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Description

Today's tremendous interdisciplinary effort towards building a quantum computer promises to tackle problems beyond the reach of any classical computer. Although intermediate-scale quantum computers have been recently demonstrated to exceed the capability of the most powerful supercomputers, it is widely recognized that addressing any real-world problem will require upscaling quantum computers to thousands or even millions of qubits. This proposal focuses on the grand challenge of scalability in quantum computers from a full-stack architectural standpoint and is enabled by communication networks operating within the quantum computing package at cryogenic temperatures. The QUADRATURE project aims to pioneer a new generation of scalable quantum computing architectures featuring distributed quantum cores (Qcores) interconnected via quantum-coherent qubit state transfer links and orchestrated via an integrated wireless interconnect. This novel architecture supports reconfigurability to serve massive flows of heterogeneous quantum algorithmic demands.

The main objectives are:

- (i) to experimentally prove the first micro-integrated all-RF qubit-state transfer link within a cryogenic tunable superconducting cavity waveguide in the microwave and THz frequency region for quantum-coherent frequency-multiplex and routing
- (ii) to achieve the transfer of classical data through wireless in-package links by integrated cryo-antennas and transceivers
- (iii) to build protocols for a quantum-coherent integrated network enabling the exchange of qubits through the coordination of the quantum-coherent data plane and the wireless control plane
- (iv) to develop appropriate scalable architectural methods such as mapping, scheduling, and coordination approaches across multiple Qcores and
- (v) to demonstrate the scalability of the approach via multi-scale design space optimization and for a set of quantum algorithm benchmarks, with at least 10x improvement in overall performance.

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