

Parallel Computer Architecture A Hardware Software Approach The Morgan Kaufmann Series In Computer Architecture

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Parallel Computers 2

The end of dramatic exponential growth in single-processor performance marks the end of the dominance of the single microprocessor in computing. The era of sequential computing must give way to a new era in which parallelism is at the forefront. Although important scientific and engineering challenges lie ahead, this is an opportune time for innovation in programming systems and computing architectures. We have already begun to see diversity in computer designs to optimize for such considerations as power and throughput. The next generation of discoveries is likely to require advances at both the hardware and software levels of computing systems. There is no guarantee that we can make parallel computing as common and easy to use as yesterday's sequential single-processor computer systems, but unless we aggressively pursue efforts suggested by the recommendations in this book, it will be "game over" for growth in computing performance. If parallel programming and related software efforts fail to become widespread, the development of exciting new applications that drive the computer industry will stall; if such innovation stalls, many other parts of the economy will follow suit. The Future of Computing Performance describes the factors that have led to the future limitations on growth for single processors that are based on

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complementary metal oxide semiconductor (CMOS) technology. It explores challenges inherent in parallel computing and architecture, including ever-increasing power consumption and the escalated requirements for heat dissipation. The book delineates a research, practice, and education agenda to help overcome these challenges. The Future of Computing Performance will guide researchers, manufacturers, and information technology professionals in the right direction for sustainable growth in computer performance, so that we may all enjoy the next level of benefits to society.

Algorithms and Parallel Computing

An In-Depth View of Hardware Issues, Programming Practices, and Implementation of Key Methods Exploring the challenges of parallel programming from the perspective of quantum chemists, *Parallel Computing in Quantum Chemistry* thoroughly covers topics relevant to designing and implementing parallel quantum chemistry programs. Focusing on good parallel program design and performance analysis, the first part of the book deals with parallel computer architectures and parallel computing concepts and terminology. The authors discuss trends in hardware, methods, and algorithms; parallel computer architectures and the overall system view of a parallel computer; message-passing; parallelization via multi-threading; measures for predicting and assessing the performance of parallel algorithms; and fundamental issues of designing and implementing parallel

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programs. The second part contains detailed discussions and performance analyses of parallel algorithms for a number of important and widely used quantum chemistry procedures and methods. The book presents schemes for the parallel computation of two-electron integrals, details the Hartree-Fock procedure, considers the parallel computation of second-order Møller-Plesset energies, and examines the difficulties of parallelizing local correlation methods. Through a solid assessment of parallel computing hardware issues, parallel programming practices, and implementation of key methods, this invaluable book enables readers to develop efficient quantum chemistry software capable of utilizing large-scale parallel computers.

Introduction to Parallel Computing

This book follows a step-by-step, tutorial-based approach which will teach you how to develop your own super cluster using Raspberry Pi computers quickly and efficiently. Raspberry Pi Super Cluster is an introductory guide for those interested in experimenting with parallel computing at home. Aimed at Raspberry Pi enthusiasts, this book is a primer for getting your first cluster up and running. Basic knowledge of C or Java would be helpful but no prior knowledge of parallel computing is necessary.

Parallel Programming

Advancements in microprocessor architecture, interconnection technology, and software development have fueled rapid growth in parallel and distributed computing. However, this development is only of practical benefit if it is accompanied by progress in the design, analysis and programming of parallel algorithms. This concise textbook provides, in one place, three mainstream parallelization approaches, Open MPP, MPI and OpenCL, for multicore computers, interconnected computers and graphical processing units. An overview of practical parallel computing and principles will enable the reader to design efficient parallel programs for solving various computational problems on state-of-the-art personal computers and computing clusters. Topics covered range from parallel algorithms, programming tools, OpenMP, MPI and OpenCL, followed by experimental measurements of parallel programs' run-times, and by engineering analysis of obtained results for improved parallel execution performances. Many examples and exercises support the exposition.

Computer Architecture and Parallel Processing

New sequencing technologies have broken many experimental barriers to genome scale sequencing, leading to the extraction of huge quantities of sequence data.

