECC algorithms and implementations from the quantum communication satellite networks perspective, considering the varying channels and effects of quantum error codes. Then, we propose architectures to utilize the effects of these QECCs to the maximum.