A Multiplane Architecture Proposal for the Quantum Internet (Plus some news on the MadQCI)

draft-lopez-qirg-qi-multiplane-arch

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As a Reminder
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
  - Consider the impact of virtualization
- Propose abstractions to support actual network services
  - As a base of essential network functionality: routing, access, accounting, service level…

The *Service Unit* Concept

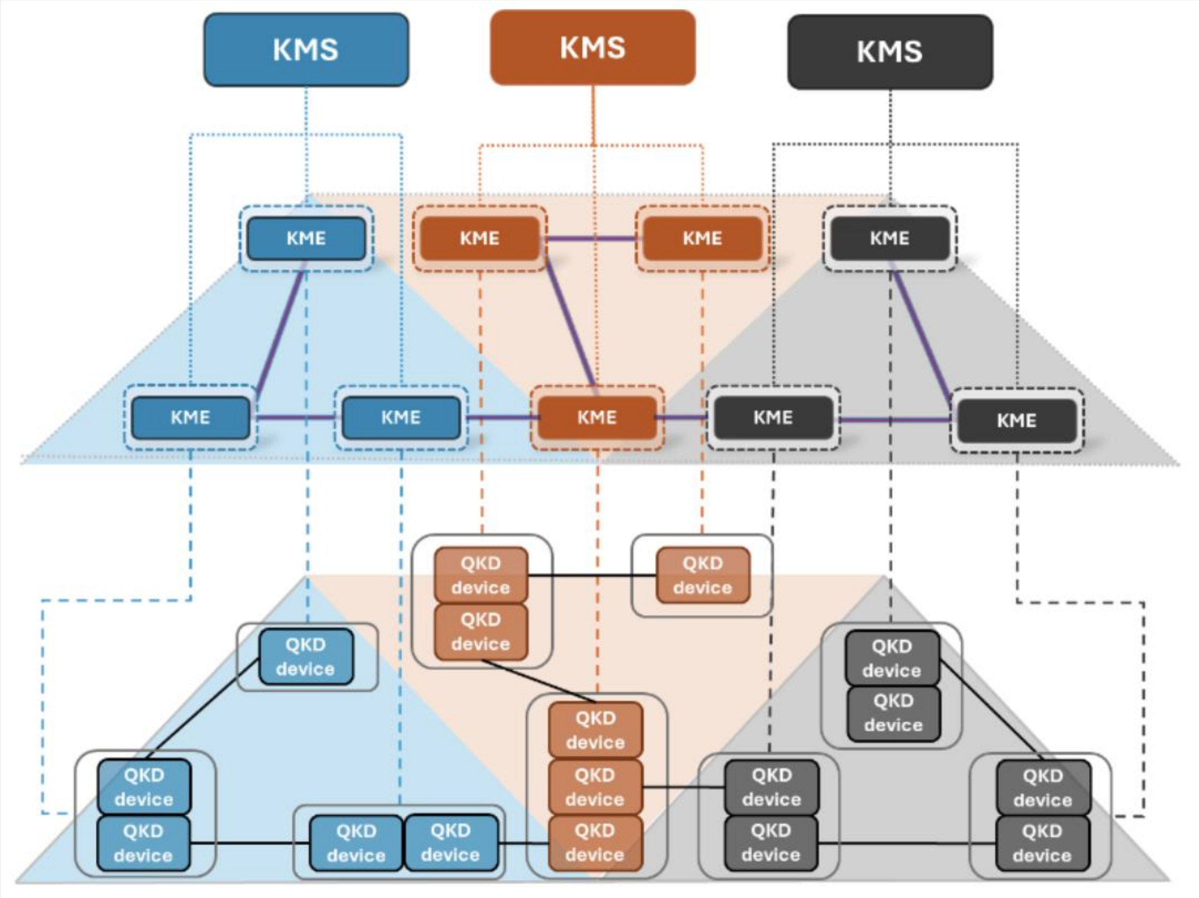
- Identifies a **shared state** between two application entities
  - Referencing the sharing application entities
  - And any parameters relevant to the shared state
  - No explicit directionality
  - Analogue to transport flows in the current Internet, rather than to packets
- Abstracted from specific link and repeating strategies
  - Focusing on network features
  - Applicable at global, regional or local levels
- In support of the three essential properties
  - *Agility*, abstracting the network operation from supporting technologies
  - *Sustainability*, enabling the integration of technology disjoint segments
  - *Pliability*, supporting the convergence with operational best practices
- A general proposal for identifying a SU by three URNs
  - One per entity plus the applicable parameters