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This expansion of biological databases established the need for new ways to harness and apply the astounding amount of available genomic information and convert it into substantive biological understanding. A compilation of recent approaches from prominent researchers, *Bioinformatics: High Performance Parallel Computer Architectures* discusses how to take advantage of bioinformatics applications and algorithms on a variety of modern parallel architectures. Two factors continue to drive the increasing use of modern parallel computer architectures to address problems in computational biology and bioinformatics: high-throughput techniques for DNA sequencing and gene expression analysis—which have led to an exponential growth in the amount of digital biological data—and the multi- and many-core revolution within computer architecture. Presenting key information about how to make optimal use of parallel architectures, this book: Describes algorithms and tools including pairwise sequence alignment, multiple sequence alignment, BLAST, motif finding, pattern matching, sequence assembly, hidden Markov models, proteomics, and evolutionary tree reconstruction Addresses GPGPU technology and the associated massively threaded CUDA programming model Reviews FPGA architecture and programming Presents several parallel algorithms for computing alignments on the Cell/BE architecture, including linear-space pairwise alignment, syntenic alignment, and spliced alignment Assesses underlying concepts and advances in orchestrating the phylogenetic likelihood function on parallel computer architectures (ranging from FPGAs upto the IBM BlueGene/L supercomputer) Covers several effective

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techniques to fully exploit the computing capability of many-core CUDA-enabled GPUs to accelerate protein sequence database searching, multiple sequence alignment, and motif finding Explains a parallel CUDA-based method for correcting sequencing base-pair errors in HTSR data Because the amount of publicly available sequence data is growing faster than single processor core performance speed, modern bioinformatics tools need to take advantage of parallel computer architectures. Now that the era of the many-core processor has begun, it is expected that future mainstream processors will be parallel systems. Beneficial to anyone actively involved in research and applications, this book helps you to get the most out of these tools and create optimal HPC solutions for bioinformatics.

Parallel Programming

Introduction to Parallel Computing provides an in-depth look at techniques for the design and analysis of parallel algorithms and for programming these algorithms on commercially available parallel platforms. The book discusses principles of parallel algorithm design and different parallel programming models with extensive coverage of MPI, POSIX threads, and OpenMP. It provides a broad and balanced coverage of various core topics such as sorting, graph algorithms, discrete optimization techniques, data-mining algorithms, and a number of algorithms used in numerical and scientific computing applications. The basic approach advocated in this text is one of portable parallel algorithm and software development, an

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emphasis lacking in all existing textbooks on parallel computing. To enhance the pedagogical value of the text, extensive examples, diagrams, exercises of varying degrees of difficulty, and bibliographical remarks are provided. In addition to serving as a textbook and a reference source for professionals and parallel software developers, the book will help students and researchers in non computer-science disciplines who need to solve computation-intensive problems using parallel computers.

Parallel Computing

Innovations in hardware architecture, like hyper-threading or multicore processors, mean that parallel computing resources are available for inexpensive desktop computers. In only a few years, many standard software products will be based on concepts of parallel programming implemented on such hardware, and the range of applications will be much broader than that of scientific computing, up to now the main application area for parallel computing. Rauber and Runger take up these recent developments in processor architecture by giving detailed descriptions of parallel programming techniques that are necessary for developing efficient programs for multicore processors as well as for parallel cluster systems and supercomputers. Their book is structured in three main parts, covering all areas of parallel computing: the architecture of parallel systems, parallel programming models and environments, and the implementation of efficient application

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algorithms. The emphasis lies on parallel programming techniques needed for different architectures. The main goal of the book is to present parallel programming techniques that can be used in many situations for many application areas and which enable the reader to develop correct and efficient parallel programs. Many examples and exercises are provided to show how to apply the techniques. The book can be used as both a textbook for students and a reference book for professionals. The presented material has been used for courses in parallel programming at different universities for many years.

Parallel Computing Architectures and APIs

Programming Massively Parallel Processors discusses the basic concepts of parallel programming and GPU architecture. Various techniques for constructing parallel programs are explored in detail. Case studies demonstrate the development process, which begins with computational thinking and ends with effective and efficient parallel programs. This book describes computational thinking techniques that will enable students to think about problems in ways that are amenable to high-performance parallel computing. It utilizes CUDA (Compute Unified Device Architecture), NVIDIA's software development tool created specifically for massively parallel environments. Studies learn how to achieve both high-performance and high-reliability using the CUDA programming model as well as OpenCL. This book is recommended for advanced students, software engineers,

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programmers, and hardware engineers. Teaches computational thinking and problem-solving techniques that facilitate high-performance parallel computing. Utilizes CUDA (Compute Unified Device Architecture), NVIDIA's software development tool created specifically for massively parallel environments. Shows you how to achieve both high-performance and high-reliability using the CUDA programming model as well as OpenCL.

