Preface

Due to the increasing miniaturization according to Moore's law, classical circuit design will reach soon its limits. Reversible computation is an interesting alternative, since it provides a fundamental approach to the design of low-power circuits, a very critical aspect already in today's circuit design. Beyond that aspect, reversible circuits can be used as a starting point for synthesizing quantum circuits. Quantum computers can efficiently solve problems such as factorization, while the best known classical algorithms have sub-exponential complexity. In this emerging research field, first approaches to key design steps have been proposed, but they suffer from problems regarding complexity and scalability. Furthermore, most of the existing approaches are not optimal. Theoretical studies looking at the complexity of the underlying circuits are hard to perform, and so far only few results in this field are available.

In this context, this book introduces important new optimization approaches as well as complexity analysis that present various improvements compared to the state-of-the-art methods. The book has considered these two aspects on the different levels of the design flow of quantum circuits: the reversible level, the mapping level, and the quantum level. First, the book provides insight and guidance in all major aspects of optimizing the implementation of a reversible function as a circuit of reversible or quantum gates. Second, it gives an extensive overview of upper bounds on the number of gates needed in reversible and quantum circuits. New and tighter bounds are provided based on several synthesis approaches, mapping schemes, and gate libraries.

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