Modeling and Performance Evaluation of a Quantum Switch

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Résumé

Entanglement is an essential component of quantum computation, information, and communication. Its applications include quantum cryptography, distributed quantum computing, and quantum sensing (e.g., multipartite entanglement for
quantum metrology and spectroscopy). These applications drive the increasing need for a quantum switching network that can supply end-to-end entanglement to groups of endpoints that request them. To realize such quantum systems, several architectures have been proposed to support high entanglement generation rates, high fidelity, and long coherence times.

In this lecture, we focus on the most basic and fundamental component of a quantum network – a single quantum switch that serves k users in a star topology. Each user has a dedicated link connected to the switch. In the most
general case, the switch serves n-partite entangled states to sets of users according to incoming requests, where n $\leq$ k. To achieve this, link-level entangled states are generated at a constant rate across each link, resulting in two-qubit
maximally-entangled states (i.e., Bell pairs or EPR states). These qubits are stored at local quantum memories: one from each Bell pair at the user and the other one at the switch. We consider the algorithm where the switch performs
multi-qubit measurements to provide end-to-end entanglement to user groups of size n when enough of these bipartite states are accrued (at least n of them).

Various models and their main performance (e.g. end-to-end entanglement rate, number of stored qubits at the switch) will be discussed under a number of structural (e.g. finite/infinite storage capabilities, homogeneous/heterogeneous
links), modeling (e.g qubit decoherence) and statistical assumptions.

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