Addressing Network Functionality

- Routing
  - URN properties allow for aggregation and delegation
  - And support global and locally restricted addressing
  - The basic elements for routing mechanisms, whatever their nature
- Access and admission control
  - Authorization policies expressed in terms of patterns
  - For entities and parameters
  - Including network state
- Accounting
  - Identification of user application entities and the requested service
  - Traceability of forwarding decisions
- Service levels
  - Monitorization
  - Match against parameter values

QKD Service Units

- What we are experimenting with right now
  - SUs are bitstrings used as keys
- Each application entity identifies using a URN to its *Key Management Entity* (KME)
  - Several KMEs operated within a domain define a *Key Management System* (KMS)
  - When building a SU, URNs can be extended with a nonce
- The management entity of a KMS decides about what URNs are shared and how
  - Entity URNs can be made global, domain-wide, local…
  - Route reflectors, SDN controllers, and any combination of them

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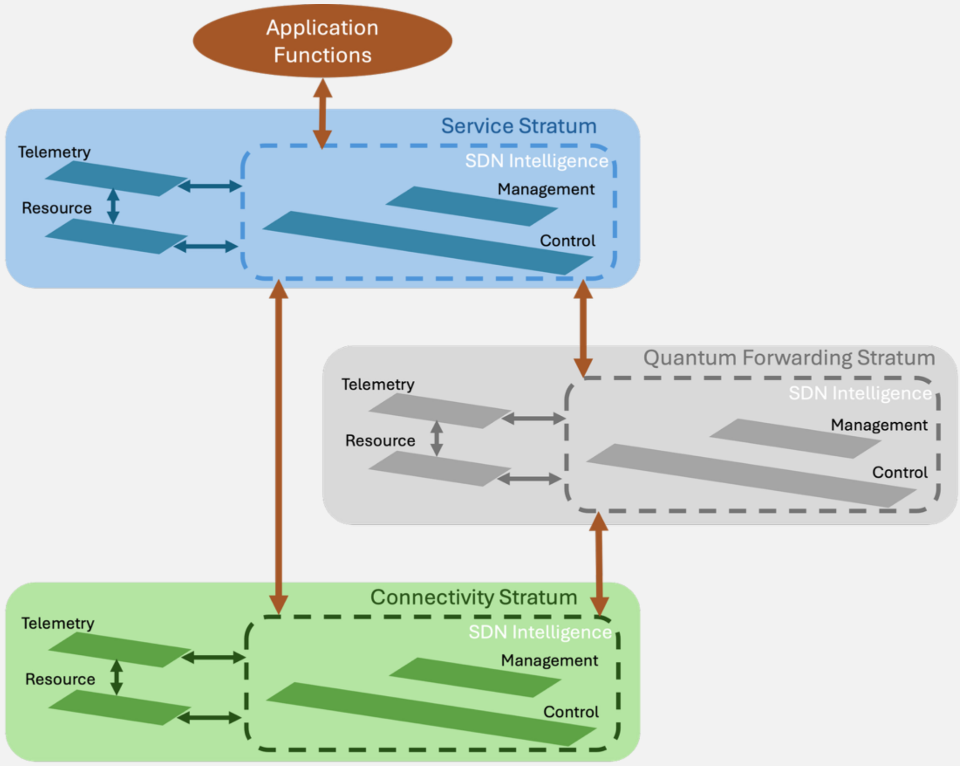
Generalizing Service Units

- A direct translation of the QKD SUs
  - Shared quantum states to be consumed by the application entities
  - Addresses in the quantum memories
  - Other specialized contents can be applied, as in the QKD case
- A similar interface
  - Application entity identifiers
  - Attached to service providing units in the Service Stratum (SS)
    - Like KMEs in QKD
  - Domain groupings similar to a KMS seem feasible
    - Together with the associated routing mechanisms
- And similar addressing format
  - Though parameters require further analysis