Parallel Computer Organization and Design

Computer Architecture/Software Engineering

Heterogeneous System Architecture

Parallel computer architectures are now going to real applications! This fact is demonstrated by the large number of application areas covered in this book (see section on applications of parallel computer architectures). The applications range from image analysis to quantum mechanics and data bases. Still, the use of parallel architectures poses serious problems and requires the development of new techniques and tools. This book is a collection of best papers presented at the first workshop on two major research activities at the Universitiit Erlangen-Niirnberg and Technis che Universitiit Miinchen. At both universities, more than 100

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researchers are working in the field of multiprocessor systems and network configurations and methods and tools for parallel systems. Indeed, the German Science Foundation (Deutsche Forschungsgemeinschaft) has been sponsoring the projects under grant numbers SFB 182 and SFB 342. Research grants in the form of a Sonderforschungsbereich are given to selected German Universities in portions of three years following a thorough reviewing process. The overall duration of such a research grant is restricted to 12 years. The initiative at Erlangen-Niirnberg was started in 1987 and has been headed since this time by Prof. Dr. H. Wedekind. Work at TU-Miinchen began in 1990, head of this initiative is Prof. Dr. A. Bode. The authors of this book are grateful to the Deutsche Forschungsgemeinschaft for its continuing support in the field of research on parallel processing. The first section of the book is devoted to hardware aspects of parallel systems.

Distributed and Parallel Computing

Designed for introductory parallel computing courses at the advanced undergraduate or beginning graduate level, Elements of Parallel Computing presents the fundamental concepts of parallel computing not from the point of view of hardware, but from a more abstract view of algorithmic and implementation patterns. The aim is to facilitate the teaching of parallel programming by surveying some key algorithmic structures and programming models, together with an abstract representation of the underlying hardware. The

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presentation is friendly and informal. The content of the book is language neutral, using pseudocode that represents common programming language models. The first five chapters present core concepts in parallel computing. SIMD, shared memory, and distributed memory machine models are covered, along with a brief discussion of what their execution models look like. The book also discusses decomposition as a fundamental activity in parallel algorithmic design, starting with a naive example, and continuing with a discussion of some key algorithmic structures. Important programming models are presented in depth, as well as important concepts of performance analysis, including work-depth analysis of task graphs, communication analysis of distributed memory algorithms, key performance metrics, and a discussion of barriers to obtaining good performance. The second part of the book presents three case studies that reinforce the concepts of the earlier chapters. One feature of these chapters is to contrast different solutions to the same problem, using select problems that aren't discussed frequently in parallel computing textbooks. They include the Single Source Shortest Path Problem, the Eikonal equation, and a classical computational geometry problem: computation of the two-dimensional convex hull. After presenting the problem and sequential algorithms, each chapter first discusses the sources of parallelism then surveys parallel algorithms.

PARALLEL COMPUTERS ARCHITECTURE AND PROGRAMMING

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There is a software gap between the hardware potential and the performance that can be attained using today's software parallel program development tools. The tools need manual intervention by the programmer to parallelize the code. Programming a parallel computer requires closely studying the target algorithm or application, more so than in the traditional sequential programming we have all learned. The programmer must be aware of the communication and data dependencies of the algorithm or application. This book provides the techniques to explore the possible ways to program a parallel computer for a given application.

Programming Massively Parallel Processors

Master efficient parallel programming to build powerful applications using Python
About This Book Design and implement efficient parallel software Master new programming techniques to address and solve complex programming problems
Explore the world of parallel programming with this book, which is a go-to resource for different kinds of parallel computing tasks in Python, using examples and topics covered in great depth
Who This Book Is For Python Parallel Programming Cookbook is intended for software developers who are well versed with Python and want to use parallel programming techniques to write powerful and efficient code. This book will help you master the basics and the advanced of parallel computing.
What You Will Learn Synchronize multiple threads and processes to manage parallel tasks Implement message passing communication between processes to

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build parallel applications Program your own GPU cards to address complex problems Manage computing entities to execute distributed computational tasks Write efficient programs by adopting the event-driven programming model Explore the cloud technology with Django and Google App Engine Apply parallel programming techniques that can lead to performance improvements In Detail Parallel programming techniques are required for a developer to get the best use of all the computational resources available today and to build efficient software systems. From multi-core to GPU systems up to the distributed architectures, the high computation of programs throughout requires the use of programming tools and software libraries. Because of this, it is becoming increasingly important to know what the parallel programming techniques are. Python is commonly used as even non-experts can easily deal with its concepts. This book will teach you parallel programming techniques using examples in Python and will help you explore the many ways in which you can write code that allows more than one process to happen at once. Starting with introducing you to the world of parallel computing, it moves on to cover the fundamentals in Python. This is followed by exploring the thread-based parallelism model using the Python threading module by synchronizing threads and using locks, mutex, semaphores queues, GIL, and the thread pool. Next you will be taught about process-based parallelism where you will synchronize processes using message passing along with learning about the performance of MPI Python Modules. You will then go on to learn the asynchronous parallel programming model using the Python asyncio module along with handling

