

Quantum computing (QC) is a new paradigm offering exponential speedups over classical computing for certain computational problems. With each additional qubit, the size of the computational state space available to a QC algorithm doubles. This exponential scaling underlies QC's power, but as a result, classical simulation of circuits produced by quantum algorithms does not scale well. Furthermore, the set of quantum circuits that can be reliably run on today's Noisy Intermediate-Scale Quantum (NISQ) devices is limited by their characteristics that include low qubit counts, and noise and qubit quality that varies from qubit to qubit.

We propose HyQC, a hybrid computing approach that combines classical computing and NISQ quantum computers to enable evaluation of quantum circuits that could not be run on classical or quantum computers alone. HyQC cuts large quantum circuits into smaller ones, enabling the use of smaller quantum devices, or use of the best qubits on a large quantum chip. A classical host computer then post-processes the results to reconstruct the output of the original circuit. With this approach, we show up to 687X speedup compared to purely classical simulations, and also demonstrate evaluation of quantum circuits that are twice the size of NISQ devices. Furthermore, we demonstrate using real-system runs the HyQC approach improves fidelity by up to 67X on state-of-the-art NISQ devices. Overall, this hybrid approach allows users to leverage classical and quantum computing resources to expand the set of circuits that can reliably be run on modern devices.