Quantum Computing: Password hacking Using Grover's Algorithm

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Motivation and Background

Through this project, I aimed to deepen my understanding of quantum computing and enhance my programming skills.

At first, I didn't clearly understand the difference between quantum and classical computers. However, as I studied Grover's algorithm and ran simulations, I gained insight into quantum mechanics and how quantum algorithms work.

This project gave me the opportunity to explore quantum search techniques and gain hands-on experience with real quantum programming tools.

METHODS

We used Grover's algorithm to search for hidden passwords.

- **Steps in Grover's algorithm**

1. **Initialization**

   All qubits were placed into a superposition using Hadamard gates.

2. **Oracle Construction**

   We applied a phase inversion to the target state using the oracle.

3. **Diffuser Application**

   We amplified the amplitude of the target state using an inversion-about-average operator.

4. **Iteration**

   We repeated the oracle and diffuser steps to increase the likelihood of measuring the correct state.

5. **Simulation & Visualization**

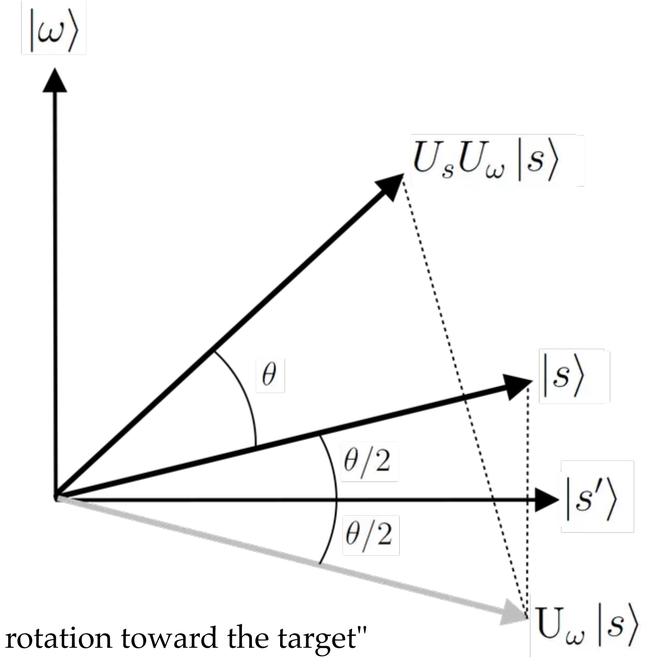
   We simulated the quantum circuit using Qiskit and visualized the measurement results.

6. **Generalization**

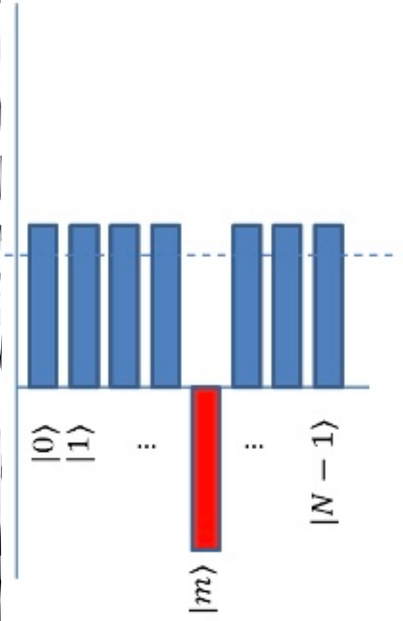
   We scaled the circuit from 2-bit (4 items) to 3-bit (8 items) search spaces to demonstrate Grover's algorithm can generalize to larger problems.

7. **Noise Testing**

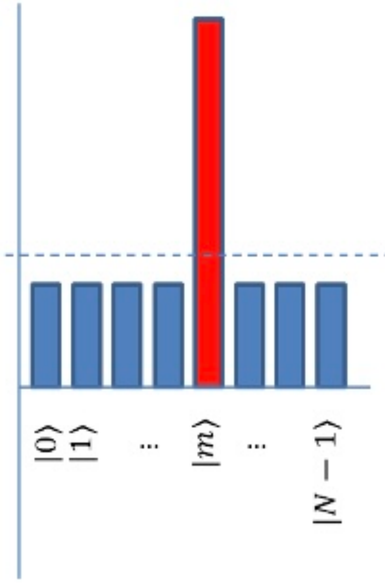
   We tested the circuit with noise using IBM's FakeVigo model to test its robustness in realistic conditions.



