Quantum-enhanced SDN Management, Control, and Orchestration

Description

An important trend for telecommunication networks and systems (e.g., 5G and 6G in the long term) is the evolution toward the execution of virtualized network functionalities and services with Cloud-Edge Computing. This will increase network flexibility and programmability but will in turn make management, control, and orchestration more complex, thus requiring automatic procedures and Artificial Intelligence methods and systems. This approach, based on Software Defined Networking (SDN) and Network Function Virtualization (NFV) is currently used in classical networks but will also most likely be used in integrated quantum-classical networks.

In the envisioned scenarios, NFV services - which provide basic networking functions - are executed as "chains" of (micro-)tasks that may be deployed closer to end-users (Edge) or more centralized (Cloud). SDN assumes the higher-level management responsibility to orchestrate overall network operations.

For scalability and reliability, the logically centralized control plane is often realized via multiple SDN controllers, forming a distributed system. There is one SDN controller per site, managing both intra and inter-site operations. Replicated databases are used, so that SDN controllers maintain an up-to-date copy of the global knowledge, thus acting as a single logical entity. To perform critical operations such as writing on such replicated databases or assigning an IP in an inter-site network, there should be a leader to take consistent decisions among all controllers.

Therefore, a Leader Election functionality must be implemented. A relevant classical consensus protocols for Leader Election is RAFT, which has two main issues: 1) it can be seriously impacted by network failures, and 2) it may create traffic overload due to the number of messages exchanged.
The Quantum Leader Election (QLE) protocol represents a valid alternative.

Quantum advantage

Classically, there is no reliable way to handle malfunctioning nodes so that each of the other nodes will have a fair chance of being elected, while it is possible using quantum protocols.