A Multiplane Architecture Proposal for the Quantum Internet

draft-lopez-qirg-qi-multiplane-arch

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A First Reminder: Why an Architecture Framework

- Provide a reference for further protocol and interface definition
- Application of architecture principles and operational experience
- Support convergence: Applications and technologies at scale
- Address three essential Quantum Internet goals
  - Universality, accommodating any application
  - Transparency, sharing physical media with classical networks
  - Scalability, supporting the growth of the network
- Acknowledging an exclusively Quantum Internet is neither feasible nor desirable
  - Working in the direction of an Internet with quantum capabilities
- Not a set of protocols or interfaces per se
  - But a way to describe and evaluate them in a consistent manner
A Second Reminder: The Foundations

• Three essential properties of the framework architecture
  • Agility, with general enough abstractions
    • Avoiding a tight coupling with specific (physical) technologies
  • Sustainability, at all levels and in full scale
    • Open availability in technological and economical terms
  • Pliability, seamless integration with classical
    • (Adapted) best practices in use by the Internet community

• Apply the operational experience with (reasonably large) QKD infrastructures
  • Interfacing applications, service semantics, and the interaction with classical networks

• Leverage SDN concepts: the CLAS architecture (RFC 8597),
  • Structured around strata, with a regular set of planes
  • Integration of control mechanisms, and the interplay with (shared) infrastructure
  • General trends: Cloud-nativeness, zero-touch management, intent…
How the Draft Is Evolving

• Addressing received comments
  • We eagerly expect more to come
• Restructure
  • Clear differentiation of base technologies and the framework proposal
  • A more thorough discussion of strata and their functions
• Initial discussion on synthetic environments
  • As an essential means to validate the proposal
  • And more
• TBP so far
  • A better term for “quantum forwarding”?
  • Mapping existing interface/protocol proposals onto the framework
  • Security considerations
New (Current) Structure

- Technology foundations
  - QKD experience
  - Interfacing with classical networks
  - Introducing the CLAS architecture
- Framework architecture proposal
  - CLAS strata for quantum networks
  - Principles for the dentification of interfaces and protocols
  - An introduction to synthetic environments
- Closing matters
  - Security considerations
  - . . .
The Role of Synthetic Environments

• The essential means
  • Given the issues with devices, scale…
  • Not strictly an NDT

• Validate the framework
  • Roles of strata and planes
  • Evidence on interfaces

• Assess its applicability
  • Using current proposals on architecture and protocols as touchstone

• Assess the integration with
  • Classical networks
  • Meshes of synthetic and real elements

• First experiments
  • Collaboration welcome
And What Comes Next

• Keep working on interfaces and protocols
  • Current proposals as touchstone
  • Identify potential gaps
  • Aligned with describing the role of planes within the different strata

• Report initial experiments with synthetic environments
  • Experiment descriptors and environment components
  • Applicability of OAM practices (automation, cloud-nativeness…)
  • Integration with similar approaches for classical networks

• Provide a supporting framework for further experimentation
And a Back-Up Slide on CLAS Itself
CLAS Strata for Quantum Networks

• A Service Stratum, dealing with the functionality related to the purpose of the quantum network
  • Generation of management of keys in QKD
  • Others: time synchronization, identity assurance, sensing…
  • Entanglement distribution in a general quantum network

• A Quantum Forwarding Stratum, in charge of the direct application of quantum protocols and algorithms
  • Between any two endpoints of a quantum link
  • Even when it is a multi-hop one, whatever the nature of *repeaters*

• A Connectivity Stratum, taking care of providing the paths to support the quantum links
  • Supported by OTN infrastructure, via fiber and/or open-space links
  • Follow a common connectivity paradigm
  • From current circuit-based approaches to any other potential *classical encapsulation*