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ANALYZING A MULTI-SATELLITE QUANTUM COMMUNICATION NETWORK

Abstract

Quantum-based satellite networks utilize the power of quantum technology to transmit and receive information globally. They are using quantum mechanics to encrypt and decrypt data, thus making it virtually impossible for someone to intercept or hack the communication. Such infrastructure can conduct highly accurate measurements, which can help precision agriculture, medical imaging, and environmental monitoring. In the future, quantum-based satellite networks can enhance distributed computing by interconnecting multiple quantum processors, significantly increasing the available computational power. Following the successful Chinese Micius satellite launch in 2016, the development of several quantum key distribution satellites was proposed. The European Quantum Communication Infrastructure will have segments in space, connecting the 27 EU Member States using terrestrial fibre and satellite links. Among others, the contract for Eagle-1 quantum communication satellite was signed in September 2022, for SAGA-1 at the last Ministerial Council of the European Space Agency (ESA) in November 2022, and for TeQuantS in January 2023.

In our work, we are interested in the effectiveness of different satellite topologies using two QKD methods: prepare-and-measure and entanglement-based, examining networks operating with one, two, and three satellites. After comparing the results, we determine each case's most effective topologies and protocols. In the paper, we compare two different systems: networks using quantum entanglement (untrusted nodes-based concept) with networks using prepare-and-measure QKD (trusted nodes or reliable satellites-based system). These give us a relatively comprehensive picture of the differences between device-dependent and device-independent satellite infrastructures using available technologies.

Our results show that state-of-the-art technology limits the performance of untrusted satellite systems. In contrast, networks with trusted nodes are robust, and including multiple satellites can significantly increase the speed of quantum key distribution.