A $\Theta(\sqrt{n})$-Depth Quantum Adder on the 2D NTC Quantum Computer Architecture

BYUNG-SOO CHOI, University of Seoul
RODNEY VAN METER, Keio University

In this work, we propose an adder for the 2-Dimensional Nearest-Neighbor, Two-Qubit gate, Concurrent (2D NTC) architecture, designed to match the architectural constraints of many quantum computing technologies. The chosen architecture allows the layout of logical qubits in two dimensions with $\sqrt{n}$ columns where each column has $\sqrt{n}$ qubits and the concurrent execution of one- and two-qubit gates with nearest-neighbor interaction only. The proposed adder works in three phases. In the first phase, the first column generates the summation output and the other columns do the carry-lookahead operations. In the second phase, these intermediate values are propagated from column to column, preparing for computation of the final carry for each register position. In the last phase, each column, except the first one, generates the summation output using this column-level carry. The depth and the number of qubits of the proposed adder are $\Theta(\sqrt{n})$ and $O(n)$, respectively. The proposed adder executes faster than the adders designed for the 1D NTC architecture when the length of the input registers n is larger than 51.

Categories and Subject Descriptors: C.1.m [**Processor Architectures**]: Miscellaneous; B.2.0 [**Arithmetic and Logic Structures**]: General; B.m [**Hardware**]: Miscellaneous

General Terms: Design, Theory

Additional Key Words and Phrases: Quantum computer, quantum circuit, quantum arithmetic algorithms, quantum adder, 2D NTC quantum computer architecture

ACM Reference Format:
Choi, B.-S. and Van Meter, R. 2012. A $\Theta(\sqrt{n})$-depth quantum adder on the 2D NTC quantum computer architecture. ACM J. Emerg. Technol. Comput. Syst. 8, 3, Article 24 (August 2012), 22 pages.
DOI = 10.1145/2287696.2287707 http://doi.acm.org/10.1145/2287696.2287707

1. INTRODUCTION

Quantum computers have been proposed to exploit the exotic properties of quantum mechanics for information processing. Among many potential uses, two quantum algorithms have received the bulk of the attention. One is Shor's large number factoring algorithm [Shor 1997], and the other is Grover's unstructured database search algorithm [Grover 1996], though there has also been much progress recently on other

A two-page short abstract was presented at AQIS 2010.
This research is supported in part by the Japan Society for the Promotion of Science (JSPS) through its Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST Program), and in part by the National Research Foundation of Korea Grant funded by the Korean Government (Ministry of Education, Science and Technology) [NRF-2010-359-D00012].
Authors' addresses: B.-S. Choi (corresponding author), Center for Quantum Information Processing, Department of Electrical and Computer Engineering, University of Seoul, Seoul, 130-743, Republic of Korea; email: bschoi3@gmail.com; R. Van Meter, Faculty of Environment and Information Studies, Keio University, Fujisawa, Japan.

DOI 10.1145/2287696.2287707 http://doi.acm.org/10.1145/2287696.2287707