CUDA Programming
Introduction to Parallel Algorithms
Topics in Parallel and Distributed Computing
Parallel Programming with MPI
Introduction to Parallel Computing
Parallel and Concurrent Programming in Haskell
Massively Parallel Processors
Encyclopedia of Parallel Computing
Introduction to Parallel Computing
Parallel Programming An Introduction to Parallel Programming, Design and Analysis of Algorithms
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Introduction to Parallel Programming
Parallel Computing Workshops
Introduction to Parallel Computing
Practical Parallel Programming
Scientific Computing
Handbook of Parallel Computing and Statistics
Introduction to Parallel Computing
Patterns for Parallel Programming
INTRODUCTION TO PARALLEL PROCESSING
Parallel Computing for Data Science
An Introduction to Distributed and Parallel Computing
Introduction to Parallel Computing
High Performance Computing
and the Art of Parallel Programming
Parallel and High Performance Computing
Parallel Computer Architectures
Introduction to Parallel Computing
Introduction to Parallel Computing
Scientific Parallel Computing
Introduction to Parallel High Performance Scientific Computing
Introduction to Parallel Computing
Introduction to Parallel Algorithms and Architectures
Algorithms and Parallel Computing
Using OpenMP
Elements of Parallel Computing
Parallel Computing Using the Prefix Problem
Introduction to Parallel Computing
Structured Parallel Programming
High Performance Parallel Computing

What does Google's management of billions of Web pages have in common with an analysis of a genome with billions of nucleotides? Both apply methods that coordinate many processors to accomplish a single task. From mining genomes to the World Wide Web, from modeling financial markets to global weather patterns, parallel computing enables computations that would otherwise be impractical if not impossible with sequential approaches alone. Its fundamental role as an enabler of simulations and data analysis continues an advance in a wide range of application areas. Scientific Parallel Computing is the first textbook to integrate all the fundamentals of parallel computing in a single volume while also providing a basis for a deeper understanding of the subject. Designed for graduate and advanced undergraduate courses in the sciences and in engineering, computer science, and mathematics, it focuses on the three key areas of algorithms, architecture, languages, and their crucial synthesis in performance. The book's computational examples, whose math prerequisites are not beyond the level of advanced calculus, derive from a breadth of topics in scientific and engineering simulation and data analysis. The programming exercises presented early in the book are designed to bring students up to speed quickly, while the book later develops projects challenging enough to guide students toward research questions in the field. The new paradigm of cluster computing is fully addressed. A supporting web site provides access to all the codes and software mentioned in the book, and offers topical information on popular parallel computing systems. Integrates all the fundamentals of parallel computing essential for today's high-performance requirements ideal for graduate and advanced undergraduate students in the sciences and in engineering, computer science, and mathematics

Extensive programming and theoretical exercises enable students to write parallel codes quickly. More challenging projects later in the book introduce research questions. A new paradigm of cluster computing is fully addressed. Supporting web site provides access to all the codes and software mentioned in the book.

Programming is now parallel programming. Much as structured programming revolutionized traditional serial programming decades ago, a new kind of structured programming, based on patterns, is relevant to parallel programming today. Parallel computing experts and industry insiders, Michael McCool, Arch Robison, and James Reinders describe how to design and implement maintainable and efficient parallel algorithms using a pattern-based approach. They present both theory and practice, and give detailed concrete examples using multiple programming models. Examples are primarily given using two of the most popular and cutting edge programming models for parallel programming: Threading Building Blocks, and Cilk Plus. These architecture independent models enable easy integration into existing applications, preserve investments in existing code, and speed the development of parallel applications. Examples from realistic contexts illustrate patterns and themes in parallel algorithm design that are widely applicable regardless of implementation technology. The patterns-based approach offers structure and insight that developers can apply to a variety of parallel programming models. Develops a composable, structured, scalable, and machine independent approach to parallel computing. Includes detailed examples in both Cilk Plus and the latest Threading Building Blocks, which support a wide variety of computers.

