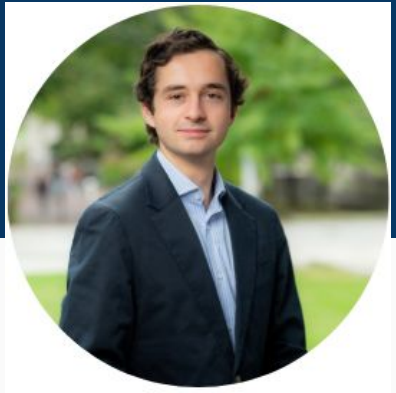
Brown Quantum Initiative 2025 Hackathon

Brown University

The Team



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Undergraduate Student

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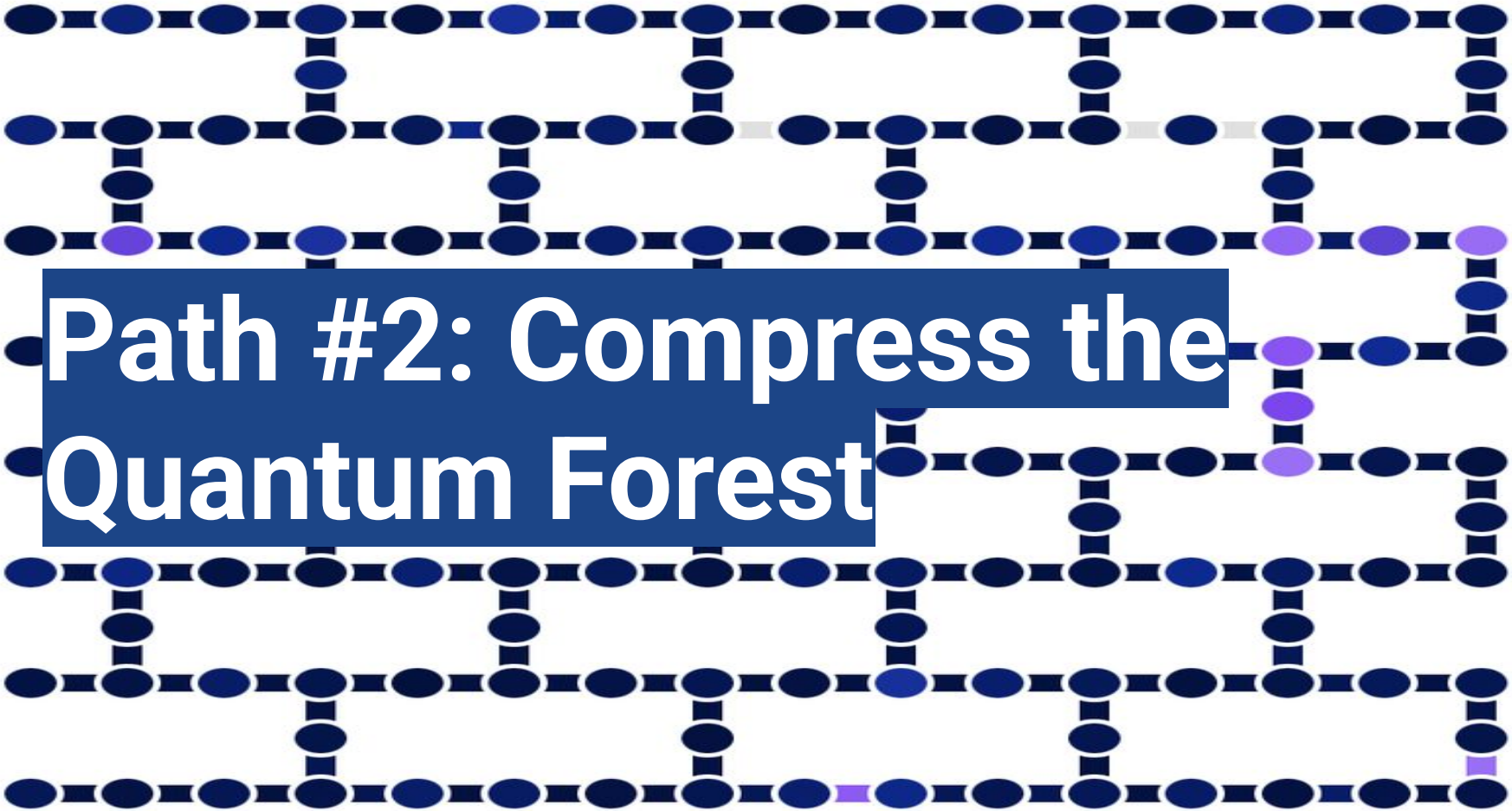
Aradhya Jain

Undergraduate student

Bachelors of Science (Physics and Applied Math)

Bruno’s Path

https://drive.google.com/file/d/1TyWJnL0SvIzFtdy1Ea7KC_Pii0K1IKdJ/view?usp=sharing


Path #2: Compress the Quantum Forest

The problem

Three quantum circuits are provided, and the following question is posed: What is the most efficient representation of these circuits for two different architectures?

