

Theory Colloquium

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“From classical networks to the Quantum Internet: the paradigm shift”

Abstract

The current Internet has undergone remarkable transformations since its inception, evolving from a simple network with a handful of static nodes to a highly complex system that connects billions of devices worldwide. However, one fundamental principle has remained constant throughout its five-decade evolution: the transmission of information encoded as classical bits. In the Quantum domain, this foundational assumption is now being challenged. Quantum devices require novel communication capabilities—specifically, the distribution of entangled states and the transmission of quantum information. As a result, quantum networks introduce phenomena that have no direct equivalent in classical networking, and demand for a communication paradigm shift in network design. Indeed, they prohibit to simply adopt classical networking solutions without significant modifications.

I will present an overview of the basic communication primitives adopted for the classical Internet and provide some insights on why entanglement and quantum communications demand a design effort towards different network protocols.

[1] J. Illiano, M. Caleffi, A. Manzalini, A. S. Cacciapuoti, "Quantum Internet Protocol Stack: a Comprehensive Survey", *Computer Networks*, vol. 213, August 2022.

[2] A.S. Cacciapuoti, J. Illiano, S. Koudia, K. Simonov, M. Caleffi, "The Quantum Internet: Enhancing Classical Internet Services one Qubit at a Time", *IEEE Network*, vol. 36, no. 5, pp. 6-12, September/October 2022

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