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exceptions. Moving on, you will discover distributed computing with Python, and learn how to install a broker, use Celery Python Module, and create a worker. You will also understand the StarCluster framework, Pycsp, Scoop, and Disco modules in Python. Further on, you will learn GPU programming with Python using the PyCUDA module along with evaluating performance limitations. Next you will get acquainted with the cloud computing concepts in Python, using Google App Engine (GAE), and building your first application with GAE. Lastly, you will learn about grid computing concepts in Python and using PyGlobus toolkit, GFTP and GASS COPY to transfer files, and service monitoring in PyGlobus. Style and approach A step-by-step guide to parallel programming using Python, with recipes accompanied by one or more programming examples. It is a practically oriented book and has all the necessary underlying parallel computing concepts.

Introduction to Parallel Computing

THE CONTEXT OF PARALLEL PROCESSING The field of digital computer architecture has grown explosively in the past two decades. Through a steady stream of experimental research, tool-building efforts, and theoretical studies, the design of an instruction-set architecture, once considered an art, has been transformed into one of the most quantitative branches of computer technology. At the same time, better understanding of various forms of concurrency, from standard pipelining to massive parallelism, and invention of architectural structures to support a

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reasonably efficient and user-friendly programming model for such systems, has allowed hardware performance to continue its exponential growth. This trend is expected to continue in the near future. This explosive growth, linked with the expectation that performance will continue its exponential rise with each new generation of hardware and that (in stark contrast to software) computer hardware will function correctly as soon as it comes off the assembly line, has its down side. It has led to unprecedented hardware complexity and almost intolerable development costs. The challenge facing current and future computer designers is to institute simplicity where we now have complexity; to use fundamental theories being developed in this area to gain performance and ease-of-use benefits from simpler circuits; to understand the interplay between technological capabilities and limitations, on the one hand, and design decisions based on user and application requirements on the other.

Elements of Parallel Computing

Parallel Computing Architectures and APIs: IoT Big Data Stream Processing commences from the point high-performance uniprocessors were becoming increasingly complex, expensive, and power-hungry. A basic trade-off exists between the use of one or a small number of such complex processors, at one extreme, and a moderate to very large number of simpler processors, at the other. When combined with a high-bandwidth, interprocessor communication facility

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leads to significant simplification of the design process. However, two major roadblocks prevent the widespread adoption of such moderately to massively parallel architectures: the interprocessor communication bottleneck, and the difficulty and high cost of algorithm/software development. One of the most important reasons for studying parallel computing architectures is to learn how to extract the best performance from parallel systems. Specifically, you must understand its architectures so that you will be able to exploit those architectures during programming via the standardized APIs. This book would be useful for analysts, designers and developers of high-throughput computing systems essential for big data stream processing emanating from IoT-driven cyber-physical systems (CPS). This pragmatic book: Devolves uniprocessors in terms of a ladder of abstractions to ascertain (say) performance characteristics at a particular level of abstraction Explains limitations of uniprocessor high performance because of Moore's Law Introduces basics of processors, networks and distributed systems Explains characteristics of parallel systems, parallel computing models and parallel algorithms Explains the three primary categorical representatives of parallel computing architectures, namely, shared memory, message passing and stream processing Introduces the three primary categorical representatives of parallel programming APIs, namely, OpenMP, MPI and CUDA Provides an overview of Internet of Things (IoT), wireless sensor networks (WSN), sensor data processing, Big Data and stream processing Provides introduction to 5G communications, Edge and Fog computing Parallel Computing Architectures and APIs: IoT Big Data Stream

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Processing discusses stream processing that enables the gathering, processing and analysis of high-volume, heterogeneous, continuous Internet of Things (IoT) big data streams, to extract insights and actionable results in real time. Application domains requiring data stream management include military, homeland security, sensor networks, financial applications, network management, web site performance tracking, real-time credit card fraud detection, etc.

Parallel Computing in Quantum Chemistry

Innovations in hardware architecture, like hyper-threading or multicore processors, mean that parallel computing resources are available for inexpensive desktop computers. In only a few years, many standard software products will be based on concepts of parallel programming implemented on such hardware, and the range of applications will be much broader than that of scientific computing, up to now the main application area for parallel computing. Rauber and Runger take up these recent developments in processor architecture by giving detailed descriptions of parallel programming techniques that are necessary for developing efficient programs for multicore processors as well as for parallel cluster systems and supercomputers. Their book is structured in three main parts, covering all areas of parallel computing: the architecture of parallel systems, parallel programming models and environments, and the implementation of efficient application algorithms. The emphasis lies on parallel programming techniques needed for

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different architectures. For this second edition, all chapters have been carefully revised. The chapter on architecture of parallel systems has been updated considerably, with a greater emphasis on the architecture of multicore systems and adding new material on the latest developments in computer architecture. Lastly, a completely new chapter on general-purpose GPUs and the corresponding programming techniques has been added. The main goal of the book is to present parallel programming techniques that can be used in many situations for a broad range of application areas and which enable the reader to develop correct and efficient parallel programs. Many examples and exercises are provided to show how to apply the techniques. The book can be used as both a textbook for students and a reference book for professionals. The material presented has been used for courses in parallel programming at different universities for many years.

