Jessica Illiano

Quantum Communication Protocols for Quantum Security and Quantum Internet

Tutor: Prof.ssa Angela Sara Cacciapuoti
      co-Tutor: Dr. Antonio Manzalini (TIM)

Cycle: XXXVI   Year: Second
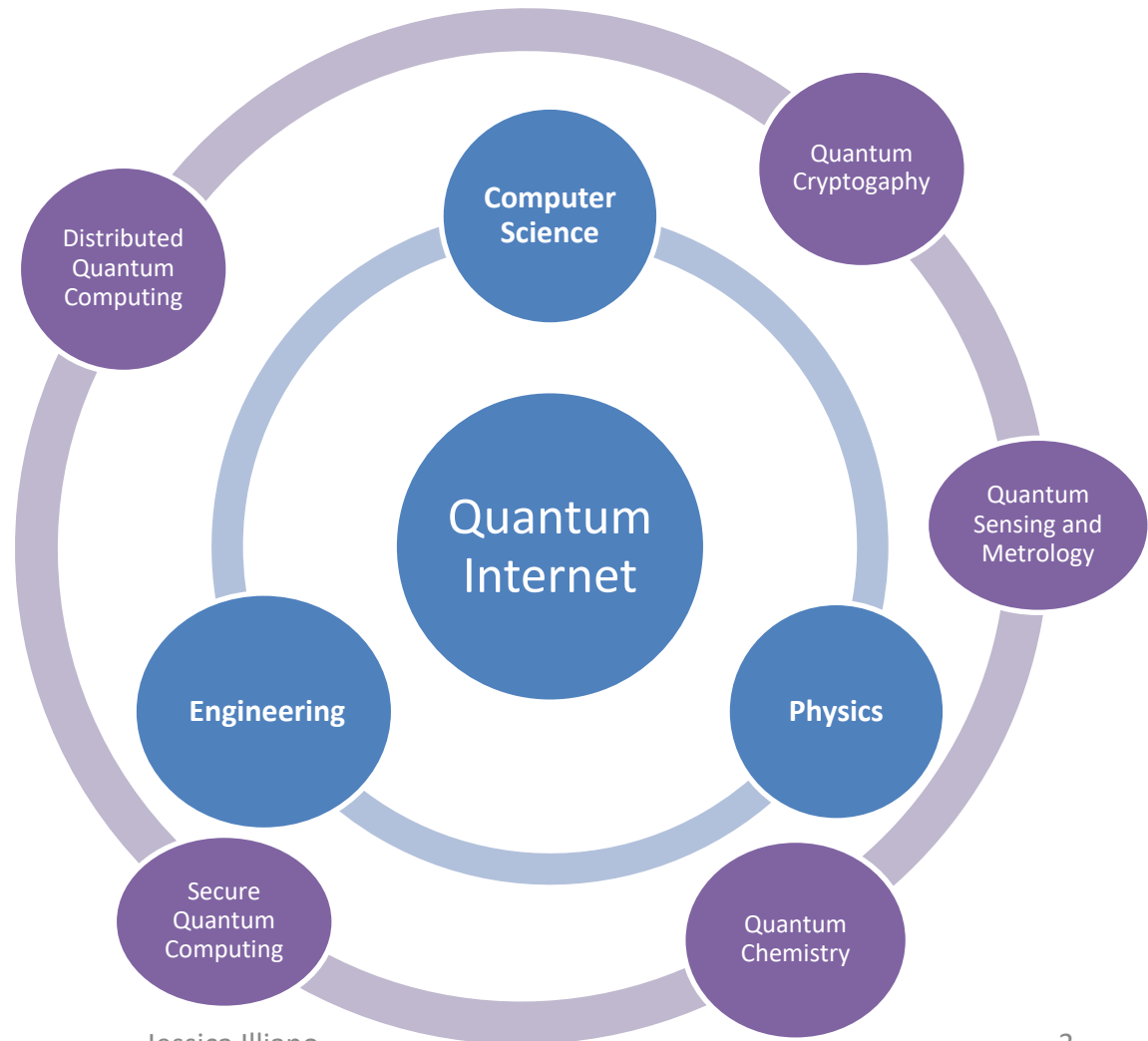
My background

- MSc degree in Telecommunication Engineering

- Quantum Internet Research group
  http://www.quantuminternet.it

- PhD start date: 1/11/2020

- Company funded Scholarship

- Partner company: TIM S.p.A.