Methodologies and tools

We used an open source tool called Qiskit to optimize the circuits

Qiskit’s “transpile” method can be used to efficiently optimize each circuit for both architectures!

How Does this Transpilation Work?

Step 1: Unroll the circuit

- Rewrite all quantum gates in terms of the computer's basis gates
  - Quantinuum H1-2: R, RZZ
  - IBM Fez: CZ, I, RZ, SX, X

Step 2:

- Map quantum operations (logical qbits) onto hardware (physical qbits)
- Minimize the total distance between interacting qbits by
  - Placing heavily interacting qbits close together
  -

How Does this Transpilation Work?

Step 3: Unroll the circuit

- Merge consecutive rotations (Rz(a) + Rz(b) = Rz(a+b))
- Cancel consecutive inverses (H + H = I)

Note on determinism:

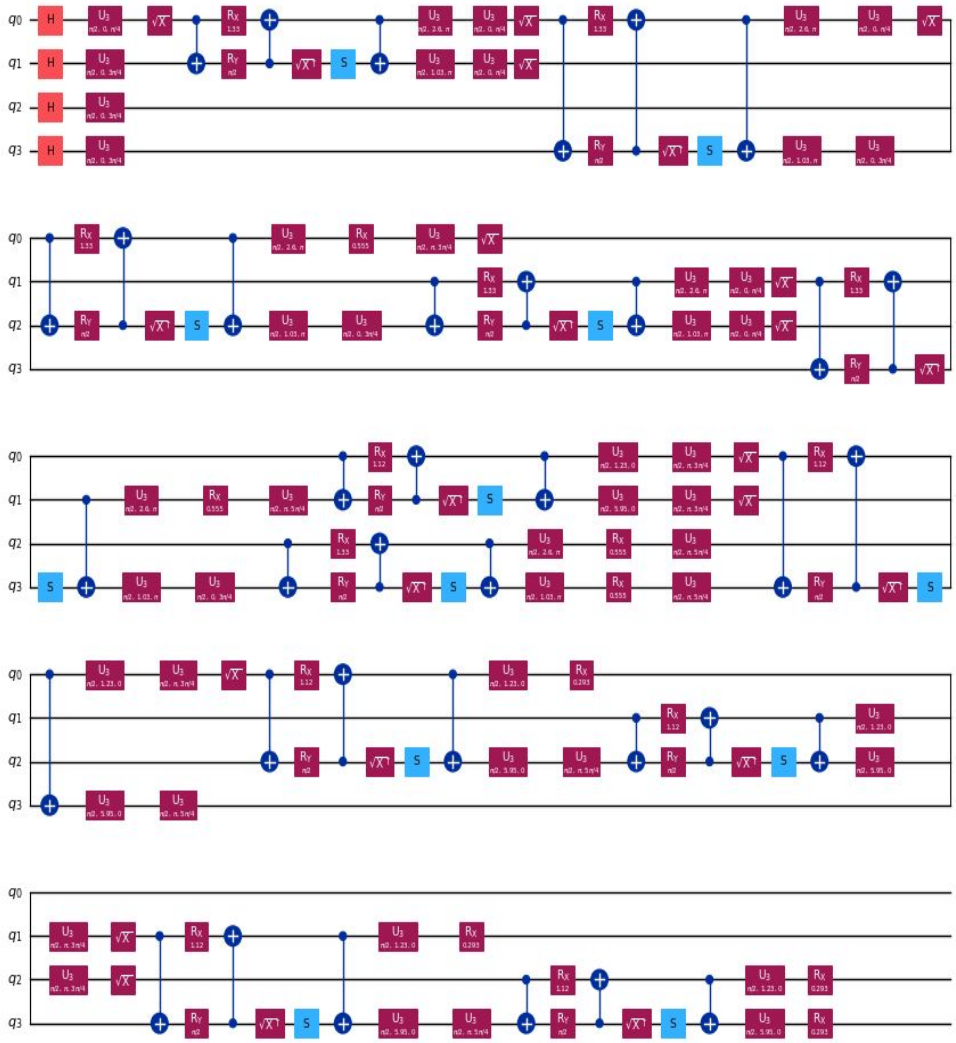
- Optimization level 3 uses the SABRE Algorithm (Simulated Annealing for Better Routing and Embedding) for SWAP routing
- This algorithm is stochastic, so it is not deterministic