Bioinformatics

A design-oriented text for advanced computer architecture courses, covering parallelism, complexity, power, reliability and performance.

Programming Massively Parallel Processors

The goal of this book is to present an overview of the current state-of-the-art in

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computer architecture performance evaluation. The book covers various aspects that relate to performance evaluation, ranging from performance metrics, to workload selection, to various modeling approaches such as analytical modeling and simulation. And because simulation is by far the most prevalent modeling technique in computer architecture evaluation, the book spends more than half its content on simulation, covering an overview of the various simulation techniques in the computer designer's toolbox, followed by various simulation acceleration techniques such as sampled simulation, statistical simulation, and parallel and hardware-accelerated simulation. The evaluation methods described in this book have a primary focus on performance. Although performance remains to be a key design target, it no longer is the sole design target. Power consumption and reliability have quickly become primary design concerns, and today they probably are as important as performance. Other important design constraints relate to cost, thermal issues, yield, etc. This book focuses on performance evaluation methods only. This does not compromise on the importance and general applicability of the techniques described in this book because power and reliability models are typically integrated into existing performance models. These integrated models pose similar challenges to the ones handled in this book. The book also focuses on presenting fundamental concepts and ideas. The book does not provide much quantitative data. Although quantitative data is crucial to performance evaluation, to understand the fundamentals of performance evaluation methods it is not. Moreover, quantitative data from different sources may be hard to compare,

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and may even be misleading, because the contexts in which the results were obtained may be very different - a comparison based on these numbe

Parallel Computer Architectures

Introduction to Parallel Processing

Heterogeneous Systems Architecture - a new compute platform infrastructure presents a next-generation hardware platform, and associated software, that allows processors of different types to work efficiently and cooperatively in shared memory from a single source program. HSA also defines a virtual ISA for parallel routines or kernels, which is vendor and ISA independent thus enabling single source programs to execute across any HSA compliant heterogeneous processor from those used in smartphones to supercomputers. The book begins with an overview of the evolution of heterogeneous parallel processing, associated problems, and how they are overcome with HSA. Later chapters provide a deeper perspective on topics such as the runtime, memory model, queuing, context switching, the architected queuing language, simulators, and tool chains. Finally, three real world examples are presented, which provide an early demonstration of how HSA can deliver significantly higher performance thru C++ based applications.

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Contributing authors are HSA Foundation members who are experts from both academia and industry. Some of these distinguished authors are listed here in alphabetical order: Yeh-Ching Chung, Benedict R. Gaster, Juan Gómez-Luna, Derek Hower, Lee Howes, Shih-Hao Hung, Thomas B. Jablin, David Kaeli, Phil Rogers, Ben Sander, I-Jui (Ray) Sung. Provides clear and concise explanations of key HSA concepts and fundamentals by expert HSA Specification contributors Explains how performance-bound programming algorithms and application types can be significantly optimized by utilizing HSA hardware and software features Presents HSA simply, clearly, and concisely without reading the detailed HSA Specification documents Demonstrates ideal mapping of processing resources from CPUs to many other heterogeneous processors that comply with HSA Specifications

Fundamentals of Parallel Computer Architecture

An Introduction to Parallel Programming is the first undergraduate text to directly address compiling and running parallel programs on the new multi-core and cluster architecture. It explains how to design, debug, and evaluate the performance of distributed and shared-memory programs. The author Peter Pacheco uses a tutorial approach to show students how to develop effective parallel programs with MPI, Pthreads, and OpenMP, starting with small programming examples and building progressively to more challenging ones. The text is written for students in undergraduate parallel programming or parallel computing courses designed for

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the computer science major or as a service course to other departments; professionals with no background in parallel computing. Takes a tutorial approach, starting with small programming examples and building progressively to more challenging examples Focuses on designing, debugging and evaluating the performance of distributed and shared-memory programs Explains how to develop parallel programs using MPI, Pthreads, and OpenMP programming models

