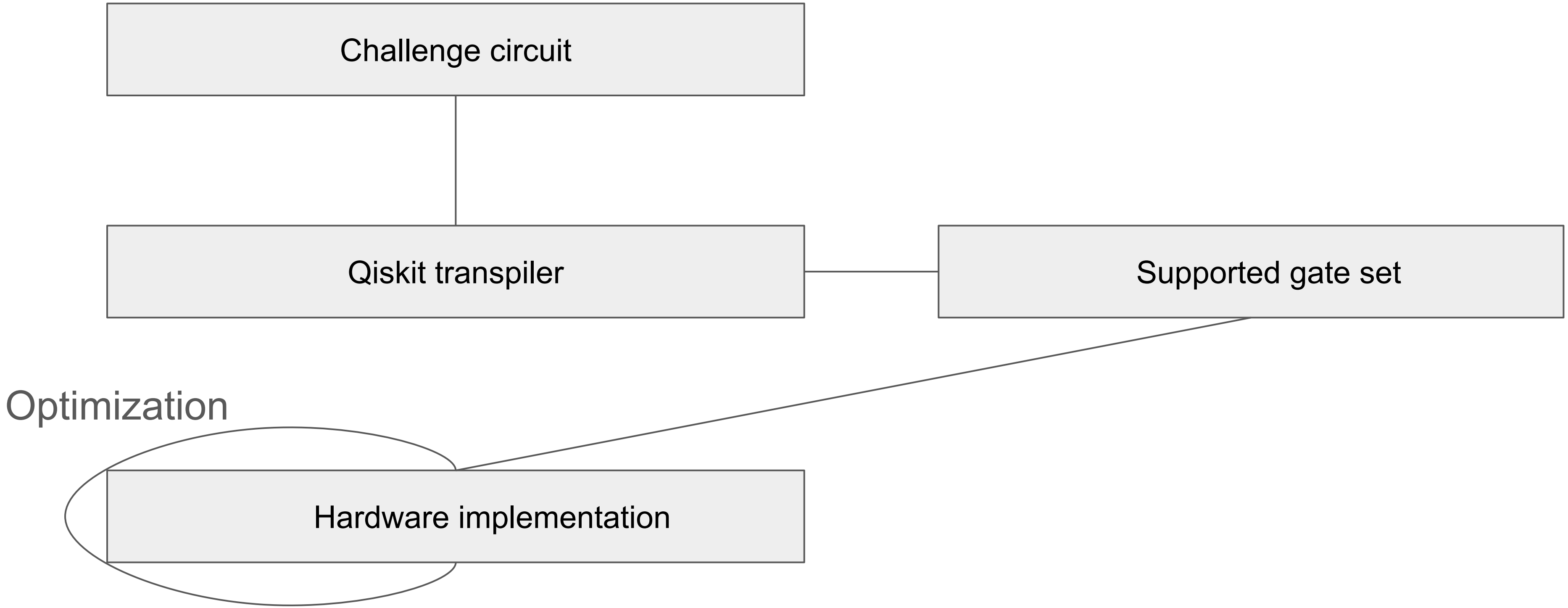
UCLA

QuBruin - QuEra Challenge Solution

John Ye, Himshikha Nath, Keshavi Charde, Lorenzo Ballerio, Alex Androutsos


Challenge circuit
Qiskit transpiler
Supported gate set
Optimization
Hardware implementation

Introduction and Results Table

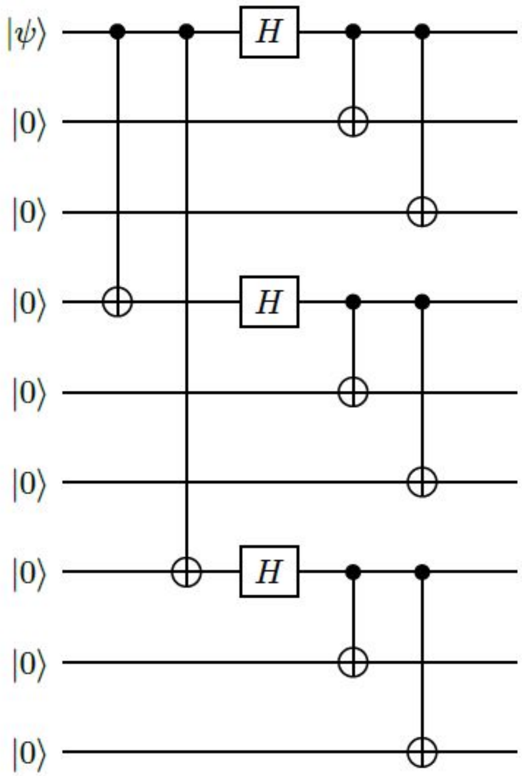
Challenge Number	1.1	1.2	2	3	4	5	Bonus 1
Optimised Cost Score	9.53	29.8	-	83.4	48.9	35.2	-