SUs in the Architecture

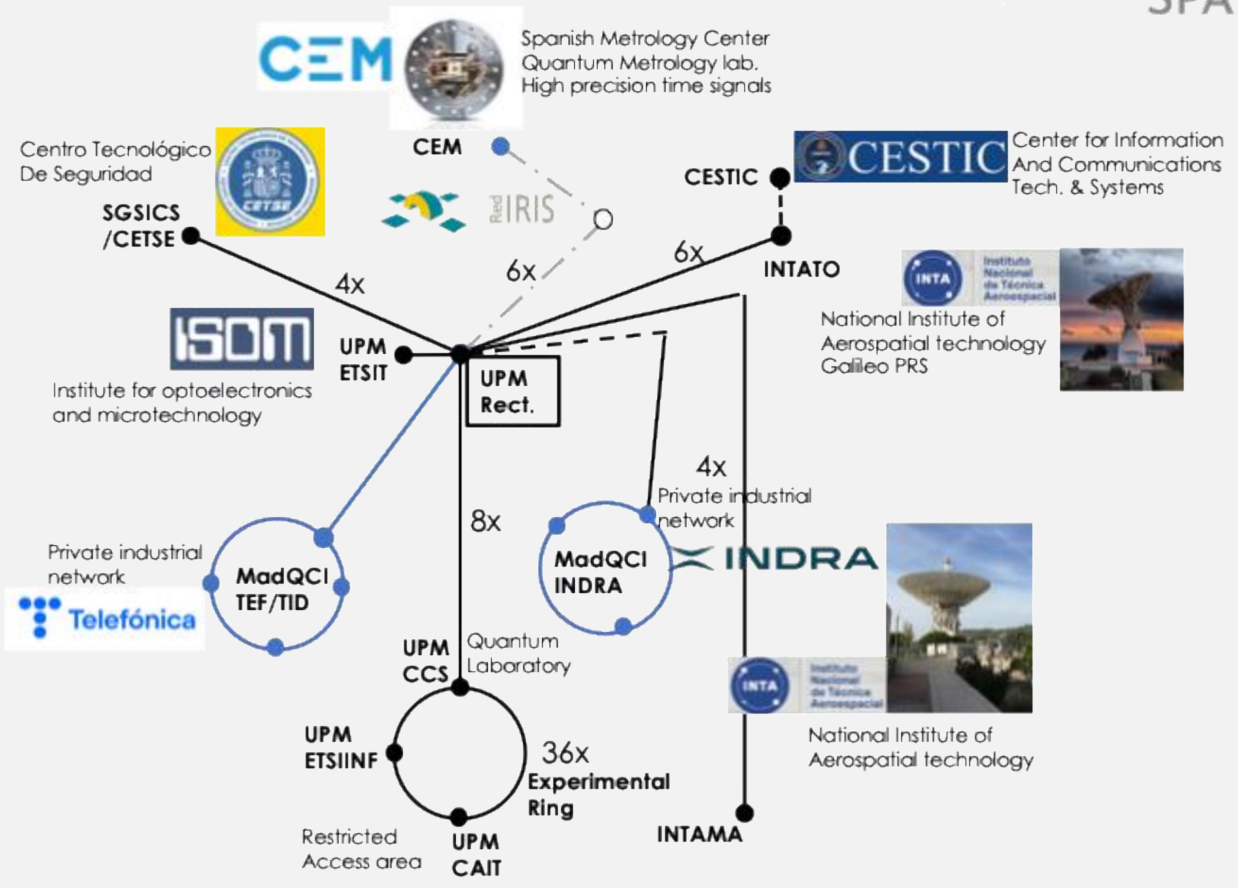
- The SS elements attached to application entities interact with
  - Elements in the control plane of the SS for routing decisions
  - Elements in the control plane of the QFS for quantum link activations
  - Elements in the control plane of the CS for required physical links
- Monitoring can be activated at each stratum
  - Need to understand metrics and telemetry data models for both the SS and the QFS
  - As already being defined for QKD



Experimenting with All This: EuroQCI Spain

- Fully dedicated to research, development and industrialization of quantum communications
  - Production facilities
  - + 400 km
  - +40 QKD modules (CV, DV, MDI)
  - 9 vendors
  - QRNGs
  - HSMs
  - Classical comms
- Quditto for experimenting at scale
- Token-based application access control
- Experiments beyond QKD
  - Multiparty secure computation
  - Location
  - Load balancing
- Evolving to address general QC as soon as technology supports it
- And reaching out to other QCIs

EUROQCI SPAIN



MadQCI: Engineering the Architecture