

Stefanos Kaxiras · Margaret Martonosi

Computer Architecture Techniques for Power-Efficiency

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Margaret Martonosi

Clemens Wendtner



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Computer Architecture Techniques for Power-Efficiency Stefanos Kaxiras, Margaret Martonosi, 2022-06-01 In the last few years power dissipation has become an important design constraint on par with performance in the design of new computer systems Whereas in the past the primary job of the computer architect was to translate improvements in operating frequency and transistor count into performance now power efficiency must be taken into account at every step of the design process While for some time architects have been successful in delivering 40% to 50% annual improvement in processor performance costs that were previously brushed aside eventually caught up The most critical of these costs is the inexorable increase in power dissipation and power density in processors Power dissipation issues have catalyzed new topic areas in computer architecture resulting in a substantial body of work on more power efficient architectures Power dissipation coupled with diminishing performance gains was also the main cause for the switch from single core to multi core architectures and a slowdown in frequency increase This book aims to document some of the most important architectural techniques that were invented proposed and applied to reduce both dynamic power and static power dissipation in processors and memory hierarchies A significant number of techniques have been proposed for a wide range of situations and this book synthesizes those techniques by focusing on their common characteristics Table of Contents Introduction Modeling Simulation and Measurement Using Voltage and Frequency Adjustments to Manage Dynamic Power Optimizing Capacitance and Switching Activity to Reduce Dynamic Power Managing Static Leakage Power Conclusions

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constraint on par with performance in the design of new computer systems Whereas in the past the primary job of the computer architect was to translate improvements in operating frequency and transistor count into performance now power efficiency must be taken into account at every step of the design process While for some time architects have been successful in delivering 40% to 50% annual improvement in processor performance costs that were previously brushed aside eventually caught up The most critical of these costs is the inexorable increase in power dissipation and power density in processors Power dissipation issues have catalyzed new topic areas in computer architecture resulting in a substantial body of work on more power efficient architectures Power dissipation coupled with diminishing performance gains was also the main cause for the switch from single core to multi core architectures and a slowdown in frequency increase This book aims to document some of the most important architectural techniques that were invented proposed and applied to reduce both dynamic power and static power dissipation in processors and memory hierarchies A significant number of techniques have been proposed for a wide range of situations and this book synthesizes those techniques by focusing on their common characteristics Table of Contents Introduction Modeling Simulation and Measurement Using Voltage and Frequency Adjustments to Manage Dynamic Power Optimizing Capacitance and Switching Activity to Reduce Dynamic Power Managing Static Leakage Power Conclusions *Power-Efficient Computer Architectures* Magnus Sjölander, Margaret Martonosi, Stefanos Kaxiras, 2014-12-01 As Moore's Law and Dennard scaling trends have slowed the challenges of building high performance computer architectures while maintaining acceptable power efficiency levels have heightened Over the past ten years architecture techniques for power efficiency have shifted from primarily focusing on module level efficiencies toward more holistic design styles based on parallelism and heterogeneity This work highlights and synthesizes recent techniques and trends in power efficient computer architecture Table of Contents Introduction Voltage and Frequency Management Heterogeneity and Specialization Communication and Memory Systems Conclusions Bibliography Authors Biographies [FPGA-Accelerated Simulation of Computer Systems](#) Hari Angepat, Derek Chiou, Eric S. Chung, James C. Hoe, 2022-05-31 To date the most common form of simulators of computer systems are software based running on standard computers One promising approach to improve simulation performance is to apply hardware specifically reconfigurable hardware in the form of field programmable gate arrays FPGAs This manuscript describes various approaches of using FPGAs to accelerate software implemented simulation of computer systems and selected simulators that incorporate those techniques More precisely we describe a simulation architecture taxonomy that incorporates a simulation architecture specifically designed for FPGA accelerated simulation survey the state of the art in FPGA accelerated simulation and describe in detail selected instances of the described techniques Table of Contents Preface Acknowledgments Introduction Simulator Background Accelerating Computer System Simulators with FPGAs Simulation Virtualization Categorizing FPGA based Simulators Conclusion Bibliography Authors Biographies [Quantum Computer Systems](#) Yongshan Ding, Frederic T. Chong, 2022-05-31 This book

targets computer scientists and engineers who are familiar with concepts in classical computer systems but are curious to learn the general architecture of quantum computing systems It gives a concise presentation of this new paradigm of computing from a computer systems point of view without assuming any background in quantum mechanics As such it is divided into two parts The first part of the book provides a gentle overview on the fundamental principles of the quantum theory and their implications for computing The second part is devoted to state of the art research in designing practical quantum programs building a scalable software systems stack and controlling quantum hardware components Most chapters end with a summary and an outlook for future directions This book celebrates the remarkable progress that scientists across disciplines have made in the past decades and reveals what roles computer scientists and engineers can play to enable practical scale quantum computing