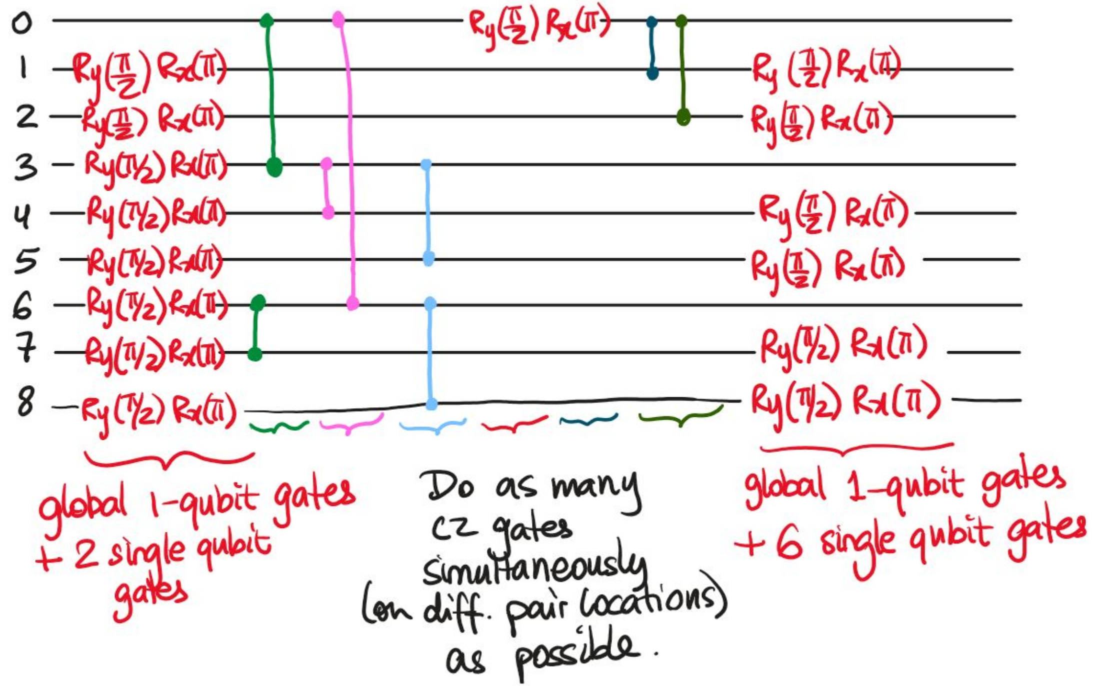
Translating the Circuit to code

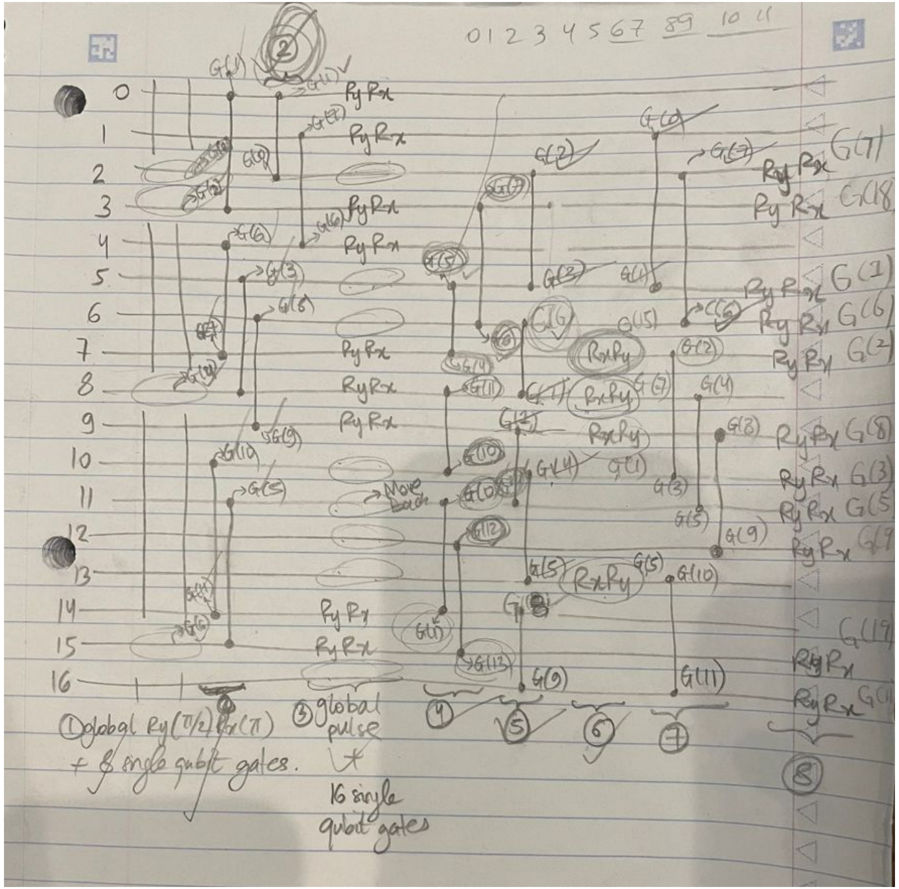
Our aim was to optimise the cost function to encode the circuit:

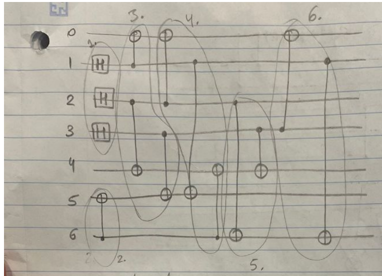
- Minimising local 1-qubit gates by maximally using global 1-qubit gates = translated all rotation gates to the end + combine
- Minimising the number of times we perform CZ = combining all possible CZ gates and performing them globally, simultaneously (on different gate set pairs).
- Minimise the number of moves (and hence the number of picks and drops) = once a qubit is initialised, we tried not to move it and minimise the moves between each gate.

Example - Shor Code

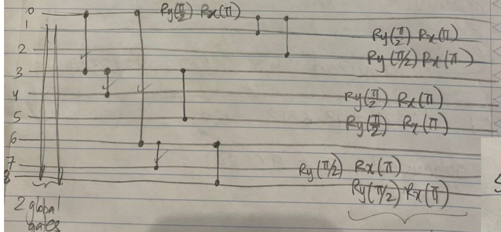








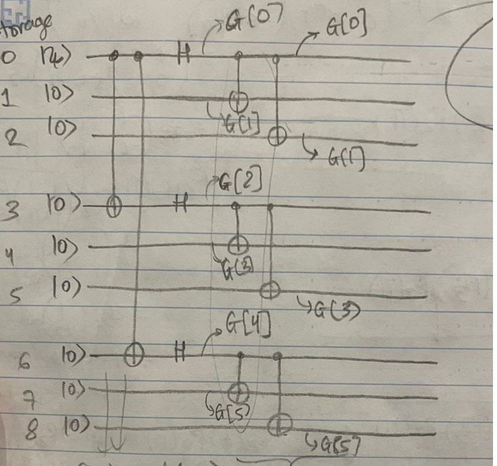
1. Hadamards
2. to 6. are rest of steps.



2 global gates + 2 single qubit gates

make in 2 gates & 6 qubit gates

Storage



(0,3) and (0,6)
↳ Optimise moves.

Do S(0,1)