Research field of interest: Quantum Internet

Quantum Network

Collection of nodes that is able to exchange qubits and distribute entangled states amongst themselves.

- Qubits
- No-Cloning Theorem
- Entanglement
- Quantum Teleportation Process

Quantum Internet

Computer Science

Quantum Cryptogaphy

Distributed Quantum Computing

Quantum Sensing and Metrology

Engineering

Physics

Secure Quantum Computing

Quantum Chemistry

Jessica Illiano

itee PhD
information technology
electrical engineering

Summary of study activities

- Course: Quantum Photonic Technologies
- Technical report:
  - Entanglement: a bridge between Quantum Communications and the Quantum Internet
  - Quantum Light States: a Telecommunication Engineering Perspective
- Seminars (partial list):
  - Entanglement transitions in the quantum Ising chain: a comparison between different unravelings of the same Lindbladian
  - Seeqc: the digital quantum computing company
  - The Quantum Internet: the quest for a network paradigm shift
- SQMS/GGI Summer School on Quantum Simulation of Field Theories
- Attended Conferences:
  - ACM NanoCom2022, 9th ACM International Conference on Nanoscale Computing and Communication Barcelona, Catalunya, Spain, October 5-7, 2022.
    - Conference paper "*Quantum Internet: the Dawn of the Quantum Paths*" presented

Research activity: Overview

- Problem:

The Quantum Internet is governed by the laws of quantum mechanics and it is based on phenomena with no counterpart in classical networks. This imposes new challenging constraints for network design. Specifically, classical network functionalities are based on the assumption that classical information can be safely read and copied. This assumption does not hold in the Quantum Internet. As a consequence, its design requires a major network-paradigm shift to harness the quantum mechanics specificities.
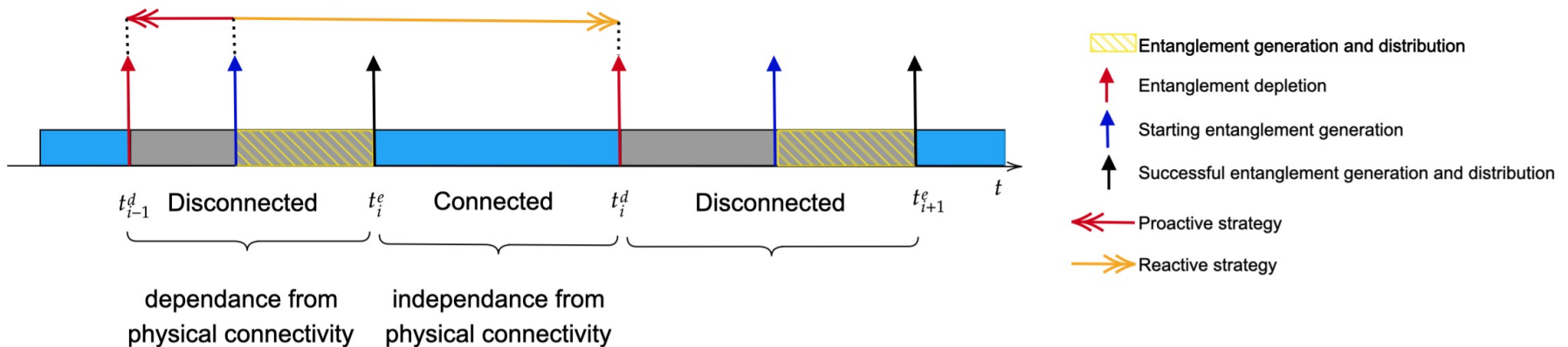
- Objective:
  - Abstract model for the Quantum Internet
  - Interplay between Quantum Internet and classical Internet
  - Entanglement-based protocols for network functionalities

- Methodology:
  - Study of the characterizing phenomena
  - System Model
  - Mathematical Analysis