A comprehensive overview of OpenMP, the standard application programming interface for shared memory parallel computing—a reference for students and professionals. “I hope that readers will learn to use the full expressibility and power of OpenMP. This book should provide an excellent introduction to beginners, and the performance section should help those with some experience who want to push OpenMP to its limits.” — from the foreword by David J. Kuck, Intel Fellow, Software and Solutions Group, and Director, Parallel and Distributed Solutions, Intel Corporation

OpenMP, a portable programming interface for shared memory parallel computers, was adopted as an informal standard in 1997 by computer scientists who wanted a unified model on which to base programs for shared memory systems. OpenMP is now used by many software developers; it offers significant advantages over both hand-threading and MPI. Using OpenMP offers a comprehensive introduction to parallel programming concepts and a detailed overview of OpenMP. Using OpenMP discusses hardware developments, describes where OpenMP is applicable, and compares OpenMP to other programming interfaces for shared and distributed memory parallel architectures. It introduces the individual features of OpenMP, provides many source code examples that demonstrate the use and functionality of the language, and offers tips on writing an efficient OpenMP program. It describes how to use OpenMP in full-scale applications to achieve high performance on large scale architectures, discussing several case studies in detail, and offers in-depth troubleshooting advice. It explains how OpenMP is translated into explicitly multithreaded code, providing a valuable behind-the-scenes account of OpenMP program performance. Finally, Using OpenMP considers trends likely to influence OpenMP development, offering a glimpse of the possibilities of a future OpenMP 3.0 from the vantage point of the current OpenMP 2.5. With multicore computer use increasing, the need for a comprehensive introduction and overview of the standard interface is clear. Using OpenMP provides an essential reference not only for students at both undergraduate and graduate levels but also for professionals who intend to parallelize existing codes or develop new parallel programs for shared memory computer architectures.

Introduction to Parallel Algorithms and Architectures: Arrays Trees Hypercubes provides an introduction to the expanding field of parallel computing.
algorithms and architectures. This book focuses on parallel computation involving the most popular network architectures, namely, arrays, trees, hypercubes, and some closely related networks. Organized into three chapters, this book begins with an overview of the simplest architectures of arrays and trees. This text then presents the structures and relationships between the dominant network architectures, as well as the most efficient parallel algorithms for a wide variety of problems. Other chapters focus on fundamental results and techniques and on rigorous analysis of algorithmic performance. This book discusses as well a hybrid of network architecture based on arrays and trees called the mesh of trees. The final chapter deals with the most important properties of hypercubes. This book is a valuable resource for readers with a general technical background.

The prefix operation on a set of data is one of the simplest and most useful building blocks in parallel algorithms. This book cogently illustrates how the approach leads to fast and efficient solutions to many different kinds of problems.

If you have a working knowledge of Haskell, this hands-on book shows you how to use the language’s many APIs and frameworks for writing both parallel and concurrent programs. You’ll learn how parallelism exploits multicore processors to speed up computation-heavy programs, and how concurrency enables you to write programs with threads for multiple interactions. Author Simon Marlow walks you through the process with lots of code examples that you can run, experiment with, and extend. Divided into separate sections on Parallel and Concurrent Haskell, this book also includes exercises to help you become familiar with the concepts presented: Express parallelism in Haskell with the Eval monad and Evaluation Strategies Parallelize ordinary Haskell code with the Par monad Build parallel array-based computations, using the Repa library Use the Accelerate library to run computations directly on the GPU Work with basic interfaces for writing concurrent code Build trees of threads for larger and more complex programs. Learn how to build high-speed concurrent network servers. Write distributed programs that run on multiple machines in a network.

This book introduces the basic concepts of parallel and vector computing in the context of an introduction to numerical methods. It contains chapters on parallel and vector matrix multiplication and solution of linear systems by direct and iterative methods. It is suitable for advanced undergraduate and beginning graduate courses in computer science, applied mathematics, and engineering. Ideally, students will have access to a parallel or Vector computer, but the material can be studied profitably in any case. Gives a modern overview of scientific computing including parallel and vector computation Introduces numerical methods for both ordinary and partial differential equations Has considerable discussion of both direct and iterative methods for linear systems of equations, including parallel and vector algorithms Covers most of the main topics for a first course in numerical methods and can serve as a text for this course.

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 in 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.

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 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 and then surveys parallel algorithms.

