



THE QUBIT MAPPING PROBLEM

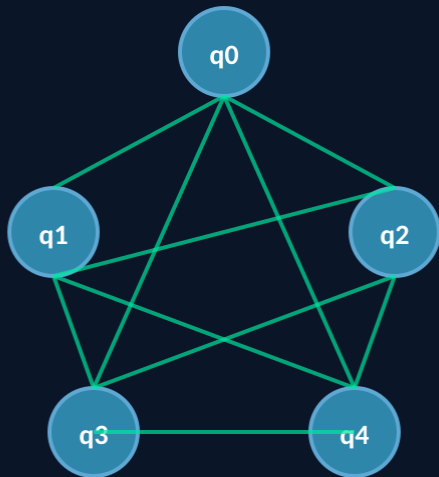
Compiling Quantum Algorithms for NISQ-Era Devices

Based on Li, Ding & Xie · ASPLOS 2019

THE CORE PROBLEM

Algorithms assume full connectivity. Hardware doesn't.

Logical Interaction Graph

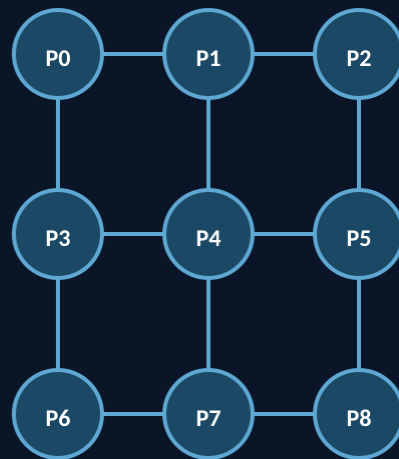


Any qubit can interact with any other

≠

MISMATCH

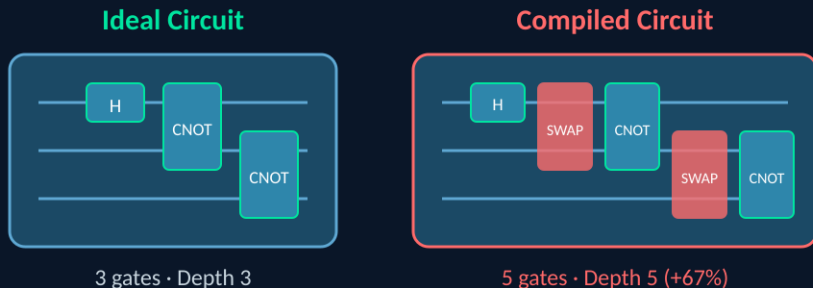
Physical Coupling Graph



Only nearest-neighbor interactions

WHY IT MATTERS IN NISQ

SWAP Gate Overhead



NOISY GATES

Every additional gate introduces error. SWAPs compound noise, reducing fidelity.



SHORT COHERENCE

Deeper circuits risk qubit decoherence. Excess depth from SWAPs wastes precious time.

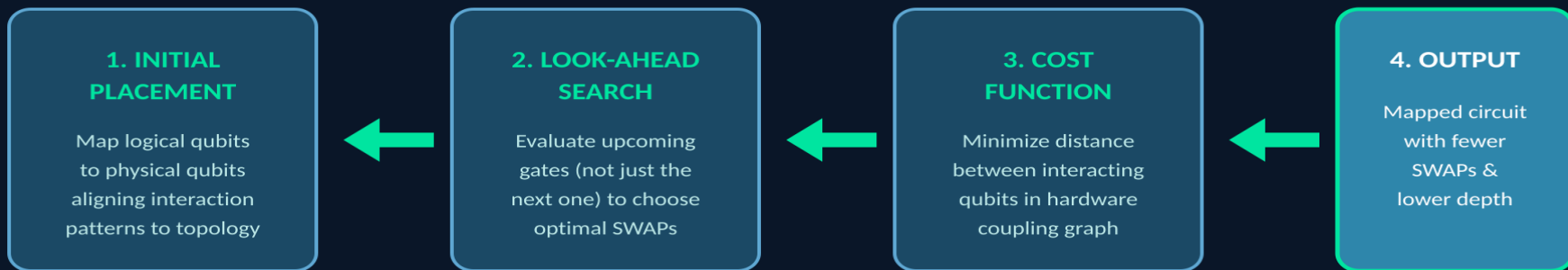


NO ERROR CORRECTION

NISQ devices lack full error correction. Compilation overhead directly degrades results.

THE SOLUTION: HEURISTIC SEARCH

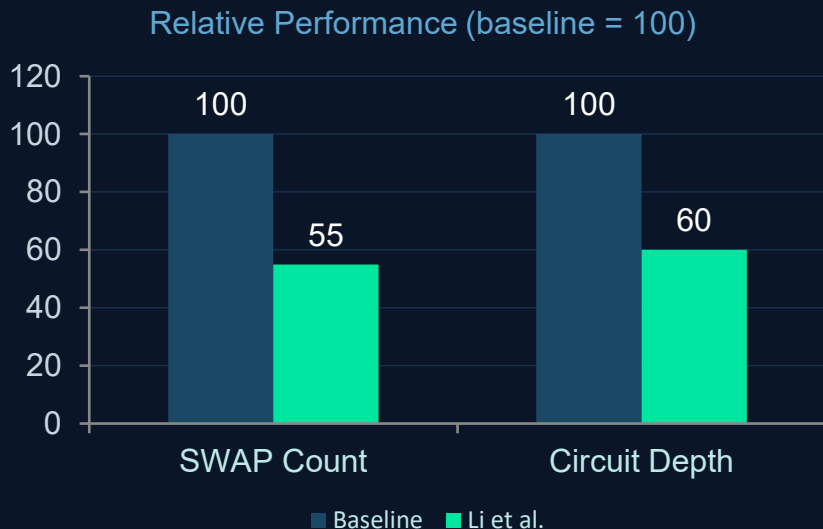
Look ahead, not just at the next gate



Heuristic search-based mapping algorithm (Li, Ding & Xie, ASPLOS 2019)

	Greedy Approach	Heuristic Search (Li et al.)
Decision basis	Next gate only	Multiple upcoming gates
Quality	Locally optimal, globally poor	Better global decisions
Tradeoff	Fast but wasteful	More compute, fewer SWAPs

RESULTS & IMPLICATIONS



QFT

Long-range interactions make mapping overhead dominate. Efficient compilation is essential.



VQE / QAOA

Repeated execution amplifies inefficient mappings. Even small SWAP reductions compound over thousands of iterations.



Co-Design Imperative

Algorithm design and hardware-aware compilation must be coordinated. Compilation is a core part of performance, not an afterthought.

KEY TAKEAWAYS

01 The Mapping Problem

Logical qubit interactions must be embedded onto hardware with limited connectivity — creating unavoidable routing overhead.

02 NISQ Makes It Critical

Noisy gates, short coherence, no error correction. Every extra SWAP directly hurts fidelity and success probability.

03 Look-Ahead Beats Greedy

By considering future gates (not just the next one), the heuristic search algorithm consistently reduces SWAPs and circuit depth.

04 Compilation = Performance

In the NISQ era, compilation is not an afterthought. It is a core determinant of whether an algorithm succeeds on real hardware.