Implementation of Parallel Arbitrary Single-qubit Gates on High-qubit-count Processors Using a Truly Scalable Control Stack

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Controlling large quantum processors is an engineering challenge for the entire control stack, and simple steps like calibrating simultaneous single-qubit gates may become computationally prohibitive due to crosstalk and interaction between qubits, which requires characterizing and optimizing a number of combinations of gates (i.e., cycles [1]) that grows exponentially with the number of qubits.
In this talk we introduce the necessary hardware and software components of a truly scalable control stack, and we describe a practical methodology to calibrate parallel arbitrary single-qubit gates in large processors. The method uses parallel rabi oscillations experiments and state tomography to obtain high-tolerance X90 gates. The result can be fed into a fully customizable circuit compiler to create arbitrary single-qubit gates in any number of qubits in parallel (i.e., any arbitrary single-qubit gate cycle), using gate decomposition with virtual Z gates. The result can be tested using Cycle Benchmarking (CB) and K-body Noise Reconstruction (KNR), an advanced crosstalk analysis tool.

References

[1] Characterizing large-scale quantum computers via cycle benchmarking. Nat. Commun., 10:5347 (2019)

Figures

Figure 1: A modular and scalable control system hardware

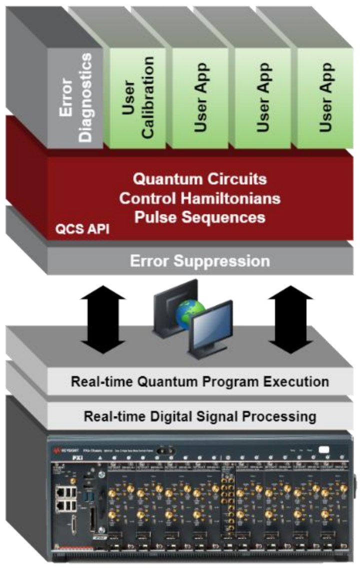

Figure 2: A software stack with custom gate decomposition linkers

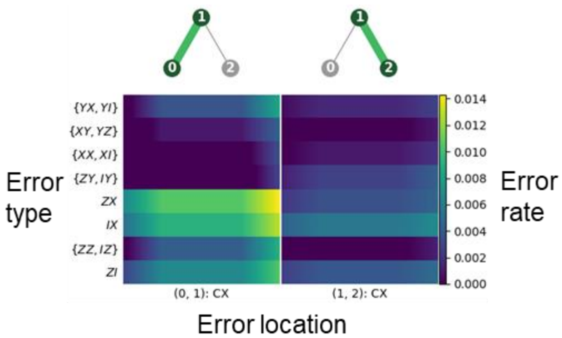

Figure 3: K-body Noise Reconstruction (KNR) example