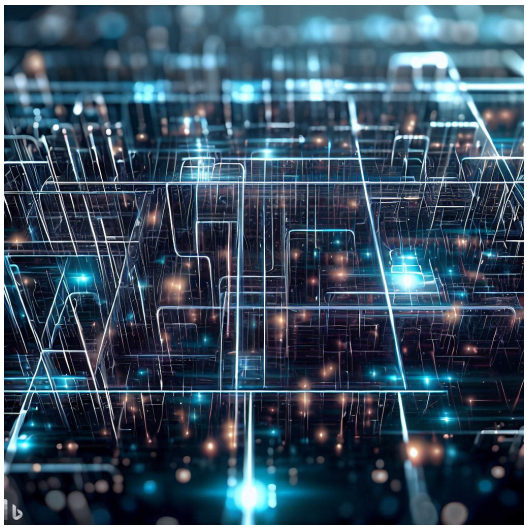
NQSTI – Quantum Internet



Background

The application of quantum systems to computing and communication is pushing research into a new era of unlimited possibilities. The Quantum Internet will accelerate the development of quantum computing applications by pooling the (initially scarce and dispersed) quantum computation resources. At the same time, forthcoming distributed consensus schemes and unconditionally secure communications will advance the features offered by classical communication/computation infrastructures, leading to novel exciting opportunities. However, the nascent quantum networks have several research challenges ahead, which will need significant progress in science and technology, including solutions to combat the inherent fragility of communications; algorithms for a smart allocation of resources to best use the relatively limited capabilities; innovative communication protocols that work well with the sparse deployments due to the incremental adoption of technologies in the field; and, the definition of Application Programming Interfaces (APIs) that overcome the difficulty of interoperability between systems due to the lack of best practices and standards in the area.

Topic description

Quantum Internet research activities span across an area largely defined by the target technology transfer timeframe, which, in turn, depends on whether end-to-end entanglement through quantum repeaters is required to expand the quantum network beyond single-link direct communications.

Quantum Key Distribution (QKD) can be deployed on a geographical scale without quantum repeaters (substituted by trusted nodes), hence it is suitable for short-term adoption. However, the integration of QKD network network elements (devices, trusted relay nodes, key management systems, etc.) with classical devices and systems is an open research area, which can be addressed in this topic in different directions: support of Software Defined Networking (SDN) architectures; commoditisation of resources for QKD-enabled unconditional security and edge-cloud computation offloading through joint allocation/scheduling; exploration of the serverless paradigm, which foresees a stateless execution of elementary functions that are not bound to a specific computation node; optimal operation of hybrid architectures including Measurement Device Independent (MDI) stations.

On the other hand, the long-term vision of the Quantum Internet encompasses the opportunity to enable end-to-end entanglement between qubits physically located on remote quantum computers interconnected through a network of quantum repeaters. This opens the door to many more new applications, which would not be feasible otherwise, such as distributed/blind quantum computing, but also requires a more radical approach to the design of architectures and protocols to be used, which may be fundamentally different

from what we use today in the Internet, such as TCP/IP. In this topic, there are several investigation opportunities: definition of architectures and management interfaces for local/metropolitan/wide-area quantum networks; design and evaluation of centralised/distributed algorithms for the optimisation of the Quantum Internet operation; definition and analysis of link-/network-layer quantum routing protocols and their interaction with the application layer; scouting and experimentation with novel applications enabled by the Quantum Internet.

Type of prospect postions

We plan to open positions at the level of **Post-doc Research Fellow** on this topic.

Funding and partnerships

The activities of this topic are supported by the National Quantum Science and Technology Institute (**NQSTI**), funded by the National Recovery and Resilience Plan (NRRP) – European Union (NextGenerationEU), and they will establish strategic partnerships with the European project Quantum Italy Deployment (QUID).

Candidate profile

Ideal candidates should have, or be about to obtain, a PhD in Computer Science, Computer Engineering, Telecommunications Engineering, Mathematics, Physics, or closely related disciplines, and a proven track record of excellent scientific publications. Preferably, the PhD should be in one of the relevant research areas: quantum communications, quantum network architectures and protocols, or management of classical communications/computation infrastructures. Knowledge of quantum computing, though preferable, is not a prerequisite for application. Good written and spoken communication skills in English are required.

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