Research activity: Abstract model for the Quantum Internet
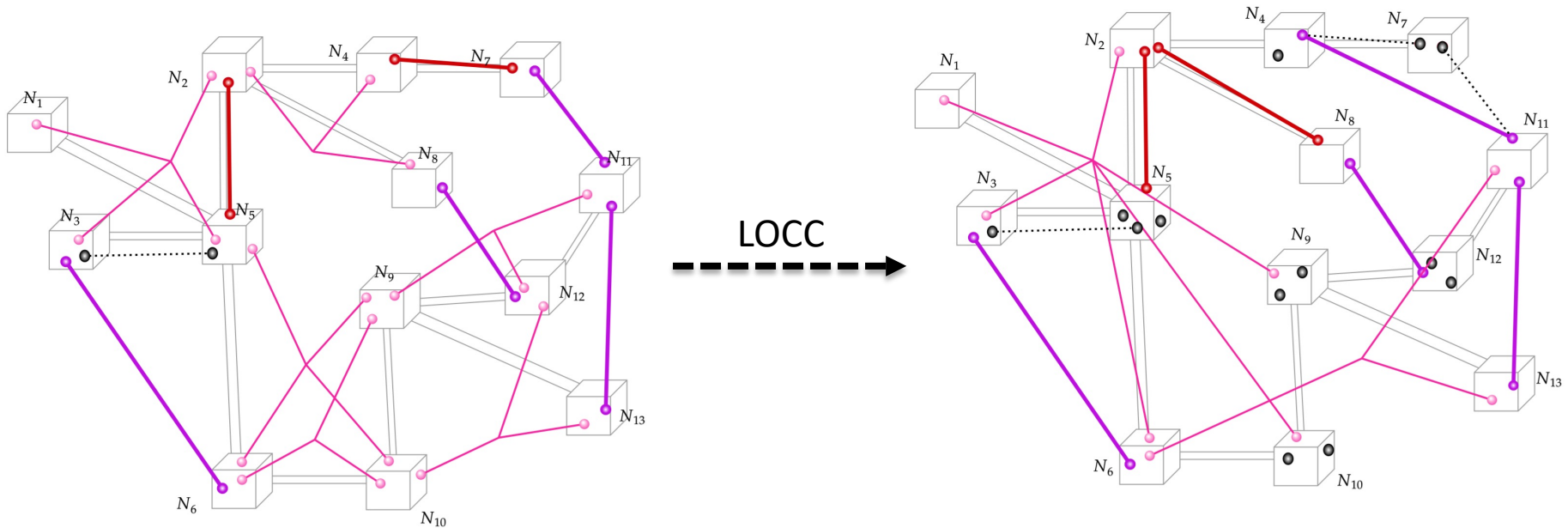
Entanglement-based Connectivity

EPR → Virtual Connectivity

J. Illiano, M. Caleffi, A. Manzalini, A. S. Cacciapuoti, "*Quantum Internet Protocol Stack: a comprehensive survey*", Computer Networks, p. 109092, 2022

Abstract model for the Quantum Internet
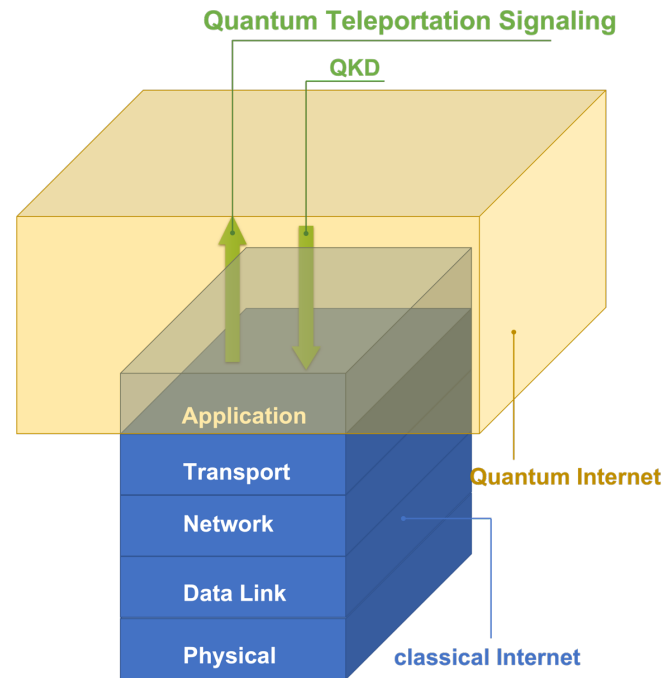
Entanglement-based Connectivity

