A.13 justification for new Supplement: Technical considerations towards Quantum Network

Question:	16/13	**Proposed new ITU-T Supplement**	Geneva, 23 October - 03 November 2023	
Reference and title:	ITU-T Supplement on "Technical considerations towards Quantum Network"			
Base text:	Annex B		**Timing:**	March 2025
Editor(s):	Hyungsoo (Hans) KIM, KT corp., e-mail: hans9@kt.com Yazi Wang, BUPT, e-mail: yazi_wang@bupt.edu.cn; Jun HEO, Korea University, e-mail : junheo@korea.ac.kr Xiaosong Yu, BUPT, e-mail: xiaosongyu@bupt.edu.cn; Yongli Zhao, BUPT, yonglizhao@bupt.edu.cn; Dong-Hi SIM, SK Telecom, donghee.shim@sk.com		**Approval process:**	Agreement

Purpose and scope

This new Supplement is aiming to introduce the technical considerations towards Quantum Network. It helps that how to standardize a quantum network in Study Group 13.

In particular, the scope of this Supplement includes:

- Technical considerations for Quantum Network;
- Migration scenarios of QKDN towards Quantum Network;
- Standardization roadmap including technical readiness.

Summary

Quantum network is expected to provide new applications based on fundamental quantum mechanics such as entanglement, superposition, and non-cloning, and those are not possible with non-quantum networks (e.g., conventional digital networks).

This Supplement aims to identify technical considerations for quantum network.

NOTE – ITU-T Supplement 75 "TU-T Y.3000 series – Quantum key distribution networks – Quantum-enabled future networks" has been published. This supplement 75 focuses on the activity status of studies and research from academia, research institute, and SDOs. However, this new supplement will study more technical aspects which might be required towards Quantum Network.

Relations to ITU-T Recommendations or to other standards (approved or under development):

ITU-T Y.3800-series, ITU-T Y Suppl. 75, ITU-T TR.QN_UC, IRTF RFC 9340

Liaisons with other study groups or with other standards bodies:

ITU-T SG2, SG3, SG11, SG12, SG15, SG16, SG17, SG20, ITU-R, 3GPP, ETSI, IETF, IRTF, IEEE

Supporting members that are committing to contributing actively to the work item:

KT corp., Korea University, ETRI, KAIST, Beijing University of Posts and Telecommunications, China; CAS Quantum Network Co., Ltd. China; University of Science and Technology Beijing, China; QuantumCTek Co., Ltd., China, SK Telecom.

Annex B: Initial draft of Y.supp.TC-QN

Draft new Supplement ITU-T Y.supp.TC-QN

Technical considerations toward Quantum Network

Summary

Quantum network is expected to provide new applications based on fundamental quantum mechanics such as entanglement, superposition and non-cloning, and those are not possible with non-quantum networks (e.g. conventional digital networks).

This Supplement aims to identify technical considerations for quantum network.

NOTE 1 – ITU-T Supplement 75 “TU-T Y.3000 series – Quantum key distribution networks – Quantum-enabled future networks” has been published. This supplement 75 focuses on the activity status of studies and research from academia, research institute, and SDOs. However, this new supplement will study more technical aspects which might be required towards Quantum Network.

Keywords

QKDN (quantum key distribution network), Migration Scenario, Fully Quantum Networking, Quantum Network

Table of Contents

Draft new Supplement ITU-T Y.supp.TC-QN

Technical considerations toward Quantum Network

Scope

This new Supplement is aiming to introduce the technical considerations towards Quantum Network. It helps that how to standardize a quantum network in Study Group 13.

In particular, the scope of this Supplement includes:

- Technical consideration for Quantum Network
- Migration scenarios of QKDN towards Quantum Network
- Standardization roadmap including technical readiness;

1 References

[ITU-T Y.3800] Recommendation ITU-T Y.3800 (2019), Overview on networks supporting quantum key distribution.

[ITU-T Y Suppl. 75] Supplement 75 to ITU-T Y-series Recommendations (2023), Quantum key distribution networks – Quantum-enabled future networks.

2 Terms and Definitions

2.1 Terms defined here

- TBD

3 Abbreviations

This Supplement uses the following abbreviations:

- TBD

4 Introduction

[Editor's note] Details of contents in this clause might be revised to take into account in the future progress of technologies with submitted contributions.

Quantum network is a network enabled by quantum information technologies between quantum end devices and quantum network nodes. The quantum end devices refer to QKD modules, quantum sensors and quantum computers, etc., where hosts user applications. On the other hand, quantum network nodes are expected to be quantum repeaters, quantum switches and quantum routers in cooperated with quantum memories, quantum entanglement sources and quantum entanglement distributors.

