CC-03-02

Entanglement-efficient bipartite-distributed quantum computing

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Abstract

We investigate distributed quantum computation (DQC) between two quantum computers connected via a quantum communication channel. By analyzing the distributed implementation of a global quantum circuit through entanglement-assisted local operations and communication, we develop an algorithm to reduce the quantum communication cost given by the entanglement cost in DQC. Our work extends the protocol introduced in [Eisert et al., Phys. Rev. A 62, 052317 (2000)], which implements each nonlocal controlled-unitary gate locally with a single maximally entangled pair, into a packing protocol capable of consolidating multiple nonlocal controlled-unitary gates locally using just one maximally entangled pair. We propose heuristic algorithms for finding an entanglement-efficient packing of distributed operations for a given quantum circuit to be executed by two quantum computers. When applied to the bipartite DQC of unitary coupled-cluster circuits, these algorithms yield a significant reduction in entanglement costs. This method establishes a constructive upper bound on the entanglement cost for DQC of quantum circuits and can be extended to DQC across multiple quantum computers.

Reference: J-Y Wu, K. Matsui, T. Forrer, A. Soeda, P. Andrés-Martínez, D. Mills, L. Henaut and M. Murao, Entanglement-efficient bipartite-distributed quantum computing with entanglement-assisted packing processes, Quantum 7, 1196 (2023)