Parallel Computer Architecture

Parallel Programming: Concepts and Practice provides an upper level introduction to parallel programming. In addition to covering general parallelism concepts, this text teaches practical programming skills for both shared memory and distributed memory architectures. The authors' open-source system for automated code evaluation provides easy access to parallel computing resources, making the book particularly suitable for classroom settings. Covers parallel programming approaches for single computer nodes and HPC clusters: OpenMP, multithreading, SIMD vectorization, MPI, UPC++ Contains numerous practical parallel programming exercises Includes access to an automated code evaluation tool that enables students the opportunity to program in a web browser and receive immediate feedback on the result validity of their program Features an example-based teaching of concept to enhance learning outcomes

Computer Organization and Design

Programming Massively Parallel Processors: A Hands-on Approach, Third Edition shows both student and professional alike the basic concepts of parallel programming and GPU architecture, exploring, in detail, various techniques for constructing parallel programs. Case studies demonstrate the development process, detailing computational thinking and ending with effective and efficient parallel programs. Topics of performance, floating-point format, parallel patterns, and dynamic parallelism are covered in-depth. For this new edition, the authors have updated their coverage of CUDA, including coverage of newer libraries, such as CuDNN, moved content that has become less important to appendices, added two new chapters on parallel patterns, and updated case studies to reflect current industry practices. Teaches computational thinking and problem-solving techniques that facilitate high-performance parallel computing Utilizes CUDA version 7.5, NVIDIA's software development tool created specifically for massively parallel environments Contains new and updated case studies Includes coverage of newer libraries, such as CuDNN for Deep Learning

Computer Architecture Performance Evaluation Methods

This best selling text on computer organization has been thoroughly updated to

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reflect the newest technologies. Examples highlight the latest processor designs, benchmarking standards, languages and tools. As with previous editions, a MIPS processor is the core used to present the fundamentals of hardware technologies at work in a computer system. The book presents an entire MIPS instruction set—instruction by instruction—the fundamentals of assembly language, computer arithmetic, pipelining, memory hierarchies and I/O. A new aspect of the third edition is the explicit connection between program performance and CPU performance. The authors show how hardware and software components--such as the specific algorithm, programming language, compiler, ISA and processor implementation--impact program performance. Throughout the book a new feature focusing on program performance describes how to search for bottlenecks and improve performance in various parts of the system. The book digs deeper into the hardware/software interface, presenting a complete view of the function of the programming language and compiler--crucial for understanding computer organization. A CD provides a toolkit of simulators and compilers along with tutorials for using them. For instructor resources click on the grey "companion site" button found on the right side of this page. This new edition represents a major revision. New to this edition: * Entire Text has been updated to reflect new technology * 70% new exercises. * Includes a CD loaded with software, projects and exercises to support courses using a number of tools * A new interior design presents defined terms in the margin for quick reference * A new feature, "Understanding Program Performance" focuses on performance from the

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programmer's perspective * Two sets of exercises and solutions, "For More Practice" and "In More Depth," are included on the CD * "Check Yourself" questions help students check their understanding of major concepts * "Computers In the Real World" feature illustrates the diversity of uses for information technology
*More detail below

Fundamentals of Parallel Multicore Architecture

Parallel Computing Architectures and APIs: IoT Big Data Stream Processing commences from the point high-performance uniprocessors were becoming increasingly complex, expensive, and power-hungry. A basic trade-off exists between the use of one or a small number of such complex processors, at one extreme, and a moderate to very large number of simpler processors, at the other. When combined with a high-bandwidth, interprocessor communication facility leads to significant simplification of the design process. However, two major roadblocks prevent the widespread adoption of such moderately to massively parallel architectures: the interprocessor communication bottleneck, and the difficulty and high cost of algorithm/software development. One of the most important reasons for studying parallel computing architectures is to learn how to extract the best performance from parallel systems. Specifically, you must understand its architectures so that you will be able to exploit those architectures during programming via the standardized APIs. This book would be useful for

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analysts, designers and developers of high-throughput computing systems essential for big data stream processing emanating from IoT-driven cyber-physical systems (CPS). This pragmatic book: Devolves uniprocessors in terms of a ladder of abstractions to ascertain (say) performance characteristics at a particular level of abstraction Explains limitations of uniprocessor high performance because of Moore's Law Introduces basics of processors, networks and distributed systems Explains characteristics of parallel systems, parallel computing models and parallel algorithms Explains the three primary categorical representatives of parallel computing architectures, namely, shared memory, message passing and stream processing Introduces the three primary categorical representatives of parallel programming APIs, namely, OpenMP, MPI and CUDA Provides an overview of Internet of Things (IoT), wireless sensor networks (WSN), sensor data processing, Big Data and stream processing Provides introduction to 5G communications, Edge and Fog computing Parallel Computing Architectures and APIs: IoT Big Data Stream Processing discusses stream processing that enables the gathering, processing and analysis of high-volume, heterogeneous, continuous Internet of Things (IoT) big data streams, to extract insights and actionable results in real time. Application domains requiring data stream management include military, homeland security, sensor networks, financial applications, network management, web site performance tracking, real-time credit card fraud detection, etc.

