

Optimizing Quantum Oracle for Standard Hash Algorithms

Korea University
Sangheon Lee, Mingyu Cho

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Introduction

Previous Work

- Studied the basics of quantum computing and Grover's Algorithm
- Analysis of reversible quantum S-DES oracle and its construction
- Implementation of quantum S-DES oracle with Grover's Algorithm in Microsoft Q#

Motivation

- Targeting SHA-2/3
 - Current de facto standard hash algorithm
- Goal is to perform a preimage attack.
 - The most straightforward to apply Grover's Algorithm.
 - It will be assumed that Grover's Algorithm(or some variation of it) will be applied
 - Therefore target is to optimize the quantum oracle for SHA-2/3.

Recap: Grover's Algorithm

- Searching in an unordered database among 2^n elements takes $\tilde{O}(2^{n/2})$ time complexity and $\tilde{O}(n)$ quantum space complexity
- Proved to be optimal in general
- Specifically, improved Grover's Algorithm for collision search yields $\tilde{O}(2^{n/3})$ time complexity and (quantum) space complexity [BHT98]
 - However, quantum queries are costly in this algorithm

Chailloux's Algorithm [CNPS17]

- Use poly-time qubits and reduce time complexity to $\tilde{O}(2^{2n/5})$ for collision search and $\tilde{O}(2^{3n/7})$ for multi-target preimage attacks with additional classic memory

SHA-2/3 Pre-image Attack Cost Estimation [ADMG⁺16]

- Suggest cost metric for quantum computation based on surface code
- Theoretically implement reversible SHA-2/3 quantum circuits
- Estimate required physical resources and its scale

Expectations

- Focus on micro-scale improvement(regarding quantum oracle)
- May be able to reduce the cost in at least one of the following metrics:
 - The cost metric from before
 - The raw number of gates
 - The number of levels after achieving parallelization
- Main target will be the cost metric, not the gates or the levels

In-depth Topics

Topics

- Surface code(Toric code) : topological quantum error correcting code
- Cost metric based on surface code
- T-par [AMM14] : an quantum circuit optimization tool
- Advanced quantum circuit (in-place adder, *etc.*)

References I



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