"State rotation toward the target"



"Initial uniform distribution"



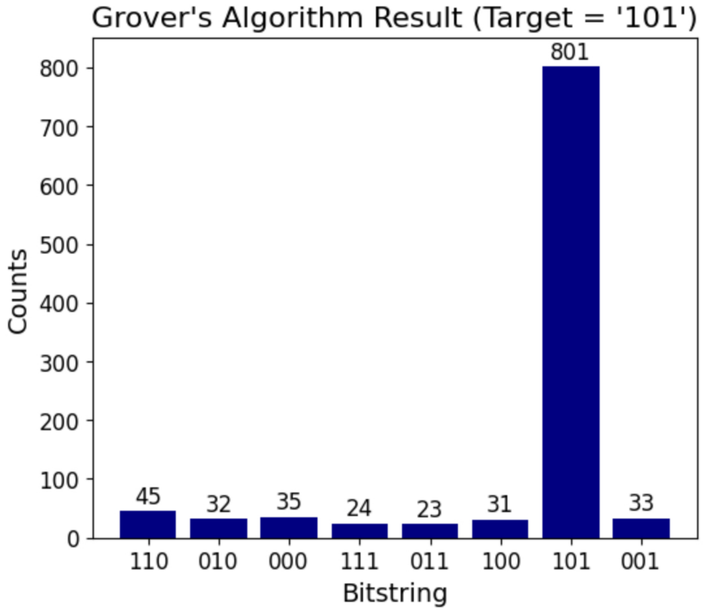
"Amplified marked state"

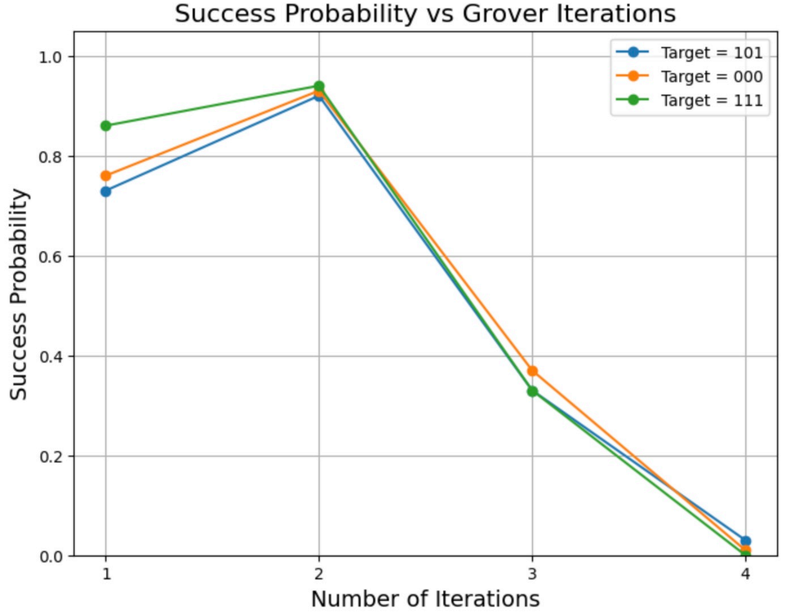
SIMULATIONS

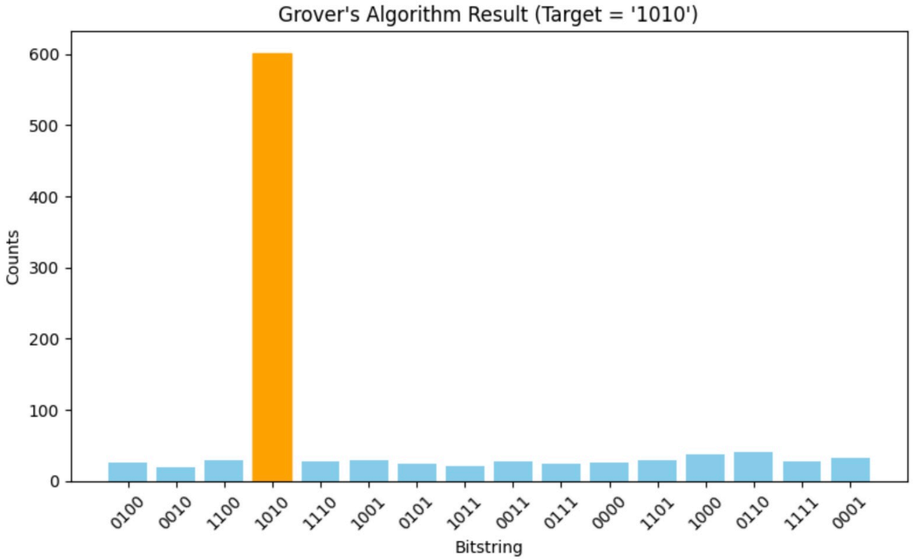
We built and tested Grover's circuits for 2-bit, 3-bit, and 4-bit password searches.

- The circuits were generalized to work for any password.
- Simulations were run using Qiskit on Google Colab.
- The number of iterations significantly affects the success rate.
- Different bit lengths require different numbers of steps.

(Each graph shows how probability of correct result increases after applying Grover's algorithm.)



