Quantum Circuit Simulation:

Balancing Efficiency through Dynamic Method Selection and Database Integration

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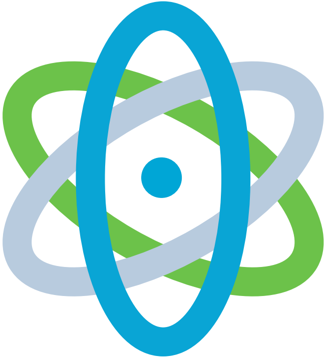


Introduction

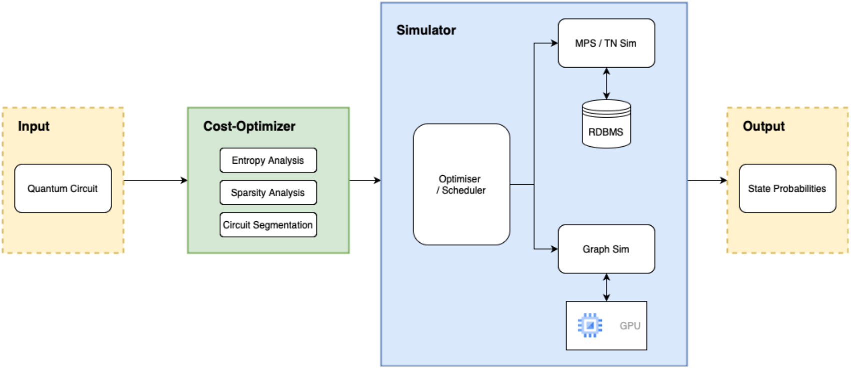
Motivation:

- Simulating quantum circuits is critical as quantum computing advances.
- Different methods (e.g., Tensor Networks, Graph-based) excel under specific conditions.
- Need for a unified system to optimize simulation dynamically.

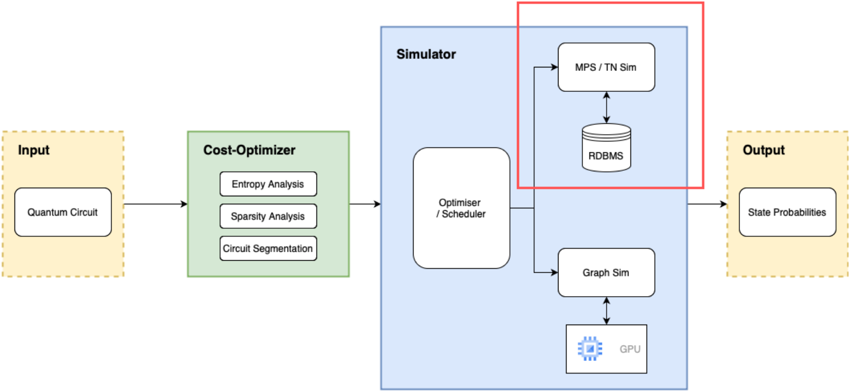
Our Proposal:

- Hybrid framework dynamically selects simulation methods based on metrics like Schmidt rank and sparsity.
- Integration of relational databases for managing tensor contractions.
- Scalability improvements for larger quantum circuits.

Proposed Architecture



Proposed Architecture



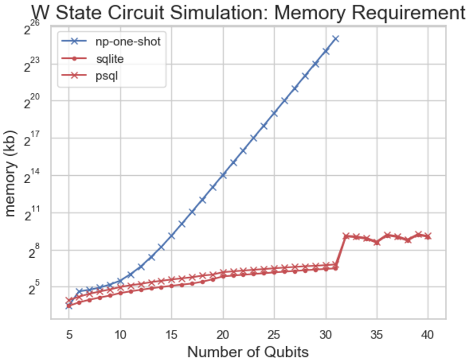
Proposed Architecture

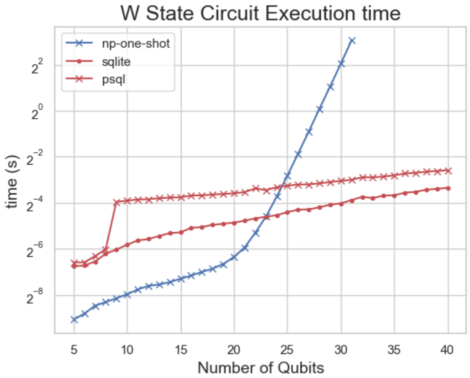
Key Components:

- **Cost-Optimizer:** Analyzes entropy, sparsity, and segments the circuit.
- **Simulator:** Dynamically selects:
  - Matrix Product State (MPS) / Tensor Networks (TN).
  - Graph-based or dense circuit simulation (leveraging GPU acceleration).
- **Relational Database (RDBMS):** Stores and manages tensor data for efficient contractions.

Preliminary Results: W State preparation (sparse)

$$|\Psi_n\rangle = \frac{1}{\sqrt{n}} |00..01\rangle + |00..10\rangle + \ldots + |01..00\rangle + |10..00\rangle$$





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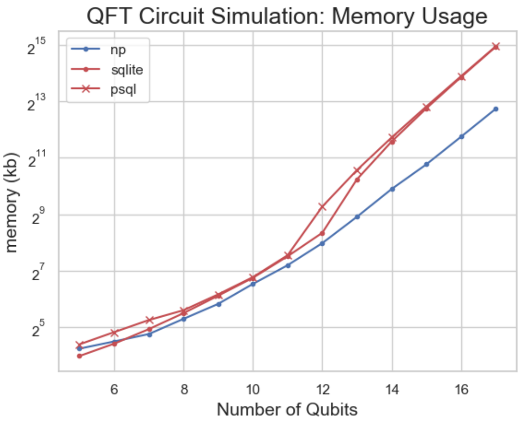
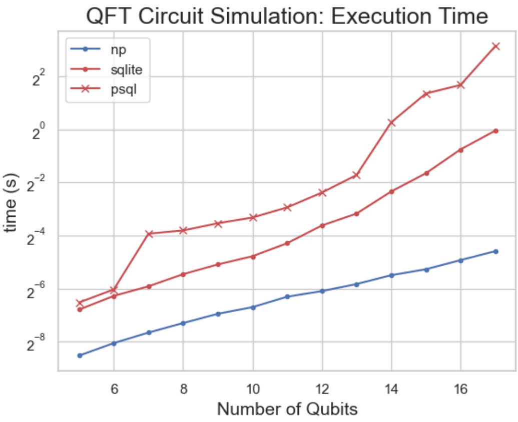
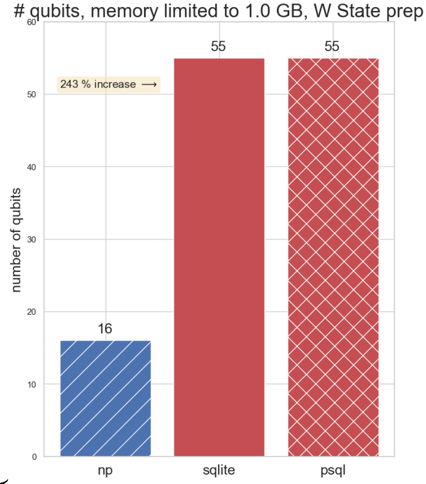
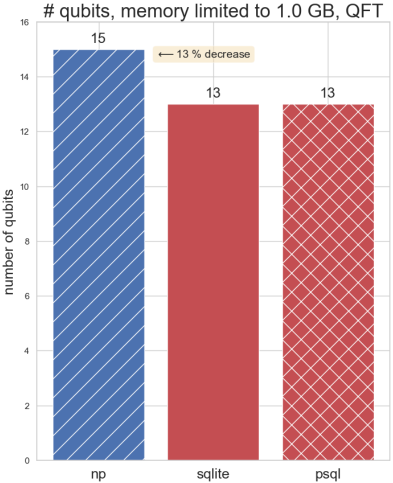
Preliminary Results: QFT Circuit (dense)





Preliminary Results: Limited Memory





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