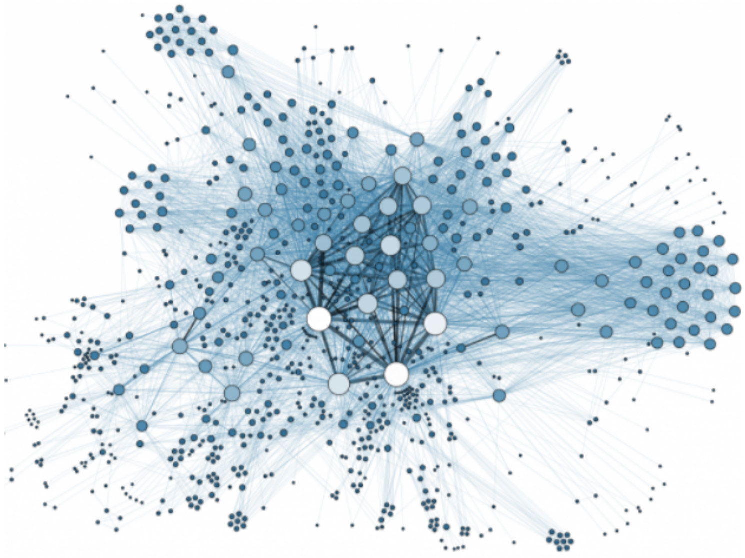
Proposta di Tesi di Laurea Magistrale

Quantum Network Topology identification



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The aim of this thesis proposal is to develop a general framework probing the connectivity structure (geometry) of a complex network via quantum multi-probing schemes, transferring methodologies from the classical scenario to the quantum one, hence moving further steps towards novel quantum technologies for metrology, information and communication science. A large collection of dynamical systems (or nodes), which communicate and/or interact with each other and usually are spatially distributed, is known as a complex network. In the last decade in several fields of science, as for example biology, chemistry, information science and physics, complex quantum networks have been introduced and studied to properly model the transport properties of energy or information. Quantum networks, for instance, are the cornerstone of quantum computing and cryptography, in which specific sets of network nodes can be able to process information as quantum logic gates.

The behavior of many dynamical quantum processes running over complex networks are closely related to the underlying geometry of the nodes (network topology), but this connection is even harder to understand when quantum effects come into play. As remarkable example, very recently it has been found that quantum effects play a crucial role in the efficient energy transport phenomena in light-harvesting complexes, where quantum coherence and dephasing noise strongly cooperate to enhance the transmission of energy. Due to the complexity of the system, even in a classical framework, measuring the interconnection of each individual system of the network is an infeasible task. Accordingly, the goal of this proposal is to design mathematical models and algorithms for the identification of the topology of a quantum dynamical network, for which the theories of system identification, open quantum systems, and quantum state estimation will have to be used.

In particular, the following objectives will be taken into account: (i) To design multi-probing schemes for the identification of the connectivity structure of a quantum network on the basis of available observation data, starting from the Schrödinger equation for the quantum dynamical evolution over the network. (ii) To investigate under what conditions and to what extent one can infer the underlying connectivity structure of a quantum network from the observation data collected by a fraction of nodes. (iii) To determine, by optimization routines, the minimum number of probes (e.g. entangled two-level quantum systems) necessary for topology identification, in the underlying case that only few components of the network are accessible.