Parallel Computing Works!

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Although multicore is now a mainstream architecture, there are few textbooks that cover parallel multicore architectures. Filling this gap, *Fundamentals of Parallel Multicore Architecture* provides all the material for a graduate or senior undergraduate course that focuses on the architecture of multicore processors. The book is also useful as a ref

Highly Parallel Computing

An Introduction to Parallel Programming

Since the publication of the first edition, parallel computing technology has gained considerable momentum. A large proportion of this has come from the improvement in VLSI techniques, offering one to two orders of magnitude more devices than previously possible. A second contributing factor in the fast development of the subject is commercialization. The supercomputer is no longer restricted to a few well-established research institutions and large companies. A new computer breed combining the architectural advantages of the supercomputer with the advance of VLSI technology is now available at very attractive prices. A pioneering device in this development is the transputer, a VLSI processor specifically designed to operate in large concurrent systems. *Parallel Computers 2:*

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Architecture, Programming and Algorithms reflects the shift in emphasis of parallel computing and tracks the development of supercomputers in the years since the first edition was published. It looks at large-scale parallelism as found in transputer ensembles. This extensively rewritten second edition includes major new sections on the transputer and the OCCAM language. The book contains specific information on the various types of machines available, details of computer architecture and technologies, and descriptions of programming languages and algorithms. Aimed at an advanced undergraduate and postgraduate level, this handbook is also useful for research workers, machine designers, and programmers concerned with parallel computers. In addition, it will serve as a guide for potential parallel computer users, especially in disciplines where large amounts of computer time are regularly used.

Parallel Computer Architectures

Parallel Computer Architectures

The most exciting development in parallel computer architecture is the convergence of traditionally disparate approaches on a common machine structure. This book explains the forces behind this convergence of shared-

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memory, message-passing, data parallel, and data-driven computing architectures. It then examines the design issues that are critical to all parallel architecture across the full range of modern design, covering data access, communication performance, coordination of cooperative work, and correct implementation of useful semantics. It not only describes the hardware and software techniques for addressing each of these issues but also explores how these techniques interact in the same system. Examining architecture from an application-driven perspective, it provides comprehensive discussions of parallel programming for high performance and of workload-driven evaluation, based on understanding hardware-software interactions. synthesizes a decade of research and development for practicing engineers, graduate students, and researchers in parallel computer architecture, system software, and applications development presents in-depth application case studies from computer graphics, computational science and engineering, and data mining to demonstrate sound quantitative evaluation of design trade-offs describes the process of programming for performance, including both the architecture-independent and architecture-dependent aspects, with examples and case-studies illustrates bus-based and network-based parallel systems with case studies of more than a dozen important commercial designs

Designing Embedded Hardware

Today all computers, from tablet/desktop computers to super computers, work in

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parallel. A basic knowledge of the architecture of parallel computers and how to program them, is thus, essential for students of computer science and IT professionals. In its second edition, the book retains the lucidity of the first edition and has added new material to reflect the advances in parallel computers. It is designed as text for the final year undergraduate students of computer science and engineering and information technology. It describes the principles of designing parallel computers and how to program them. This second edition, while retaining the general structure of the earlier book, has added two new chapters, 'Core Level Parallel Processing' and 'Grid and Cloud Computing' based on the emergence of parallel computers on a single silicon chip popularly known as multicore processors and the rapid developments in Cloud Computing. All chapters have been revised and some chapters are re-written to reflect the emergence of multicore processors and the use of MapReduce in processing vast amounts of data. The new edition begins with an introduction to how to solve problems in parallel and describes how parallelism is used in improving the performance of computers. The topics discussed include instruction level parallel processing, architecture of parallel computers, multicore processors, grid and cloud computing, parallel algorithms, parallel programming, compiler transformations, operating systems for parallel computers, and performance evaluation of parallel computers.

Raspberry Pi Super Cluster

Parallel Computing Architectures and APIs

This book outlines a set of issues that are critical to all of parallel architecture--communication latency, communication bandwidth, and coordination of cooperative work (across modern designs). It describes the set of techniques available in hardware and in software to address each issues and explore how the various techniques interact.