Key Findings

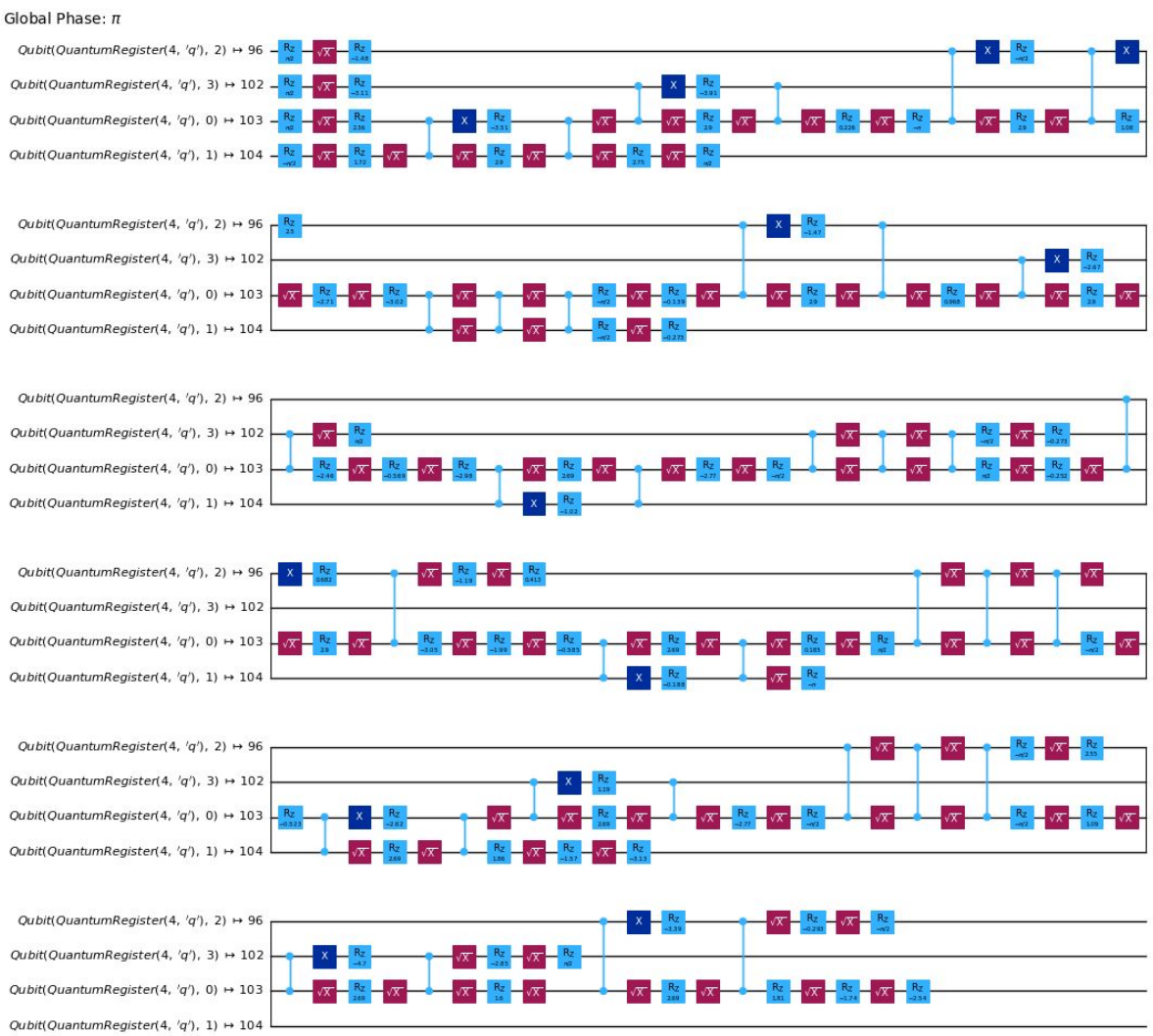
Show where you are in the process and what's left to tackle

Given two-qubit gates	Optimised for the IBM Fez	Optimised for the Quantinuum H1-2
26		26
299	650	284
1695	1695	1695

Unoptimized version



Optimized version



Additional findings/ Challenges

During implementation, we faced a transpilation issue in Qiskit, so one teammate tested an R-based simulator to check limitations. We also encountered repeated circuit #284 errors at optimization level 3 and memory overload due to large circuit sizes. Additionally, visualization files exceeded size limits, so we adjusted parameters like scale and fold to successfully render smaller images.


The technology:
GPS + RFID