This edited book aims to present the state of the art in research and development of the convergence of high-performance computing and parallel programming for various engineering and scientific applications. The book has consolidated algorithms, techniques, and methodologies to bridge the gap between the theoretical foundations of academia and implementation for research, which might be used in business and other real-time applications, in the future. The book outlines techniques and tools used for emergent areas and domains, which include acceleration of large-scale electronic structure simulations with heterogeneous parallel computing, characterizing power and energy efficiency of a data-centric high-performance computing runtime and applications, security applications of GPUs, parallel implementation of multiprocessors on MPI using FDTD, particle-based fused rendering, design and implementation of particle systems for mesh-free methods with high performance, and evolving topics on heterogeneous computing. In the coming days the need to converge HPC, IoT, cloud-based applications will be felt and this volume tries to bridge that gap.

Topics in Parallel and Distributed Computing provides resources and guidance for those learning PDC as well as those teaching students new to the discipline. The pervasiveness of computing devices containing multicore CPUs and GPUs, including home and office PCs, laptops, and mobile devices, is making even common users dependent on parallel processing. Certainly, it is no longer sufficient for even basic programmers to acquire only the traditional sequential programming skills. The preceding trends point to the need for imparting a broad-based skill set in PDC technology. However, the rapid changes in computing hardware platforms and devices, languages, supporting programming environments, and research advances pose a challenge both for newcomers and seasoned computer scientists. This edited collection has been developed over the
An Introduction to Parallel Programming, Second Edition presents a tried-and-true tutorial approach that shows students how to develop effective parallel programs with MPI, Pthreads and OpenMP. As the first undergraduate text to directly address compiling and running parallel programs on multi-core and cluster architecture, this second edition carries forward its clear explanations for designing, debugging and evaluating the performance of distributed and shared-memory programs while adding coverage of accelerators via new content on GPU programming and heterogeneous programming. New and improved user-friendly exercises teach students how to compile, run and modify example programs. Takes a tutorial approach, starting with small programming examples and building progressively to more challenging examples Explain how to develop parallel programs using MPI, Pthreads and OpenMP programming models. A robust package of online ancillaries for instructors and students includes lecture slides, solutions manual, downloadable source code, and an image bank. New to this edition: New chapters on GPU programming and heterogeneous programming. New examples and exercises related to parallel algorithms.

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 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.

In the last few years, courses on parallel computation have been developed and offered in many institutions in the UK, Europe and US as a recognition of the growing significance of this topic in mathematics and computer science. There is a clear need for texts that meet the needs of students and lecturers and this book, based on the author’s lecture at ETH Zurich, is an ideal practical student guide to scientific computing on parallel computers working up from a hardware instruction level, to shared memory machines, and finally to distributed memory machines. Aimed at advanced undergraduate and graduate students in applied mathematics, computer science, and engineering, subjects covered include linear algebra, fast Fourier transform, and Monte-Carlo simulations, including examples in C and, in some cases Fortran. This book is also ideal for practitioners and programmers.

A comprehensive guide for students and practitioners to parallel computing models, processes, metrics, and implementation in MPI and OpenMP.

Parallel Computing for Data Science: With Examples in R, C++ and CUDA is one of the first parallel computing books to concentrate exclusively on parallel data structures, algorithms, software tools, and applications in data science. It includes examples not only from the classics in “n observations, p variables” matrix format but also from time series.

Technological improvements continue to push back the frontier of processor speed in modern computers. Unfortunately, the computational intensity demanded by modern research problems grows even faster. Parallel computing has emerged as the most successful bridge to this computational gap, and many popular solutions have emerged based on its concepts.

Written with a straightforward and student-centred approach, this extensively revised, updated and enlarged edition presents a thorough coverage of the various aspects of parallel processing including parallel processing architectures, programmability issues, data dependency analysis, shared memory programming, thread-based implementation, distributed computing algorithms, parallel programming languages, debugging, parallelism paradigms, distributed databases as well as distributed operating systems. The book, now in its second edition, not only provides sufficient practical exposure to the programming issues but also enables its readers to make realistic attempts at writing parallel programs using easily available software tools. With all the latest information incorporated and several key pedagogical attributes included, this textbook is an invaluable learning tool for the undergraduate and postgraduate students of computer science and engineering. It also caters to the students pursuing master of computer application. What’s New to the Second Edition: A new chapter named Using Parallelism Effectively has been added covering a case study of parallelising a sorting program, and introducing commonly used parallelism models. Sections describing the mapreduce model, top-500.org initiative, Indian efforts in supercomputing, OpenMP system for shared memory programming, etc. have been added. Numerical sections have been updated with current information. Several questions have been incorporated in the chapter-end exercises to guide students from examination and practice points of view.