LOCC

Entanglement Swapping → Augmented Connectivity
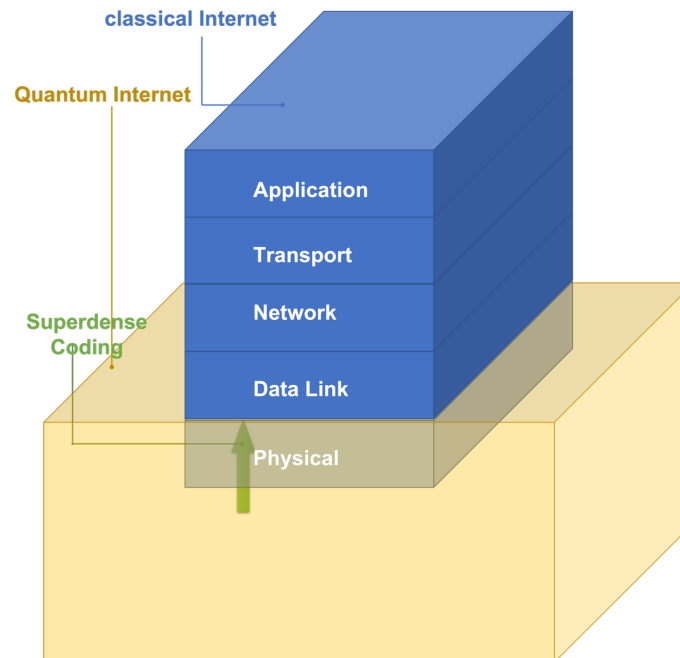
Multipartite Entanglement → On-demand Connectivity

Research Activity: Interplay between Quantum Internet and classical Internet

A. S. Cacciapuoti, J. Illiano, S. Koudia, K. Symonov, M.Caleffi "*The Quantum Internet: Enhancing Classical Internet Services one Qubit at a Time*" IEEE Network, 2022.
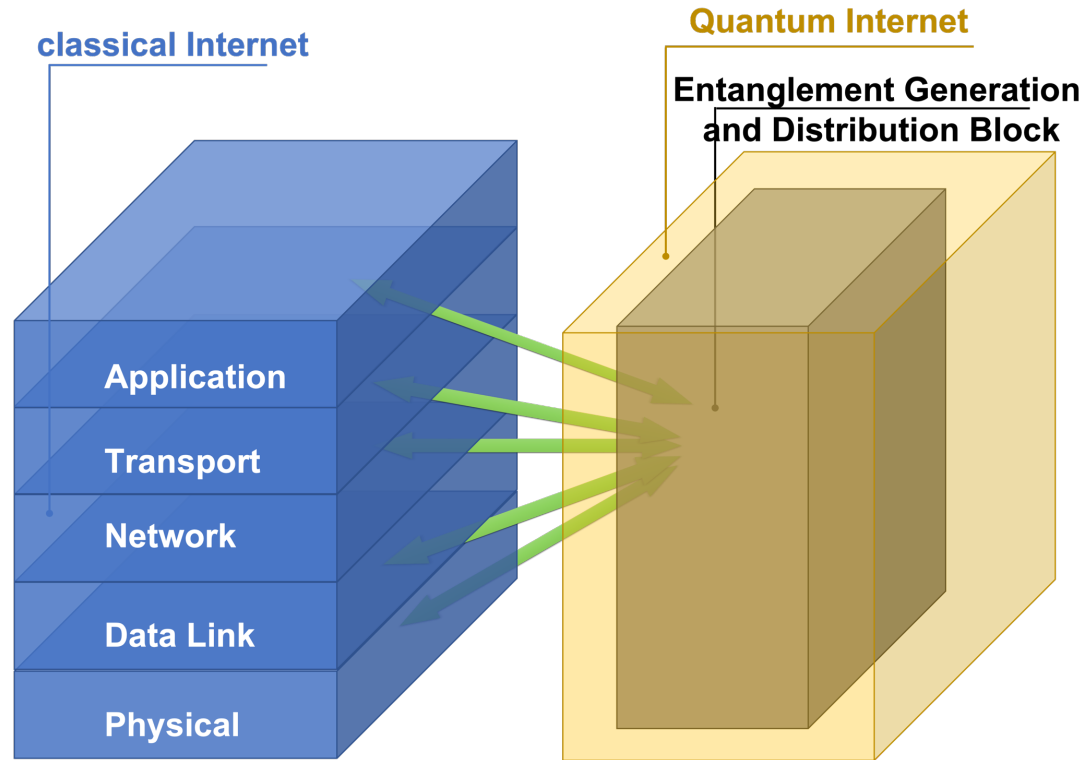
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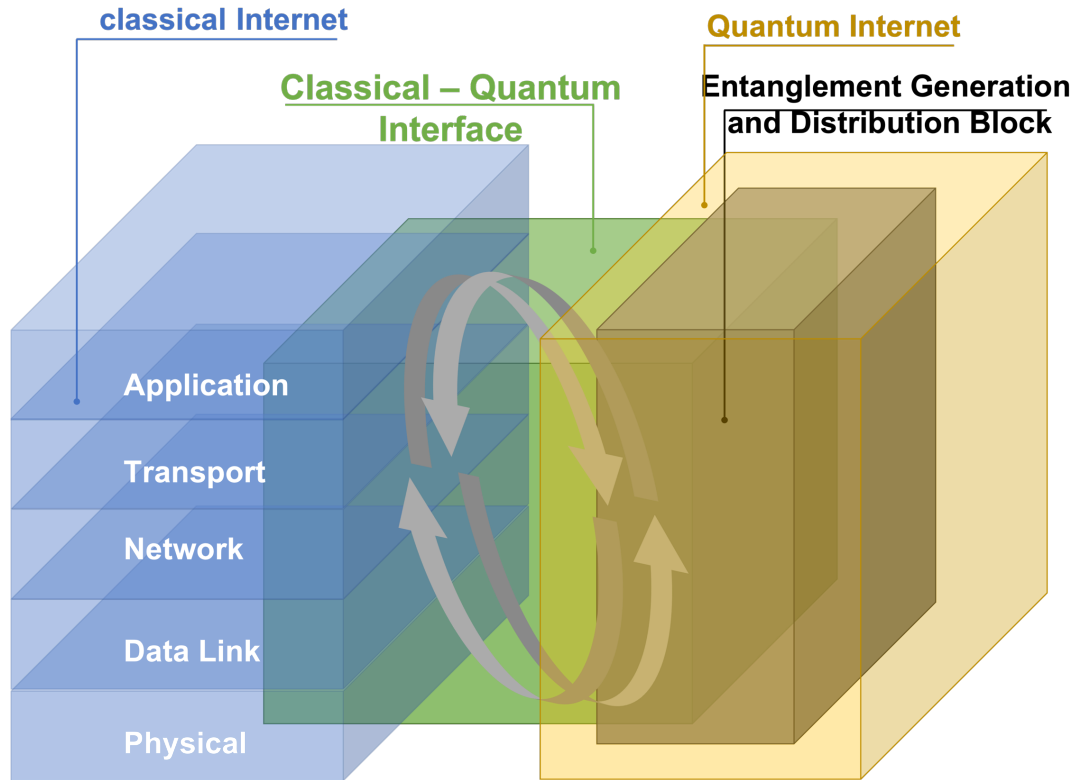
On the Network Protocol Stack for the Quantum Internet

