Preface

While the idea of creating computing systems with flexible hardware dates back to the 1960s, it was the emergence of the SRAM-based field-programmable gate array (FPGA) in the 1980s that boosted Reconfigurable Computing as a research and engineering field. Since then, reconfigurable computing has become a vibrant area with an increasingly growing research community and exciting commercial ventures.

Reconfigurable computing devices are able to adapt their hardware to application demands and serve broad and relevant application domains from embedded to high-performance computing, including automotive, aerospace and defense, telecommunication and networking, medical and biometric computing. Especially in the embedded computing domain with its many and often conflicting objectives reconfigurable computing systems offer new trade-offs. Embedded systems are fueled by microelectronics where one of the currently biggest challenges is the trade-off between flexibility and cost. Reconfigurable devices, especially FPGAs, fill this gap since they provide flexibility at both design-time and run-time. Consequently, in the last years we have seen declining ASIC design starts but continuously increasing FPGA design starts. Continuing advances in the miniaturization of microelectronic components have made it possible to integrate systems with multiple processors on a single chip at the size of a fingernail (system-on-chip (SoC)). Often, the production volumes for SoCs are rather low jeopardizing their economic benefits. On the other hand, modern FPGAs are basically complex SoCs integrating embedded processors, signal processing capabilities, multi-gigabit transceivers and a broad portfolio of IP cores. Thus FPGAs are positioned to become a real alternative to ASICs and ASPPs.

This book is the first ever to focus on the emerging field of Dynamically Reconfigurable Computing Systems. While programmable logic and design-time configurability are well elaborated and covered in various books, this book presents a unique overview over the state of the art and recent results for dynamic and run-time reconfigurable computing systems. This book targets graduate students and practitioners alike. Over the last years, many educational institutions began to offer courses and seminars on different aspects of reconfigurable computing systems. We recommend this book as reading material for the advanced graduate level and entrance into own
research on dynamically reconfigurable systems. Reconfigurable hardware is not only of utmost importance for large manufacturers and vendors of microelectronic devices and systems, but also a very attractive technology for smaller and medium-sized companies. Hence, this book addresses also researchers and engineers actively working in the field and updates them on the newest developments and trends in run-time reconfigurability.

The book is organized into four parts that present recent efforts and breakthroughs in architectures, design methods and tools, and applications for dynamically reconfigurable computing systems:

Architectures: Three chapters on architectures discuss different dynamically reconfigurable platforms, including multigrained and application-specific architectures as well as an FPGA-based computing system supporting efficient partial reconfiguration.

Design Methods and Tools—Modeling, Evaluation and Compilation: The first part on design methods and tools features four chapters focusing on modeling and evaluation aspects for dynamically reconfigurable hardware, on creating compilers for reconfigurable devices, and on supporting dynamic reconfiguration through object-oriented programming.

Design Methods and Tools—Optimization and Runtime Systems: The second part on design methods and tools comprises six chapters that are devoted to resource allocation in dynamically reconfigurable systems, split into challenging optimization problems that need to be solved during compilation time, e.g., temporal partitioning, and online resource allocation which is provided by a novel breed of reconfigurable hardware runtime systems.

Applications: The last part of the book presents seven chapters with applications of dynamically reconfigurable hardware technology to relevant and demanding domains, including mobile communications, network processors, automotive vision, and geometric algebra.

This book presents the results of a six-years research initiative on dynamically reconfigurable computing systems, initiated and coordinated by Jürgen Teich and funded by the German Research Foundation (DFG) within the Priority Programme (Schwerpunktprogramm) 1148 from 2003 to 2009. To make dynamic reconfigurable computing become a reality this joint research initiative bundled multiple projects and, at times, involved up to 50 researchers working in the topic.

Equivalently, this book summarizes more than 100 person years of research work and more than 20 PhD students have already submitted and defended their theses based on research performed in this initiative. The material presented in this book thus summarizes the golden fruits, major achievements and biggest milestones of this joint research initiative.

We are very grateful to the German Research Foundation for funding and continuously supporting this initiative. We would also like to thank all the researchers contributing to the programme and to this book, the many national and international reviewers as well as the industrial companies that have been steadily supporting our efforts. Additionally, we would like to acknowledge the assistance of Josef Angermeyer, Martina Jahn, Enno Lübbers, and Felix Reimann in supporting the editorial
process. Last but not least, we thank Springer for giving us the opportunity to publish our results with them.

We hope you enjoy reading this book!

Marco Platzner, Jürgen Teich, Norbert Wehn
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