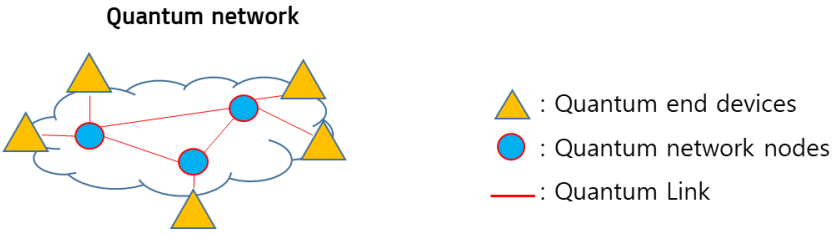

Figure 1 – Conceptual configuration of quantum network

[Editor's Note] *In order to develop a normative ITU-T document (e.g., Recommendation), those technologies for quantum end devices and quantum network nodes should be studied.*

Due to the collapse of a quantum state's superposition when a qubit's state is measured in a network node, a direct reading of the quantum state is impossible. Just copying of a qubit without measurement can be taken into account, but it is not possible in quantum mechanics, non-cloning, either.

Considering the above understanding of quantum physics, the conventional 'store and forward' process in network node is not possible in quantum network. The delivery of control information (e.g. signalling protocols) to engage/disengage an end-to-end quantum state connectivity should be collaborated with conventional digital network. Figure 2 shows the basic concept of combined quantum network with conventional digital network for this purpose.

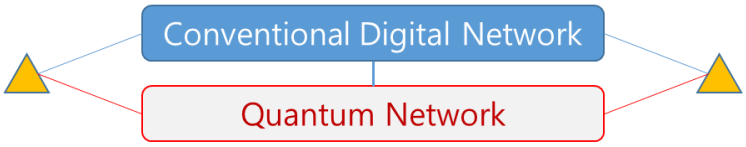

Figure 2 – Combined quantum network with conventional digital network

[Editor's Note] *In order to develop a normative ITU-T document (e.g., Recommendation), those technologies for conventional digital network and how to control and management should be studied*

QKD module is one of quantum end devices in quantum network. In [ITU-T Y.3800], the intermediate QKD node is assumed to be secure against intrusion and attacks by any unauthorized parties. However, the QKD node is not IT-secured.

In quantum network, information is retained in quantum form at the intermediate nodes, ensuring its protection at the QKD node as well as in transit in the quantum channels between nodes. A quantum network works by distributing entanglement between a series of intermediate stations placed along the link. Theoretically, such an approach represents the ideal solution to distribute keys over long distances, as the intermediate stations do not need to be trusted.

[Editor's Note] *The migration scenarios of QKDN towards quantum network should be studied.*

5 Technical considerations of Quantum End Devices

[Editor's Note] This clause introduces the technical aspects of quantum end devices.

5.1 QKD module

- TBD

5.2 Quantum sensor

- TBD

5.3 Quantum computer

- TBD

5.4 Others

- TBD

6 Technical considerations of Quantum Network Nodes

[Editor's Note] This clause introduces the technical aspects of quantum network nodes.

6.1 Quantum repeater

6.1.1 Non-quantum memory-based approach
- TBD

6.1.2 Quantum memory-based approach
- TBD

6.2 Quantum switch

6.2.1 Entanglement swapping-based circuit-oriented
- TBD

6.3 Quantum router

6.3.1 TDM-based qubits delivery (packet-oriented)
- TBD

6.4 Others

- TBD

7 Other technical considerations for quantum network

[Editor's Note] This clause introduces the other possible technologies for quantum network.

7.1 The role of conventional digital network

- TBD

7.2 Control and management (e.g., SDN-based)

7.2.1 Common control of QKDN and quantum network

- TBD

7.3 Addressing

- TBD

7.4 Others

- TBD

8 Migration scenario of QKDN towards quantum network

[Editor's Note] This clause introduces the migration scenario of QKDN towards quantum network.

In the early stage of quantum communication (including QKDN), sequential single qubits transmission was mainly considered. Differing from this technology, entangled qubits distribution is introduced for end-to-end connectivity of quantum states in quantum network.

How to migrate towards fully quantum networking should be studied.

8.1 Trusted relaying, measurement-assisted relaying, and fully quantum networking

- TBD

8.2 Migration scenario toward quantum network

- TBD

9 Standardization Roadmap including technical readiness

[Editor's Note] This clause introduces the standardization roadmap.

9.1 Technical Readiness

- TBD

9.2 Implications for Study Group 13

- TBD

_____