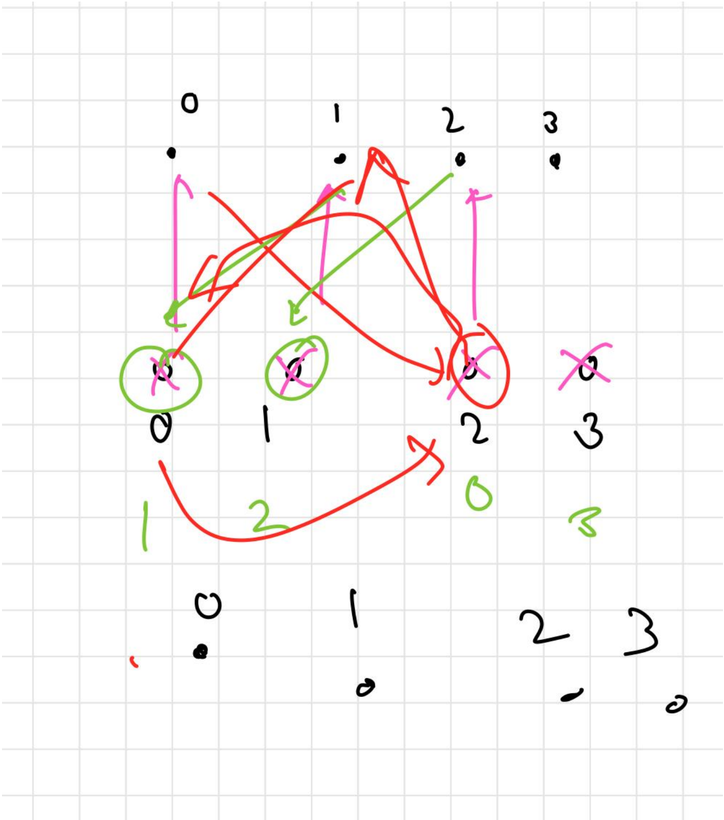
Shuttling Rules

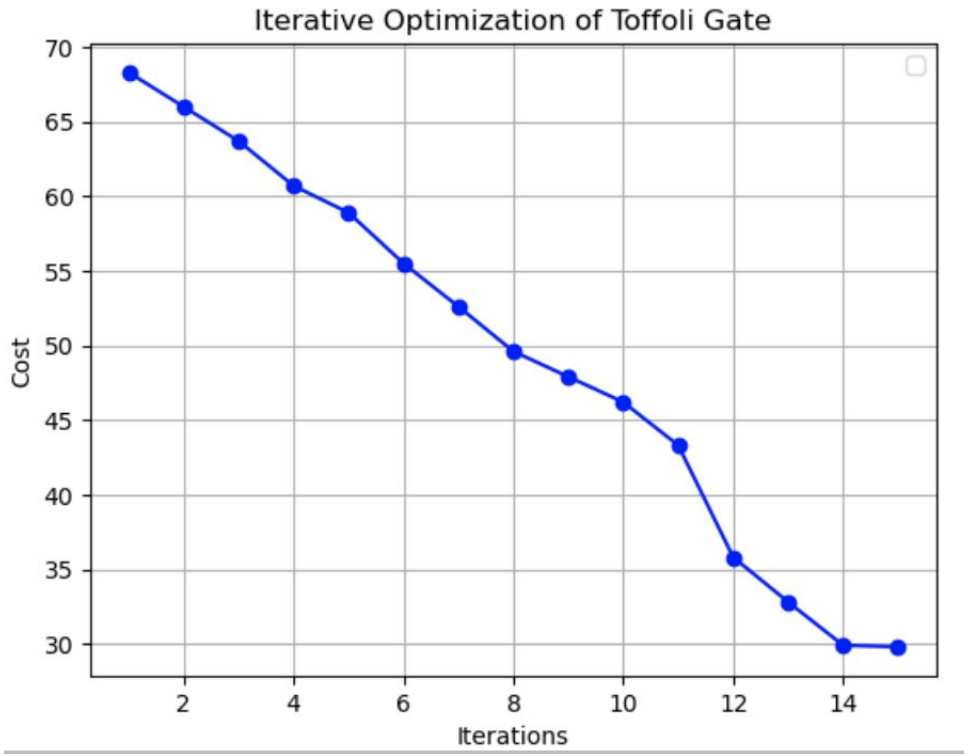
- Prioritized leaving gates at their position in the set unless absolutely necessary

Shuttling Rules:

1. No Path Crossings
2. Atoms cannot collide

Based on these shuttling dynamics, we can consider different orderings of operations within the circuit to minimize the moves required.





Conditions for Allowed Transitions

Storage Zone to Gate Zone ($S[i] \rightarrow G[j, j+1]$)

1. **Index Alignment**:

If $S[i_1], S[i_2], \ldots, S[i_n]$ are moved to $G[j_1, j_1+1], G[j_2, j_2+1], \ldots, G[j_n, j_n+1]$, then:

$$i_1 < i_2 < \cdots < i_n \implies j_1 < j_2 < \cdots < j_n$$

2. **No Path Crossings**:

For every pair of atoms $S[i_a]$ and $S[i_b]$, their destinations $G[j_a, k_a]$ and $G[j_b, k_b]$ must satisfy:

$$i_a < i_b \implies j_a \leq j_b \text{ and } k_a \leq k_b$$

3. **Distinct Destination Indices**:

$$G[j_a, k_a] \neq G[j_b, k_b] \quad \forall a \neq b$$

Gate Zone to Storage Zone ($G[j, k] \rightarrow S[i]$)

1. **Index Alignment**:

If $G[j_1, k_1], G[j_2, k_2], \ldots, G[j_n, k_n]$ are moved to $S[i_1], S[i_2], \ldots, S[i_n]$, then:

$$j_1 < j_2 < \cdots < j_n \implies i_1 < i_2 < \cdots < i_n$$

2. **No Path Crossings**:

For every pair of atoms $G[j_a, k_a]$ and $G[j_b, k_b]$, their destinations $S[i_a]$ and $S[i_b]$ must satisfy:

$$j_a < j_b \implies i_a < i_b$$

3. **Distinct Destination Indices**:

$$S[i_a] \neq S[i_b] \quad \forall a \neq b$$