Parallel Computing Set

Intelligent readers who want to build their own embedded computer systems--installed in everything from cell phones to cars to handheld organizers to refrigerators-- will find this book to be the most in-depth, practical, and up-to-date guide on the market. Designing Embedded Hardware carefully steers between the practical and philosophical aspects, so developers can both create their own devices and gadgets and customize and extend off-the-shelf systems. There are hundreds of books to choose from if you need to learn programming, but only a few are available if you want to learn to create hardware. Designing Embedded Hardware provides software and hardware engineers with no prior experience in embedded systems with the necessary conceptual and design building blocks to understand the architectures of embedded systems. Written to provide the depth

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of coverage and real-world examples developers need, Designing Embedded Hardware also provides a road-map to the pitfalls and traps to avoid in designing embedded systems. Designing Embedded Hardware covers such essential topics as: The principles of developing computer hardware Core hardware designs Assembly language concepts Parallel I/O Analog-digital conversion Timers (internal and external) UART Serial Peripheral Interface Inter-Integrated Circuit Bus Controller Area Network (CAN) Data Converter Interface (DCI) Low-power operation This invaluable and eminently useful book gives you the practical tools and skills to develop, build, and program your own application-specific computers.

Parallel Computer Architecture

This set includes Parallel Computer Architecture: A Hardware/Software Approach by David Culler and J.P. Singh with Anoop Gupta and Parallel Programming with MPI by Peter Pacheco.

Python Parallel Programming Cookbook

Parallel computer architectures are now going to real applications! This fact is demonstrated by the large number of application areas covered in this book (see section on applications of parallel computer architectures). The applications range

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from image analysis to quantum mechanics and data bases. Still, the use of parallel architectures poses serious problems and requires the development of new techniques and tools. This book is a collection of best papers presented at the first workshop on two major research activities at the Universitiit Erlangen-Niirnberg and Technis che Universitiit Miinchen. At both universities, more than 100 researchers are working in the field of multiprocessor systems and network configurations and methods and tools for parallel systems. Indeed, the German Science Founda tion (Deutsche Forschungsgemeinschaft) has been sponsoring the projects under grant numbers SFB 182 and SFB 342. Research grants in the form of a Sonder forschungsbereich are given to selected German Universities in portions of three years following a thoroughful reviewing process. The overall duration of such a research grant is restricted to 12 years. The initiative at Erlangen-Niirnberg was started in 1987 and has been headed since this time by Prof. Dr. H. Wedekind. Work at TU-Miinchen began in 1990, head of this initiative is Prof. Dr. A. Bode. The authors of this book are grateful to the Deutsche Forschungsgemeinschaft for its continuing support in the field of research on parallel processing. The first section of the book is devoted to hardware aspects of parallel systems.

Computer Architecture

This book constitutes the refereed proceedings of the 6th International Conference on Algorithms and Architectures for Parallel Processing, ICA3PP 2005, held in

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Melbourne, Australia in October 2005. The 27 revised full papers and 25 revised short papers presented were carefully reviewed and selected from 95 submissions. The book covers new architectures of parallel and distributed systems, new system management facilities, and new application algorithms with special focus on two broad areas of parallel and distributed computing, i.e., architectures, algorithms and networks, and systems and applications.

Parallel Programming

A clear illustration of how parallel computers can be successfully applied to large-scale scientific computations. This book demonstrates how a variety of applications in physics, biology, mathematics and other sciences were implemented on real parallel computers to produce new scientific results. It investigates issues of fine-grained parallelism relevant for future supercomputers with particular emphasis on hypercube architecture. The authors describe how they used an experimental approach to configure different massively parallel machines, design and implement basic system software, and develop algorithms for frequently used mathematical computations. They also devise performance models, measure the performance characteristics of several computers, and create a high-performance computing facility based exclusively on parallel computers. By addressing all issues involved in scientific problem solving, *Parallel Computing Works!* provides valuable insight into computational science for large-scale parallel architectures. For those in the

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sciences, the findings reveal the usefulness of an important experimental tool. Anyone in supercomputing and related computational fields will gain a new perspective on the potential contributions of parallelism. Includes over 30 full-color illustrations.

The Future of Computing Performance

This text takes a two-fold approach: to provide a foundation for understanding and evaluating the design principles incorporated in modern computers; and to present basic techniques for designing parallel systems and parallel algorithms.

Computer Architecture

This second edition includes new exercises for each chapter, a quantitative treatment of speedup, seismic migration, using a workstation network as a parallel computer, recent changes in technology, more languages, fat trees, wormhole switching, new SIMD hardware, an expanded section on CM-2, new MIMD hardware, using workstation clusters as a MIMD system, and directory based caches. Annotation copyright by Book News, Inc., Portland, OR

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