A complete source of information on almost all aspects of parallel computing from introduction, to architectures, to programming paradigms, to algorithms, to programming standards. It covers traditional Computer Science algorithms, scientific computing algorithms and data intensive algorithms.
Parallel algorithms. The complexity of today's applications coupled with the widespread use of parallel computing has made the design and analysis of parallel algorithms topics of growing interest. This volume fills a need in the field for an introductory treatment of parallel algorithms—appropriate even at the undergraduate level, where no other textbooks on the subject exist. It features a systematic approach to the latest design techniques, providing analysis and implementation details for each parallel algorithm described in the book. Introduction to Parallel Algorithms covers foundations of parallel computing, parallel algorithms for trees and graphs, parallel algorithms for sorting, searching, and merging, and numerical algorithms. This remarkable book: * Provides basic concepts in clear and simple terms * Incorporates numerous examples to enhance students' understanding * Shows how to develop parallel algorithms for all classical problems in computer science, mathematics, and engineering * Employs extensive illustrations of new design techniques * Discusses parallel algorithms in the context of PRAM model * Includes end-of-chapter exercises and detailed references on parallel computing. This book enables universities to offer parallel algorithm courses at the senior undergraduate level in computer science and engineering. It is also an invaluable text/reference for graduate students, scientists, and engineers in computer science, mathematics, and engineering.

Containing over 300 entries in an A-Z format, the Encyclopedia of Parallel Computing provides easy, intuitive access to relevant information for professionals and researchers seeking access to any aspect within the broad field of parallel computing. Topics for this comprehensive reference were selected, written, and peer-reviewed by an international pool of distinguished researchers in the field. The Encyclopedia is broad in scope, covering machine organization, programming languages, algorithms, and applications. Within each area, concepts, designs, and specific implementations are presented. The highly-structured essays in this work comprise synonyms, a definition and discussion of the topic, bibliographies, and links to related literature. Extensive cross-references to other entries within the Encyclopedia support efficient, user-friendly searches for immediate access to useful information. Key concepts presented in the Encyclopedia of Parallel Computing include: laws and metrics; specific numerical and non-numerical algorithms; asynchronous algorithms; libraries of subroutines; benchmark suites; applications; sequential consistency and cache coherence; machine classes such as clusters, shared-memory multiprocessors, special-purpose machines and dataflow machines; specific machines such as Cray supercomputers, IBM's SP2 processor and Intel's multicore machines; race detection and auto parallelization; parallel programming languages, synchronization primitives, collective operations, message passing libraries, checkpointing, and operating systems. Topics covered: Speedup, Efficiency, Isoefficiency, Redundancy, Amdahl's law, Computer Architecture Concepts, Parallel Machine Designs, Benchmarking, Parallel Programming concepts & design, Algorithms, Parallel applications. This authoritative reference will be published in two formats: print and online. The online edition features hyperlinks to cross-references and to additional significant research.

Related Subjects: supercomputing, high-performance computing, distributed computing

Programming Massively Parallel Processors: A Hands-on Approach, Second Edition, teaches students how to program massively parallel processors. It offers a detailed discussion of various techniques for constructing parallel programs. Case studies are used to demonstrate the development process, which begins with computational thinking and ends with effective and efficient parallel programs. This guide shows both student and professional alike the basic concepts of parallel programming and GPU architecture. Topics of performance, floating-point format, parallel patterns, and dynamic parallelism are covered in depth. This revised edition contains more parallel programming examples, commonly-used libraries such as Thrust, and explanations of the latest tools. It also provides new coverage of CUDA 5.0, improved performance, enhanced development tools, increased hardware support, and more. Increased coverage of related technology, OpenCL and new material on algorithm patterns, GPU clusters, host programming, and data parallelism, and two new case studies (on MRF reconstruction and molecular visualization) that explore the latest applications of CUDA and GPUs for scientific research and high-performance computing. This book should be a valuable resource for advanced students, software engineers, programmers, and hardware engineers. New coverage of CUDA 5.0, improved performance, enhanced development tools, increased hardware support, and more. Increased coverage of related technology, OpenCL and new material on algorithm patterns, GPU clusters, host programming, and data parallelism. Two new case studies (on MRI reconstruction and molecular visualization) explore the latest applications of CUDA and GPUs for scientific research and high-performance computing.

