SC26 Network Research Exhibition: Demonstration Publishable Abstract

Demonstrating Entanglement Distribution: Quantum-Classical Co-existence on Deployed Fiber

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Abstract

The research team plans a first-of-its-kind demonstration of deployed quantum-classical coexistence with quantum entanglement distribution at SC26. The proposed NRE seeks to demonstrate co-existence of quantum and classical communications on a multi-node network over deployed commercial dark fiber spanning 35 kilometers between Northwestern University in Evanston, the International Center for Advanced Internet Research (iCAIR)/StarLight facility, and the SC26 venue in downtown Chicago. This effort, led by Professor Prem Kumar and Gina Talcott, is focused on designing entangled photon sources and quantum network protocols that enable quantum measurements between physically separated locations, moving entanglement-based coexistence experimentation beyond current laboratory or loopback limitations. Quantum photons will transmit alongside SC26 conference infrastructure traffic spanning the C+L-band, as well as an S-band synchronization signal to enable GPS-disciplined synchronization and picosecond-level syntonization. Furthermore, a quantum network orchestrator will employ software-defined networking principles to provide end-to-end control of the network, autonomously coordinating all calibration and quantum measurements. This NRE will significantly advance implementations of hybrid quantum-classical networking for real-world network environments.

Goals

1. Overarching Goal: Establish a synchronized, multi-node network to demonstrate entanglement-based quantum communication over 35 kilometers of deployed commercial fiber between Northwestern University in Evanston, the International Center for Advanced Internet Research (iCAIR)/StarLight facility, and SC26 in downtown Chicago.
2. Primary Goal: Co-propagate an entangled photon with a combined C+L-band Ciena optical line system to perform entanglement distribution alongside broadband, data-carrying classical communications. This is critical for future quantum networks that can be established alongside existing classical infrastructure. The goal supports important future applications, such as multi-node quantum networks and distributed quantum computing, in an architecture that mimics real-world network profiles.
3. Primary goal: Implement software-defined orchestration for quantum communication, including entanglement generation, synchronization, and quantum measurements to enable end-to-end control.
4. Stretch goal: Incorporate Quantum Wrapper Networking [1] to provide active polarization compensation during the demonstration, allowing for long-term, stable quantum operation in a fluctuating network environment.

Impacts

Coexistence of quantum and classical communications is crucial to enable integration of quantum networks into existing classical network infrastructure, rather than building up new, costly, dark-fiber quantum networks [2]. As classical communication systems transition toward Terabits per second (Tb/s) transmissions, demonstrating coexistence with high-power, high-capacity classical line systems between physically-separated nodes is important to prove compatibility with real-world networking conditions. The knowledge gained from this unique NRE, enabled by access to SCInet metro fibers, supports future critical applications, such as multi-node quantum networks and distributed quantum computing within the classical infrastructure, in an architecture that mimics real-world network settings.

Resources

1. Metro Dark Fibers: 2 strands of NDSF SMF between StarLight and the SC26 SCinet NOC.
2. Venue Dark Fibers: Single-mode fiber, two dark fiber pairs with duplex cross-connects and duplex fiber drops (LC connectors) from the NOC to Booth 5035 (Ciena). Aerial fiber required - experiment cannot tolerate polarization fluctuation from foot traffic.
3. Space and power in SCinet NOC for RLS C+L ROADM node, fiber spools, and passive optical filters to extract demo signals and direct them to the booth.
4. Delivery of VLAN 1900 from Starlight to Booth 5035 via a 100GE SCinet connection.

Involved Parties

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[1] S. J. Ben Yoo *et al*., "Quantum Wrapper Networking," *IEEE Commun. Mag.*, **62**(3), 76-81 (2024).
[2] P. Kumar and J.M. Thomas, “Building Quantum Networks on Classical Fiber Infrastructure,” *Opt. Photonics News* **37**(6) (2026).