

A Synthesis Algorithm for 4-Bit Reversible Logic Circuits with Minimum Quantum Cost

ZHIOIANG LI, Yangzhou University
HANWU CHEN, Southeast University
XIAOYU SONG and MAREK PERKOWSKI, Portland State University

This article presents an algorithm which can quickly find the exact minimum solution to almost all of 4-bit reversible functions. We assume minimization of quantum cost (MQC). This algorithm is designed in the most memory-efficient way or it will quickly run out of memory. Therefore, we construct the shortest coding of permutations, the topological compression and flexible data structures for the memory savings. First, hash tables are used for all 4-bit reversible circuits with the minimization of gate count (MGC) by using the GT library (with NOT, CNOT, Toffoli and Toffoli-4 gates). Second, we merge and split the hash tables, thus generating a single longer hash table for high performance. Third, we synthesize these circuits with MQC by using the GT library (with GT, Peres, and Inverted Peres gates) based on the hash table. Finally, according to the comparison of the QC of circuits, the algorithm can quickly converge for any 4-bit reversible circuit with MQC. By synthesizing all benchmark functions, in comparison with Szeprowski and Kerntopf (2011), the running time and QC are reduced up to 99.95% and 18.2%, respectively.

Categories and Subject Descriptors: B.6.3 (Logic Design): Design Aids

General Terms: Design, Algorithms, Performance

Additional Key Words and Phrases: Automatic synthesis, reversible logic, quantum cost, optimization

ACM Reference Format:

Zhiqiang Li, Hanwu Chen, Xiaoyu Song, and Marek Perkowski. 2014. A synthesis algorithm for 4-bit reversible logic circuits with minimum quantum cost. *ACM J. Emerg. Technol. Comput. Syst.* 11, 3, Article 29 (November 2014), 19 pages.
DOI: <http://dx.doi.org/10.1145/2629542>

1. INTRODUCTION

Quantum computer can be constructed by cascading and combining the quantum logical gates (circuits). Quantum circuits are inherently reversible, a quantum circuit is a model for quantum computation in which a computation is a sequence of quantum gates, and binary reversible logic provides a basis for quantum algorithms, such as Shor and Grover algorithms. Many kinds of reversible quantum gates have been proposed, for example, CNOT gate [Feynman 1986], Toffoli gate, and Peres gate [Peres

This work is supported by the National Natural Science Foundation of China under grant 61070240 and grant 61170321, by the Natural Science Foundation of College of Jiangsu Province under grant (No. 10KJ520023), and by Specialized Research Fund for the Doctoral Program of Higher Education under grant 20110092110024.

Authors' addresses: Z. Li, College of Information Engineering, Yangzhou University, Yangzhou, China; H. Chen, School of Computer Science and Engineering, Southeast University, Nanjing, China; X. Song and M. Perkowski, Department of ECE, 1825 SW Broadway, Portland, OR 97201; Correspondence email: yzqzhang@163.com.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions.acm.org.

© 2014 ACM 1550-4832/2014/11-ART29 \$15.00

DOI: <http://dx.doi.org/10.1145/2629542>

ACM Journal on Emerging Technologies in Computing Systems, Vol. 11, No. 3, Article 29, Pub. date: November 2014.

29

QUANTUM LOGIC SYNTHESIS LIBRARY. SERIES VOL PDF - Search results,. Hans Reichenbach (September 26, a. April 9,) was a quantum logic synthese library pdf -. Sun, 08 Jul GMT - Hans Reichenbach (September 26, April 9,) was a leading philosopher of .QUANTUM LOGIC SYNTHESIS LIBRARY. SERIES VOL PDF - Search results,. The question of the nature and plausibility of realism arises with respect .Quantum Logic (Synthese Library) (Volume) by Peter Mittelstaedt (04): Peter Mittelstaedt: Books - thejosiebagglecompany.comNeumann published an article with the title 'The logic of quantum mechanics'. Synthese Library This calculus has sometimes been called 'quantum logic'. Register Free To Download Files File Name: Quantum Logic Synthese Library Series Vol PDF. QUANTUM LOGIC SYNTHESIS LIBRARY SERIES .SYNTHESIS LIBRARY VOLUME PETER MITTELSTAEDT QUANTUM LOGIC D. REIDEL PUBLISHING COMPANY DORDRECHT HOLLAND BOSTON .Show that under the conditions of Theorem , (L,S) is a sum logic. London- Don Mills, () 6. Mittelstaedt, P.: Quantum Logic. Synthese Library, vol. SYNTHESIS LIBRARY. STUDIES IN Library of Congress Cataloging-in- Publication Data. Suppes . 15 THE LOGIC OF CLINICAL JUDGMENT: BAYESIAN AND OTHER 23 PROBABILISTIC CAUSALITY IN QUANTUM MECHANICS. 1. . Kant's philosophy of science, this is the only article in the volume dealing. Volume One of the Tenth International Congress of Logic, Methodology and Philosophy of Science, J.M. Jauch: Foundations of quantum mechanics, Addison- Wesley, Reading-Menlo Co., Dordrecht, Synthese Library, Vol. , (). SYNTHESIS LIBRARY R. D. Rosenkrantz [Boston Studies in the Philosophy of Science, Vol. LV] ISBN P. Mittelstaedt, Quantum Logic. ISBN. Volume One of the 11th International Congress of Logic, Methodology and Philosophy of Science, Cracow, August SYNTHESIS LIBRARY LVIII] ISBN ; Pb X P. Mittelstaedt, Quantum Logic. SYNTHESIS LIBRARY 1 R. D. Rosenkrantz [Boston Studies in the Philosophy of Science, Vol. LV] 1 ISBN P. Mittelstaedt, Quantum Logic. ISBN. Peter Mittelstaedt Quantum Logic. Synthese Library/Volume , D. Eeidel preted as a generalized logical calculus for propositions about quantum physical. With quantum logic, the same six element common lattice can serve us Quantum Logic, Synthese Library;. Vol. (Reidel, London,). A C.I.P. Catalogue record for this book is available from the Library of Congress. Published by tributors, volume of Synthese Library. Kluwer P. Mittelstaedt, Quantum Logic. ISBN K. A. Bowen, Model. Buy Quantum Logic at thejosiebagglecompany.com you see here, and we have not verified it. See our disclaimer. Quantum Logic, Vol. Synthese Library (Hardcover). [Boston Studies in the Philosophy of Science, Vol. R. P. McArthur, Tense Logic. LVIII] ISBN ; Pb X P. Mittelstaedt, Quantum Logic. SYNTHESIS LIBRARY .Series, Vol. 4. PHILOSOPHY AND PHENOMENO LOGICAL RESEARCH Mittelstaedt, Peter, Quantum Logic. Synthese Library, Vol. Dordrecht: D.