This book provides a comprehensive overview of both the hardware and software issues involved in designing state-of-the-art distributed and parallel computing systems. Essential for both students and practitioners, this book explores distributed computing from the bottom-up approach, starting with computing organization, communications and networks, and then discussing operating systems, client/server architectures, distributed databases and other applications. The book also includes coverage of parallel language design, including Occam and Linda. Each chapter ends with questions, and the book contains an extensive glossary and list of reference sources.

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 comprehensive textbook provides, in one place, three mainstream parallelization approaches: OpenMP, MPI and OpenCL, for multicore computers, interconnected computers and graphical processing units. An overview of practical parallel computing and programming 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.

Mathematics of Computing -- Parallelism.

This is a practical student guide to scientific computing on parallel computers, working up from a hardware instruction level, to shared memory machines, and finally to distributed memory machines.

Take advantage of the power of parallel computers with this comprehensive introduction to methods for the design, implementation, and analysis of parallel algorithms. You'll examine many important core topics, including sorting and graph algorithms, discrete optimization techniques, and scientific computing applications, as you consider parallel algorithms for realistic machine models. Features: presents parallel algorithms as a small set of basic data communication operations in order to simplify their design and increase understanding, emphasizes practical issues of performance, efficiency, and scalability, provides a self-contained discussion of the basic concepts of parallel computer architectures, covers
Parallel computers have become widely available in recent years. Many scientists are now using them to investigate the grand challenges of science, such as modeling global climate change, determining the masses of elementary particles from first principles, or sequencing the human genome. However, software for parallel computing has developed far more slowly than the hardware. Many incompatible programming systems exist, and many useful programming techniques are not widely known. Practical Parallel Programming provides scientists and engineers with a detailed, informative, and often critical introduction to parallel programming techniques. Following a review of the fundamentals of parallel computer theory and architecture, it describes four of the most popular parallel programming models in use today—data parallelism, shared variables, message passing, and Linda—and shows how each can be used to solve various scientific and numerical problems. Examples, coded in various dialects of Fortran, are drawn from such domains as the solution of partial differential equations, solution of linear equations, the simulation of cellular automata, studies of rock fracturing, and image processing. Practical Parallel Programming will be particularly helpful for scientists and engineers who use high-performance computers to solve numerical problems and do physical simulations but who have little experience of networking or concurrency. The book can also be used by advanced undergraduate and graduate students in computer science in conjunction with material covering parallel architectures and algorithms in more detail. Computer science students will gain a critical appraisal of the current state of the art in parallel programming.

Introduction to Parallel Programming focuses on the techniques, processes, methodologies, and approaches involved in parallel programming. The book first offers information on Fortran, hardware and operating system models, and processes, shared memory, and simple parallel programs. Discussions focus on processes and processors, joining processes, shared memory, time-sharing with multiple processors, hardware, loops, passing arguments in function subroutine calls, program structure, and arithmetic expressions. The text then elaborates on basic parallel programming techniques, barriers and race conditions, and nested loops. The manuscript takes a look at overcoming data dependences, scheduling summary, linear recurrence relations, and performance tuning. Topics include parallel programming and the structure of programs, effect of the number of processes on overhead, loop splitting, indirect scheduling, block scheduling and forward dependency, and induction variable. The publication is a valuable reference for researchers interested in parallel programming.

