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Quantum Computing with Qudits on a Graph

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Abstract : Building a scalable platform for quantum computing remains one of the most challenging tasks in quantum science and technologies. However, the implementation of most important quantum operations with qubits (quantum analogues of classical bits), such as multiqubit Toffoli gate, requires either a polynomial number of operation or a linear number of operations with the use of ancilla qubits. Therefore, the reduction of the number of operations in the presence of scalability is a crucial goal in quantum information processing. One of the most elegant ideas in this direction is to use qudits (multilevel systems) instead of qubits and rely on additional levels of qudits instead of ancillas. Although some of the already obtained results demonstrate a reduction of the number of operation, they suffer from high complexity and/or of the absence of scalability. We show a strong reduction of the number of operations for the realization of the Toffoli gate by using qudits for a scalable multi-qudit processor. This is done on the basis of a general relation between the dimensionality of qudits and their topology of connections, that we derived.

Keywords : quantum computing, qudits, Toffoli gates, gate decomposition
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