A Multiplane Architecture Proposal for the Quantum Internet

draft-irtf-qirg-qi-multiplane-arch

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Why and How an Architecture Framework

- A reference to support further element and protocol definition
  - Working in the direction of an Internet with quantum capabilities
  - Not proposing a concrete choice of elements or protocols
  - But the foundations to describe and assess them coherently
- Using the operational experience gained with QKD infrastructures as example
  - Apply experience on coexistence with classical networks and service semantics
  - Generalize operational best practices, including orchestration patterns
- Leverage SDN concepts
  - Based on the CLAS architecture (RFC 8597)
  - Integration of the interplay with (shared) infrastructure
- Propose abstractions to support actual network services
  - As a base of essential network functionality: routing, access, accounting, service level…
  - Integrate those abstractions to support a consolidated approach
  - A Quantum-enabled Internet

Maturing towards LC

- A framework applicable for reasoning about network service aspects related to the future Quantum Internet
  - Protocols and interfaces, control and management, telemetry…
  - In support for further service-oriented experimentation
- Enhance service view and integration
  - Consolidate the service unit concept
  - Address the interplay of the different strata
  - Provide an example procedure for service unit provisioning
- Analysis of different reference proposals
  - Provide a mapping of solutions at the different strata and planes
  - Identify open questions and direct potential experimentation
  - Set the foundation for a methodology for further application
  - Mostly derived from the references in QIRG RFCs

Service Units and QUIs

- The service unit concept is basically *user-facing*
  - Oriented towards applications
  - Naturally associated to the Service Stratum
- A *resource-facing* abstraction complements the service view
  - Oriented towards infrastructure
  - Naturally associated to the Quantum Fabric Stratum
  - And bridging the SS and the Connectivity Stratum
- Domain-scoped QUI
  - Not expected to be globally unique
  - Applicable at any operational scope appropriate to the deployment
  - Identifying a single entangled pair, a set of entangled pairs, a quantum memory allocation, a local share of an end-to-end shared state…
- A service unit comprises one or more of these resource-facing handles
  - Preserving the service-unit abstraction presented to applications

The SU-QUI Mapping

- SU are mapped to QUIs at the interface between the SS and QFS control planes
- QUIs are mapped to device-local resource handles by QFS resource-plane agents, managed by the QFS control plane
- QUIs include time-sensitive information
  - Lifecycle
  - Freshness
- And support re-binding
  - Bind the same service-unit context to a new local quantum resource allocation
  - As a control-plane mechanism for replacing or refreshing the underlying resource(s) associated with a service unit

QoS and Ancillary Functions

- Complementing the control planes at the different strata
  - And especially the interfaces among them
- QoS parameters define the requested and available features of the quantum connectivity service
  - Fidelity, entanglement generation rate, latency…
  - Applicable to SU addressing
  - Basic service functionality: admission, monitoring, billing…
- Ancillary functions supply much of these basic service functionality
  - Addressing the control and consumption of quantum services
  - Leveraging good-ole basic technologies, and especially virtualization
  - Applying the Quantum-enabled Internet principles to OAM

Reference Mapping

- Illustrate the framework and guide experiments
  - Plus the foundation of a methodology for applying it
- Based on the references used by QIRG RFCs
- Grouped in four categories
  - Quantum physical foundations and repeater technology
  - Network architecture and protocols
  - Service abstractions and application frameworks
  - Security
- For each reference the document includes
  - An analysis of how it fits in the reference framework
  - Considerations on its interplay within the framework
  - Possible experimentation paths

Current Status and Next Steps

- We believe this document has reached a sufficient grade of maturity
- Aligned with the purpose of IRTF documents
  - Exploration of protocols, applications, architecture, and technology
  - Dissemination of experimental and informational research results
  - Address research topics that may guide future standards but are not yet mature enough for IETF consideration
- We would like to request to move the coming version to last call, once we
  - Address any comments we get at this meeting
  - Enhance the discussion on synthetic environments, according to next presentation