Parallel and High Performance Computing offers techniques guaranteed to boost your code’s effectiveness. Summary Complex calculations, like training deep learning models or running large scale simulations, can take an extremely long time. Efficient parallel programming can save hours—or even days—of computing time. Parallel and High Performance Computing shows you how to deliver faster run-times, greater scalability, and increased energy efficiency to your programs by mastering parallel techniques for multicore processor and GPU hardware. About the technology, Write fast, powerful, energy efficient programs that scale to tackle huge volumes of data. Using parallel programming, your code spreads data processing tasks across multiple CPUs for radically better performance. With a little help, you can create software that maximizes both speed and efficiency. About the book, Parallel and High Performance Computing offers techniques guaranteed to boost your code’s effectiveness. You’ll learn to evaluate hardware architectures and work with industry standard tools such as OpenMP and MPI. You’ll master the data structures and algorithms best suited for high performance computing and learn techniques that save energy on handheld devices. You’ll even run a massive tsunami simulation across a bank of GPUs. What’s inside? A parallel project Understanding differences in CPU and GPU architecture Addressing underperforming kernels and loops Managing applications with batch scheduling About the reader For experienced programmers proficient with a high-performance computing language like C, C++, or Fortran. About the author, Robert Robey works at Los Alamos National Laboratory and has been active in the field of parallel computing for over 30 years. Yuliana Zamora is currently a PhD student and Siebel Scholar at the University of Chicago, and has lectured on programming modern hardware at numerous national conferences. Table of Contents PART I INTRODUCTION TO PARALLEL COMPUTING 1 Why parallel computing? 2 Planning for parallelization 3 Performance limits and profiling 4 Data design and performance models 5 Parallel algorithms and patterns PART II CPU: THE PARALLEL WORKHORSE 6 Vectorization: FLOPs for free 7 OpenMP that performs 8 MPI: The parallel backbone PART III GPUS: BUILT TO ACCELERATE 9 GPUs and architectures and concepts 10 GPU programming model 11 Directive-based GPU programming 12 GPU languages Getting down to basics 13 GPU profiling and tools PART IV HIGH PERFORMANCE COMPUTING ECOSYSTEMS 14 Affinity: Truce with the kernel 15 Batch schedulers Bringing order to chaos 16 File operations for a parallel world 17 Tools and resources for better code

The constantly increasing demand for more computing power can seem impossible to keep up with. However, multi-core processors capable of performing computations in parallel allow computers to tackle ever larger problems in a wide variety of applications. This book provides a comprehensive introduction to parallel computing, discussing theoretical issues such as the fundamentals of concurrent processes, models of parallel and distributed computing, and metrics for evaluating and comparing parallel algorithms, as well as practical issues, including methods of designing and implementing shared- and distributed-memory programs, and standards for parallel program implementation, in particular MPI and OpenMP interfaces. Each chapter presents the basics in one place followed by advanced topics, allowing novices and experienced practitioners to quickly find what they need. A glossary and more than 80 exercises with selected solutions aid comprehension. The book is recommended as a text for advanced undergraduate or graduate students and as a reference for practitioners.

If you need to learn CUDA but don’t have experience with parallel computing, CUDA Programming: A Developer’s Introduction offers a detailed guide to CUDA with a grounding in parallel fundamentals. It starts by introducing CUDA and bringing you up to speed on GPU parallelism and hardware, then delving into CUDA installation. Chapters on core concepts including threads, blocks, grids, and memory focus
on both parallel and CUDA-specific issues. Later, the book demonstrates CUDA in practice for optimizing applications, adjusting to new hardware, and solving common problems. Comprehensive introduction to parallel programming with CUDA, for readers new to both. Detailed instructions help readers optimize the CUDA software development kit. Practical techniques illustrate working with memory, threads, algorithms, resources, and more. Covers CUDA on multiple hardware platforms: Mac, Linux, and Windows with several NVIDIA chipsets. Each chapter includes exercises to test reader knowledge.

The Parallel Programming Guide for Every Software Developer: From grids and clusters to next-generation game consoles, parallel computing is going mainstream. Innovations such as Hyper-Threading Technology, HyperTransport Technology, and multicore microprocessors from IBM, Intel, and Sun are accelerating the movement’s growth. Only one thing is missing: programmers with the skills to meet the soaring demand for parallel software. That’s where Patterns for Parallel Programming comes in. It’s the first parallel programming guide written specifically to serve working software developers, not just computer scientists. The authors introduce a complete, highly accessible pattern language that will help any experienced developer “think parallel” and start writing effective parallel code almost immediately. Instead of formal theory, they deliver proven solutions to the challenges faced by parallel programmers, and pragmatic guidance for using today’s parallel APIs in the real world. Coverage includes: Understanding the parallel computing landscape and the challenges faced by parallel developers. Finding the concurrency in a software design problem and decomposing it into concurrent tasks. Managing the use of data across tasks. Creating an algorithmic structure that effectively exploits the concurrency you’ve identified. Connecting your algorithmic structures to the APIs needed to implement them. Specific software constructs for implementing parallel programs. Working with today’s leading parallel programming environments: OpenMP, MPI, and Java. Patterns have helped thousands of programmers master object-oriented development and other complex programming technologies. With this book, you will learn that they’re the best way to master parallel programming too.

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.

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 issue and explore how the various techniques interact.


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 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.

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