Architectural Principles of a Quantum Internet

https://datatracker.ietf.org/doc/draft-irtf-qirg-principles/

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Recap

- First version of draft prepared and presented at IETF 104 in Prague on 26 March 2019
- Main motivation is to address charter point:

  An architectural framework delineating network node roles and definitions, to build a common vocabulary and serve as the first step toward a quantum network architecture.

- Also want to create a good starting point for people with no quantum background

Recap

- Draft was adopted by QIRG at IETF 104
- Discussions continued
  - Four web calls to cover sections 1-5 document in Sep/Oct/Nov 2019
  - One web call to cover section 6 in Jun 2020
  - Presented updates at IETF 106, 107
- Following lots of feedback the entire document has been reworked
- More comprehensive and accessible now and representative of the wider community

GitHub

- A GitHub repo is maintained at https://github.com/Wojtek242/draft-irtf-qirg-principles
- A more convenient way to share updates at a finer granularity than datatracker allows
- However, all discussions are still done on the mailing list so no fancy CI/CD

Overview of changes (since 107)

- One new author: Shota Nagayama
  - Completely reworked error management (quantum repeater generations)
  - “Store and swap” vs “store and forward”
- Reworked section 6 “Architectural Principles”
- Incorporated remaining feedback from mailing list
- Several other minor edits for readability and consistency

Goals and Principles

- Discussed on web call on 9 Jun 2020
- In summary: goals align with classical networks but considerations are different
- Security might need some more work (review and feedback is welcome)
- Section was rewritten in light of feedback

Error Management

- Significantly expanded on error management thanks to Shota’s PR
- Three different generations of error management.
- Generations are more like categories and do not obsolete each other, but higher generations require better hardware

Error Management

	1G	2G	3G
Loss tolerance (qubit transmission losses)	Heralded entanglement generation (bi-directional signalling)	Heralded entanglement generation (bi-directional signalling)	Quantum error correction (no signalling)
Error tolerance (quantum state errors)	Entanglement distillation (bi-directional signalling)	Entanglement distillation (uni-directional signalling) OR Quantum error correction (no signalling)	Quantum error correction (no signalling)

Store and swap/forward

- Emphasizes a key difference between classical and quantum networks
- However, 3G quantum networks will be able to do “store and forward”
- After discussion on mailing list clarified that just because they can doesn’t mean they have to (they can still do “store and swap”)

Other changes

- Incorporated feedback from Rod (see mailing list for details)
- Other minor fixes to enhance readability and self-consistency of the document after changes

Discussion point

- Discrete/continuous variable encodings
- Discrete, e.g. polarisation, time bin encodings
  - High fidelity, but probabilistic
- Continuous, e.g. quadrature of light
  - Low fidelity, but deterministic
- Current status: already included (by mentioning there will be various hardware architectures) so no need for extra detail

Looking Forward

- Add references for completeness
- Wrap up discussion with Rod on mailing list
  - Shortest-path definition
  - Control plane definition
  - Time-skewed entangled pairs
  - Review whether all-optical is excluded by the language
- Document complete once the above two points addressed