classical Internet

Classical – Quantum Interface

Quantum Internet

Entanglement Generation and Distribution Block

Application

Transport

Network

Data Link

Physical

- No one-to-one mapping between classical network layers and quantum network functionalities
- Cross-layer interactions between classical Internet and Quantum Internet

A. S. Cacciapuoti, J. Illiano, S. Koudia, K. Symonov, M.Caleffi "*The Quantum Internet: Enhancing Classical Internet Services one Qubit at a Time*" IEEE Network, 2022.

Research activity: Entanglement-based Protocols for Network Functionalities

Entanglement Access Control Protocol
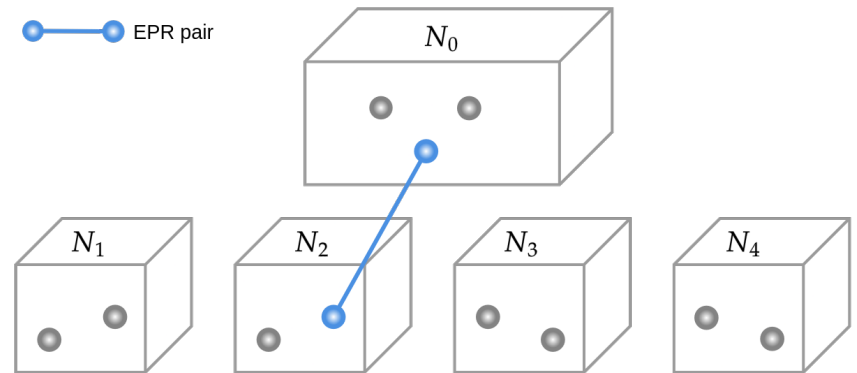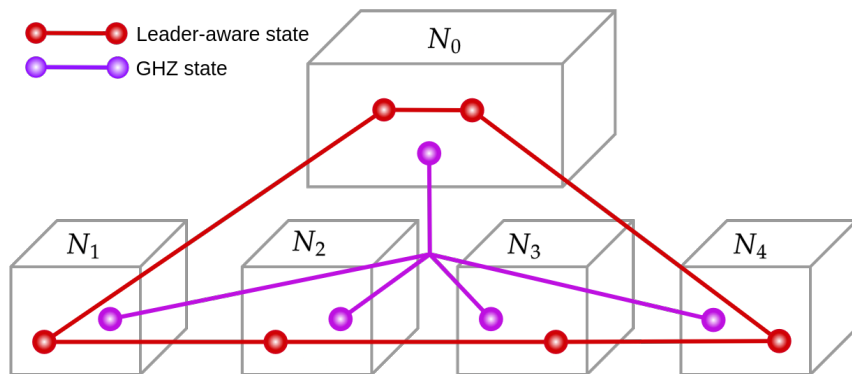
- Contention Resolution
- Communication
- Anonymity

