

The Quantum Internet: a Communication Engineering Perspective

(Invited)

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Abstract—Internet just turned 50: five decades that shaped the world we live in. Indeed, Internet itself evolved astonishingly since the beginning, from a network prototype consisting of a few static nodes in the early days to a leviathan interconnecting with billions of devices half of the world’s population. Yet the fundamental assumption underlying Internet’s design – i.e., transmitting messages that can be encoded in a sequence of classical bits – remained unchanged during these five decades. But the dawn of the engineering phase of quantum technologies is challenging Internet’s fundamental assumption. Quantum devices demand for communication primitives – namely, the ability to distribute entangled states and to transmit quantum information – governed by the laws of quantum mechanics. Hence, principles and phenomena with no counterpart in classical networks require a major network-paradigm shift to harness the quantum mechanics specificities. This presentation aims at shedding light on the challenges and the open problems arising with the design of a protocol stack for the Quantum Internet.

Index Terms—Quantum Internet, Quantum Networks, Quantum Communications.

REFERENCES

- [1] M. Caleffi, A. S. Cacciapuoti, and G. Bianchi, “Quantum Internet: From communication to distributed computing!”, *invited paper*, Proc. of ACM NANOCOM, 2018.
- [2] A. S. Cacciapuoti, M. Caleffi, F. Tafuri, F. S. Cataliotti, S. Gherardini, and G. Bianchi, “Quantum Internet: Networking challenges in distributed quantum computing”, *IEEE Network*, vol. 34, no. 1, pp. 137-143, January/February 2020.
- [3] A.S. Cacciapuoti, M. Caleffi, R. Van Meter, L. Hanzo, “When Entanglement meets Classical Communications: Quantum Teleportation for the Quantum Internet”, *invited paper*, *IEEE Transactions on Communications*, vol. 68, no. 6, pp. 3808-3833, June 2020.
- [4] M. Caleffi, D. Chandra, D. Cuomo, S. Hassanpour, A.S. Cacciapuoti, “The Rise of the Quantum Internet”, *IEEE Computer*, vol. 53, no. 6, pp. 67-72, June 2020.
- [5] D. Cuomo, M. Caleffi, A.S. Cacciapuoti, “Towards a Distributed Quantum Computing Ecosystem”, *invited paper*, *IET Quantum Communication*, vol. 1, no. 1, pp. 3-8, July 2020.
- [6] W. Kozlowski, S. Wehner, R. V. Meter, B. Rijsman, A.S. Cacciapuoti, M. Caleffi, S. Nagayama, “Architectural principles for a Quantum Internet”, Internet-Draft draft-irtf-qirg-principles-07, Internet Engineering Task Force (IETF), Work in Progress.

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