

Contents

1	Introduction	1
1.1	Book Overview	4
1.1.1	Optimization of Quantum Circuits	4
1.1.2	Complexity Analysis	5
1.2	Outline	6
2	Background	9
2.1	Boolean Functions	9
2.2	Boolean Function Decomposition	10
2.2.1	Ashenhurst Decomposition	10
2.2.2	Curtis Decomposition	11
2.2.3	Bi-decomposition	12
2.2.4	Multiplexer Decomposition	12
2.3	Exclusive-OR Sum of Products	13
2.4	Boolean Satisfiability and SAT Modulo Theory	15
2.5	Reversible Logic	16
2.5.1	Reversible Function	17
2.5.2	Reversible Gates	20
2.5.3	Reversible Circuits	22
2.6	Quantum Computation	23
2.6.1	Quantum Systems	24
2.6.2	Quantum Libraries	26
2.6.3	Quantum Circuits	30
2.7	Cost Metrics for Reversible and Quantum Circuits	31
2.7.1	Quantum Cost	31
2.7.2	Number of Gates	33
2.7.3	Number of Lines	34
2.7.4	Depth	35
2.7.5	Nearest Neighbor Cost	36

2.8	Decision Diagrams	36
2.8.1	Binary Decision Diagrams	36
2.8.2	Quantum Multiple-Valued Decision Diagrams	38
3	Optimizations and Complexity Analysis on the Reversible Level	45
3.1	Related Work	45
3.1.1	Optimization Approaches of Reversible Circuits	46
3.1.2	Complexity of Reversible Circuits	51
3.2	Exact Quantum Cost Optimization	52
3.2.1	General Idea	52
3.2.2	Encoding Using SMT	53
3.2.3	Experimental Results	59
3.3	Heuristic Quantum Cost Optimization	65
3.3.1	Simulated Annealing	66
3.3.2	Rewriting Rules	67
3.3.3	Algorithms	68
3.3.4	Experimental Results	71
3.4	Complexity Analysis of Reversible Circuits	83
3.4.1	Complexity of Single-Target Circuits	83
3.4.2	Complexity of MPMCT Circuits	84
3.4.3	Upper Bounds for Single-Target Gates	85
3.4.4	Upper Bounds for Reversible Circuits	87
3.5	Summary	89
4	Optimization and Complexity Analysis on the Mapping Level	91
4.1	Related Work	91
4.1.1	Mapping Approaches	92
4.1.2	Complexity of NCT Circuits	100
4.2	Improving the Mapping of Single-Target Gates	100
4.2.1	Motivation	101
4.2.2	Mapping of Single-Target Gates	101
4.2.3	Experimental Evaluation	104
4.2.4	Remarks and Observations	111
4.3	Improving the Mapping of MPMCT Gates to Clifford + T Circuits	112
4.3.1	Clifford + T Aware Reversible Circuit Mapping	112
4.3.2	Proposed Mapping Approaches	113
4.3.3	MPMCT Gates Mapping	114
4.3.4	Experimental Results	122
4.4	Complexity Analysis of NCT Circuits	127
4.4.1	Upper Bounds for MPMCT Gates	128
4.4.2	Upper Bounds for Single-Target Gates	129
4.4.3	Upper Bounds for NCT Circuits	138
4.5	Summary	140

- 5 Optimizations and Complexity Analysis on the Quantum Level** 141
 - 5.1 Related Work 141
 - 5.1.1 Optimization of Quantum Circuits 141
 - 5.1.2 Complexity of Quantum Circuits 145
 - 5.2 Depth Optimization for NCV Circuits 145
 - 5.2.1 General Idea 147
 - 5.2.2 Optimization Approaches 148
 - 5.2.3 Experimental Results 153
 - 5.3 NCV-Cost Optimization 156
 - 5.3.1 Proposed Idea 157
 - 5.3.2 Application 158
 - 5.3.3 Experimental Results 159
 - 5.4 Complexity Analysis of Quantum Circuits 163
 - 5.4.1 Complexity of NCV Quantum Circuits 163
 - 5.4.2 Complexity of Clifford+ T Quantum Circuits 169
 - 5.5 Summary 174
- 6 Conclusions** 175
- References** 179



<http://www.springer.com/978-3-319-31935-3>

Reversible and Quantum Circuits

Optimization and Complexity Analysis

Abdessaied, N.; Drechsler, R.

2016, XXII, 186 p. 105 illus., 3 illus. in color., Hardcover

ISBN: 978-3-319-31935-3