J. Illiano, M. Viscardi ,S. Koudia, M. Caleffi " *Quantum Internet: from Medium Access Control to Entanglement Access Control*" *Proc. of* IEEE GLOBECOM '22 Dec. 4-8, 2022.
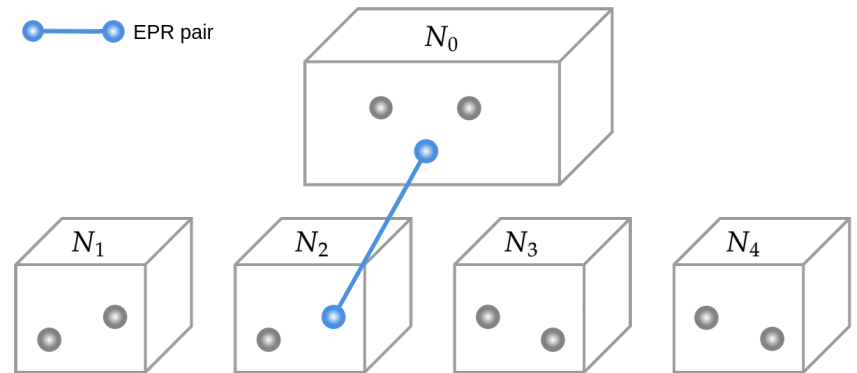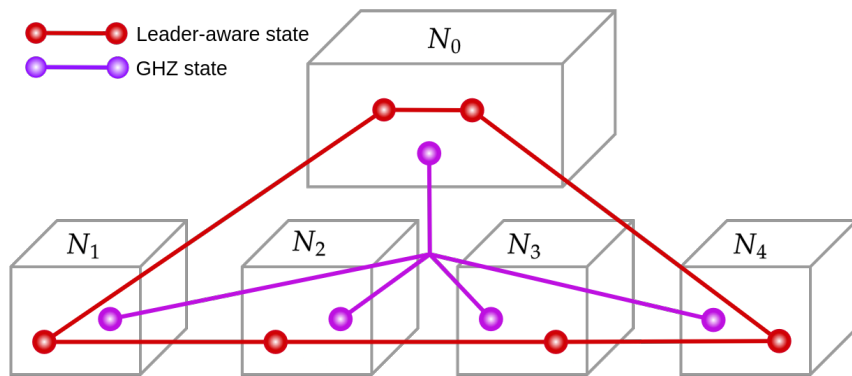
Next Year

- Internship Nu-Quantum Ltd
  - Entanglement scheduling for multichip BSM-based architectures
- Entanglement Access Control
  - Theoretical model and experimental validation
- Classical—Quantum Interface protocols

Products

[1]	J. Illiano, M. Caleffi, A. Manzalini, A. S. Cacciapuoti, "*Quantum Internet Protocol Stack: a comprehensive survey*", Computer Networks, p. 109092, 2022
[2]	A. S. Cacciapuoti, J. Illiano, S. Koudia, K. Symonov, M.Caleffi "*The Quantum Internet: Enhancing Classical Internet Services one Qubit at a Time.*" IEEE Network, in press, 2022
[3]	J. Illiano, M. Viscardi ,S. Koudia, M. Caleffi " *Quantum Internet: from Medium Access Control to Entanglement Access Control.*" Proc. of IEEE GLOBECOM '22 Dec. 4-8, 2022.
[4]	A.S. Cacciapuoti, J. Illiano, M. Viscardi, M. Caleffi, "*Quantum Internet: the Dawn of the Quantum Paths*", Invited Paper, Proc. Of ACM NANOCOM , 2022

Research activity: Entanglement-based Protocols for Network Functionalities

Entanglement Access Control Protocol

- Contention Resolution
- Communication
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