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A Hardware-aware Heuristic for the Qubit Mapping Problem in the NISQ Era

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Hardware-aware (HA) mapping transition algorithm.

Cost function

\[ H = \frac{1}{|F|} \sum_{g \in F} D(\rho(g, q_1), \rho(g, q_2)) + W \times \frac{1}{|E|} \sum_{e \in E} D(\rho(g, q_1), \rho(g, q_2)) \]

Distance matrix

\[ D = \alpha_1 \times S + \alpha_2 \times \varepsilon + \alpha_3 \times T \]

- \( S \): SWAP matrix, \( \varepsilon \): SWAP error matrix, \( T \): SWAP execution time matrix

Selection between SWAP and Bridge gate.

Motivation

- NISQ devices.
- Connectivity constraint: Nearest-neighbor connections.
- Different physical qubits: various calibration data.
- Qubit mapping problem: Adapting a quantum program to given hardware connectivity.

Introduction

Methods

- Hardware-Aware (HA) mapping transition algorithm.
- Cost function
- Distance matrix
- Selection between SWAP and Bridge gate.

Results

- Comparison of number of additional gates on IBM Q 20 Almaden (large benchmarks).

Conclusion

- Map the most used qubit of the mapped circuit to the most connected physical qubit.
- Apply CNOT gates on qubits that are directly connected and with reliable interconnects.
- If a CNOT cannot be applied on two neighbor qubits, apply on two qubits whose distance is two.

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