On-Chip Networks Natalie Enright Jerger, Tushar Krishna, Li-Shiuan Peh, 2017-06-19 This book targets engineers and researchers familiar with basic computer architecture concepts who are interested in learning about on chip networks This work is designed to be a short synthesis of the most critical concepts in on chip network design It is a resource for both understanding on chip network basics and for providing an overview of state of the art research in on chip networks We believe that an overview that teaches both fundamental concepts and highlights state of the art designs will be of great value to both graduate students and industry engineers While not an exhaustive text we hope to illuminate fundamental concepts for the reader as well as identify trends and gaps in on chip network research With the rapid advances in this field we felt it was timely to update and review the state of the art in this second edition We introduce two new chapters at the end of the book We have updated the latest research of the past years throughout the book and also expanded our coverage of fundamental concepts to include several research ideas that have now made their way into products and in our opinion should be textbook concepts that all on chip network practitioners should know For example these fundamental concepts include message passing multicast routing and bubble flow control schemes

Principles of Secure Processor Architecture Design Jakub Szefer, 2022-06-01 With growing interest in computer security and the protection of the code and data which execute on commodity computers the amount of hardware security features in today's processors has increased significantly over the recent years No longer of just academic interest security features inside processors have been embraced by industry as well with a number of commercial secure processor architectures available today This book aims to give readers insights into the principles behind the design of academic and commercial secure processor architectures Secure processor architecture research is concerned with exploring and designing hardware features inside computer processors features which can help protect confidentiality and integrity of the code and data executing on the processor Unlike traditional processor architecture research that focuses on performance efficiency and energy as the first order design objectives secure processor architecture design has security as the first order design objective while still keeping the others as important design aspects that need to be considered This book aims to present the

different challenges of secure processor architecture design to graduate students interested in research on architecture and hardware security and computer architects working in industry interested in adding security features to their designs It aims to educate readers about how the different challenges have been solved in the past and what are the best practices i e the principles for design of new secure processor architectures Based on the careful review of past work by many computer architects and security researchers readers also will come to know the five basic principles needed for secure processor architecture design The book also presents existing research challenges and potential new research directions Finally this book presents numerous design suggestions as well as discusses pitfalls and fallacies that designers should avoid **The**

Memory System Bruce Jacob,2022-05-31 Today computer system optimization at both the hardware and software levels must consider the details of the memory system in its analysis failing to do so yields systems that are increasingly inefficient as those systems become more complex This lecture seeks to introduce the reader to the most important details of the memory system it targets both computer scientists and computer engineers in industry and in academia Roughly speaking computer scientists are the users of the memory system and computer engineers are the designers of the memory system Both can benefit tremendously from a basic understanding of how the memory system really works the computer scientist will be better equipped to create algorithms that perform well and the computer engineer will be better equipped to design systems that approach the optimal given the resource limitations Currently there is consensus among architecture researchers that the memory system is the bottleneck and this consensus has held for over a decade Somewhat inexplicably most of the research in the field is still directed toward improving the CPU to better tolerate a slow memory system as opposed to addressing the weaknesses of the memory system directly This lecture should get the bulk of the computer science and computer engineering population up the steep part of the learning curve Not every CS CE researcher developer needs to do work in the memory system but just as a carpenter can do his job more efficiently if he knows a little of architecture and an architect can do his job more efficiently if he knows a little of carpentry giving the CS CE worlds better intuition about the memory system should help them build better systems both software and hardware Table of Contents

Primers It Must Be Modeled Accurately and It Will Change Soon On-Chip Networks Natalie Enright,Li-shiuan

Peh,2022-11-10 With the ability to integrate a large number of cores on a single chip research into on chip networks to facilitate communication becomes increasingly important On chip networks seek to provide a scalable and high bandwidth communication substrate for multi core and many core architectures High bandwidth and low latency within the on chip network must be achieved while fitting within tight area and power budgets In this lecture we examine various fundamental aspects of on chip network design and provide the reader with an overview of the current state of the art research in this field Table of Contents Introduction Interface with System Architecture Topology Routing Flow Control Router

Microarchitecture Conclusions

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