

A Multiplane Architecture Proposal for the Quantum Internet

draft-lopez-qirg-qi-multiplane-arch

D. López, A. Pastor, L.M. Contreras (Telefónica),
V. Martín (UPM),
B. López (IMDEA Networks)

IETF#124, Montreal (CA), November 2025

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
- Leverage the operational experience gained with QKD infrastructures
 - Coexistence with classical networks
 - Service semantics
 - 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

The Base Abstraction

The *Service Unit* Concept

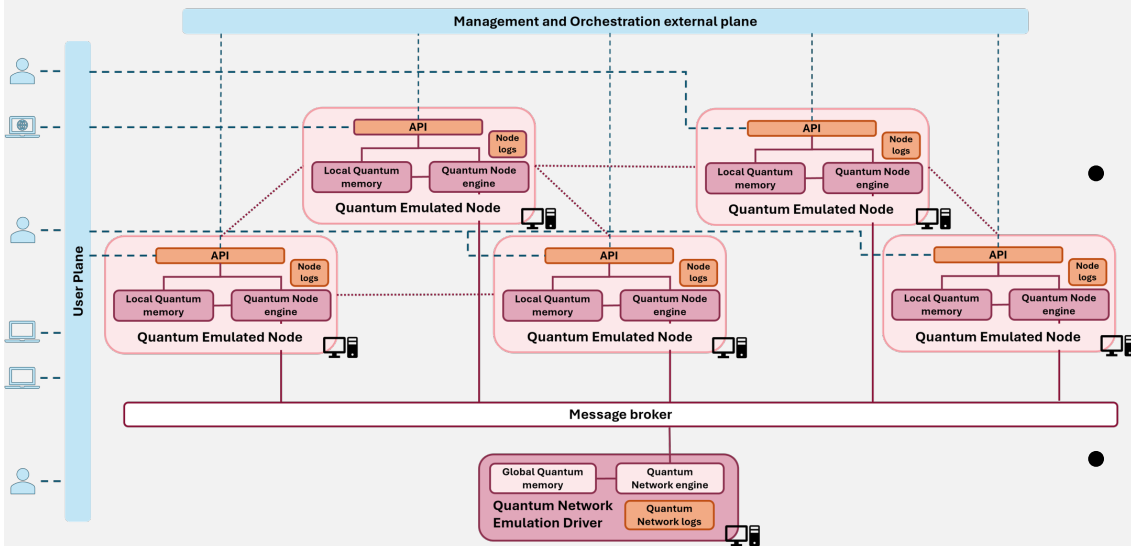
- Identifies a **shared state** between two application entities
 - Referencing the sharing application entities and relevant shared state parameters
 - Analogue to transport flows in the current Internet, rather than to packets
- Abstracted from specific link and/or repeater strategies
 - Focusing on network features
 - Applicable at global, regional or local levels
- Addressing (integral) network functionality
 - Routing: Addressing (local and global), aggregation, delegation...
 - Access and admission control: Authorization policies and usage patterns...
 - Accounting: User and provider identification, decision traceability...
 - Service levels: Monitorization, policy enforcement, agreements...

Shaping the Draft

Identification of Protocols and Interfaces

- Analyze a number of protocol proposals at each stratum
 - With the SU base abstraction as fundamental reference
- Connectivity
 - Using the ACTN as reference for the planes
 - A quantum-aware PCE
- Quantum Forwarding
 - Integration of quantum-native addressing and routing
 - Considerations on quantum repeaters
- Service
 - Mapping SUs onto physical underlay and entanglement overlays
 - Parameterization

Shaping the Draft Synthetic Environments



- An essential tool to apply the framework
 - Validate architectural and protocol proposals
 - At scale
- The QNDT concept, focused on emulation
 - Align the behavior of quantum components with the classical infrastructure
 - Shared temporal and operational constraints
 - Adaptable to technology evolution
- *Core quantum emulation engine*
 - Based on current quantum simulators
 - Timing consistency with classical and underlying infrastructural element
 - Time impact on quantum state evolution

Progressing the Draft

- We believe the draft is mature for adoption
- Intended as a framework useful for reasoning about network aspects related to the future Quantum Internet
 - Protocols
 - Control and management
 - Telemetry
- Next steps would include showing how different proposals could be considered and evaluated
 - In support of a methodology
 - Identifying research issues with a consistent tool
 - What constitutes an essential role of RG documents