Quantum Fourier Transform using Dynamic Circuits

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Abstract

In dynamic quantum circuits, classical information from mid-circuit measurements is fed forward during circuit execution. This emerging capability of quantum computers confers numerous advantages that can enable more efficient and powerful protocols by drastically reducing the resource requirements for certain core algorithmic primitives. In particular, in the case of the n-qubit quantum Fourier transform followed immediately by measurement, the scaling of resource requirements is reduced from $O(n^2)$ two-qubit gates in an all-to-all connectivity in the standard unitary formulation to O(n) mid-circuit measurements in its dynamic counterpart without any connectivity constraints (as first described in [1]). Here, we demonstrate the advantage of dynamic quantum circuits for the quantum Fourier transform on IBM's superconducting quantum hardware with certified process fidelities of >50\% on up to 16 qubits and >1\% on up to 37 qubits, exceeding previous reports across all quantum computing platforms. These results are enabled by our contribution of an efficient method for certifying the process fidelity, as well as of a dynamical decoupling protocol for error suppression during mid-circuit measurements and feed-forward within a dynamic quantum circuit that we call ``feed-forward-compensated dynamical decoupling'' (FC-DD). Our results demonstrate the advantages of leveraging dynamic circuits in optimizing the compilation of quantum algorithms.

References

[1] R. B. Griffiths and C.-S. Niu, Physical Review Letters 76, 3228–3231 (1996).

Figures

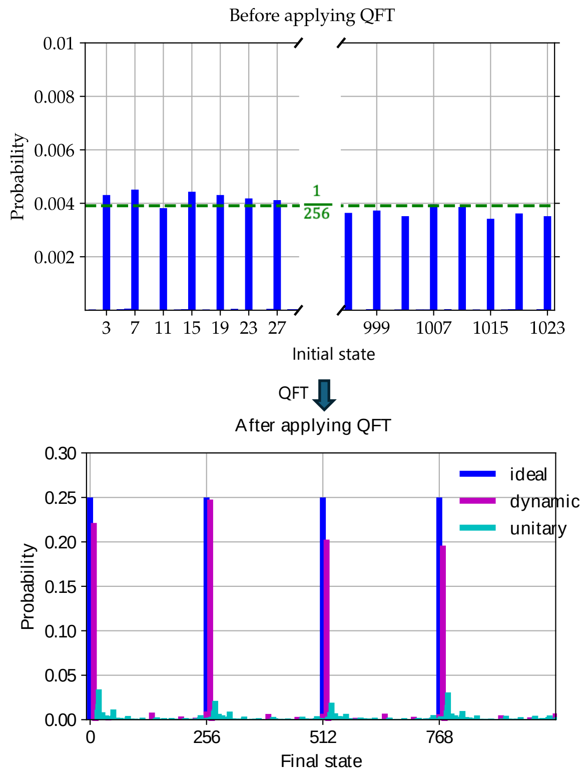

Figure 1: The quantum Fourier transform followed by measurement applied to a periodic state implemented with unitary vs. dynamic quantum circuits.