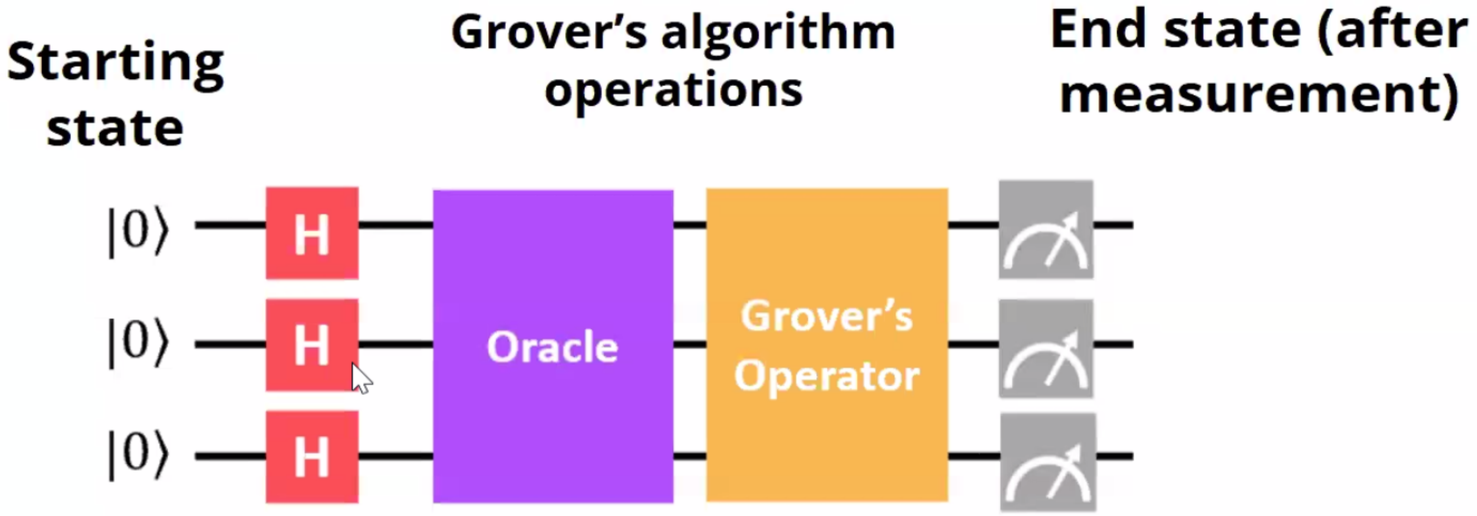


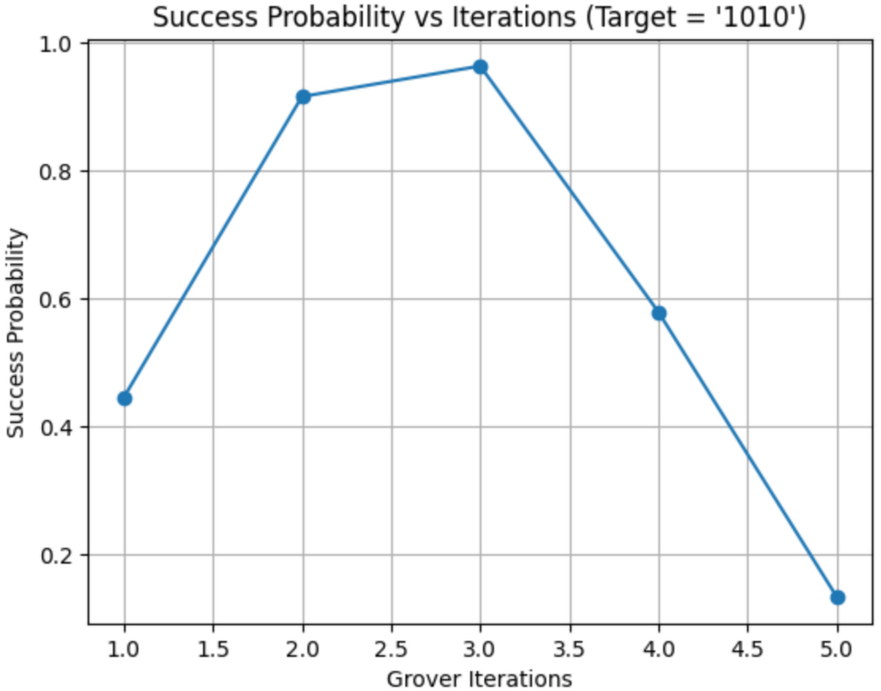


Key Findings & Conclusions

- ✓ Grover's algorithm successfully finds the password with high probability.
- ✓ It is more efficient than classical brute-force search.
- ✓ The number of iterations depends on the size of the search space.
- ✓ As the number of bits increases, fewer iterations are relatively needed (due to square-root scaling).

(Graph: Probability of success increases with number of iterations)





Reflections

This project helped me realize that understanding Grover's algorithm is deeply connected to understanding quantum computing itself.

At first, I didn't know the difference between classical and quantum computing. But as I built and simulated circuits, I gained insight into quantum search and the structure of quantum circuits.

I also experienced the challenges of working with noise and imperfections in quantum systems, which helped me see the gap between ideal algorithms and real-world implementation.

Potential Next Steps

- Extend Grover's algorithm to 4-bit passwords and analyze how the number of iterations affects success.
- Add noise using Qiskit to test how it changes the results.
- Compare with classical brute-force search to quantify quantum speedup.
- Build a simple UI to input a password and show results clearly.