Introduction To Parallel Programming Pacheco Solutions

Introduction To Parallel Programming Pacheco Solutions Introduction to Parallel Programming Pacheco Solutions In the rapidly evolving landscape of computing, efficiency and speed are paramount. As data sets grow exponentially and applications demand more processing power, traditional sequential programming models often fall short. Parallel programming emerges as a vital strategy to harness the capabilities of modern multi-core and distributed systems. Among the numerous resources available for mastering this domain, "Parallel Programming: Concepts and Practice" by Barry Wilkinson and Michael Allen Pacheco stands out as a comprehensive guide. This article provides an in-depth introduction to parallel programming solutions inspired by Pacheco's methodologies, emphasizing practical approaches, key concepts, and best practices for developers eager to optimize their applications. Understanding Parallel Programming What Is Parallel Programming? Parallel programming involves dividing a computational task into smaller sub-tasks that can be executed simultaneously across multiple processing units. Unlike sequential programming, where tasks are processed one after another, parallel programming leverages concurrency to reduce overall execution time and improve performance. Key aspects include: - Concurrency: Managing multiple tasks at the same time. - Synchronization: Ensuring correct sequencing and data consistency. - Data Sharing: Managing how data is accessed and modified by concurrent processes. Why Is Parallel Programming Important? The importance of parallel programming stems from: - Performance Gains: Significant reductions in execution time for large-scale computations. - Resource Utilization: Efficient use of multi-core processors and distributed systems. - Scalability: Ability to handle increasing data volumes and complex algorithms. - Real-time Processing: Critical for applications like simulations, data analysis, and machine learning. Foundational Concepts in Pacheco's Approach Barry Pacheco's solutions to parallel programming emphasize clarity, efficiency, and practical implementation. His approach focuses on understanding core concepts and 2 applying them using modern programming tools and paradigms. Key Concepts Covered in Pacheco's Solutions 1. Task Decomposition: Breaking down complex problems into manageable sub-tasks. 2. Data Parallelism: Distributing data across multiple processing units. 3. Task Parallelism: Executing different tasks concurrently. 4. Synchronization and Communication: Managing dependencies and ensuring data coherence. 5. Load Balancing: Distributing work evenly to avoid idle processors. 6. Scalability: Designing solutions that perform well as system size grows. Common Parallel Programming Models - Shared Memory Model: Multiple processors access shared data (e.g., OpenMP). - Distributed Memory Model: Processors have their own local memory (e.g., MPI). - Hybrid Models: Combining shared and distributed memory approaches. Pacheco's solutions often focus on shared memory architectures, which are prevalent in modern multi-core systems. Practical Implementations and Solutions Pacheco provides practical solutions and code examples to implement parallel algorithms efficiently. Here we explore some of the common techniques and how they align with his teachings. Using OpenMP for Parallelism OpenMP (Open Multi-Processing) is a popular API for parallel programming in C, C++, and Fortran. Pacheco emphasizes its simplicity in parallelizing loops and sections of code. Basic OpenMP Usage: ```c pragma omp parallel for for (int i = 0; i < N; i++) { // Perform computation on data[i] } ``` This directive automatically distributes iterations across available threads, simplifying parallel loop execution. Advantages: - Easy to implement with minimal code changes. - Suitable for shared memory systems. - Supports task synchronization and reduction operations. Parallel Reduction and Data Aggregation Many algorithms require combining data from multiple threads. Pacheco's solutions demonstrate using reduction clauses to handle such operations efficiently. ```c int sum = 0; pragma omp parallel for reduction(+:sum) for (int i = 0; i < N; i++) { sum += data[i]; } ``` 3 Task Parallelism with OpenMP Tasks Beyond data parallelism, Pacheco explores task-based parallelism for more complex workflows. ```c pragma omp parallel { pragma omp single { for (int i = 0; i < M; i++) { pragma omp task process_task(i); } } } ``` This model allows for dynamic task creation and efficient load balancing. Parallel Algorithms for Numerical Computations Pacheco emphasizes parallel algorithms for common numerical tasks such as matrix multiplication, sorting, and integration. For example, parallel matrix multiplication can be achieved by distributing row computations across threads. Example: Parallel Matrix Multiplication Skeleton ```c pragma omp parallel for for (int i = 0; i < N; i++) { for (int j = 0; j < N; j++) { result[i][j] = 0; for (int k = 0; k < N; k++) { result[i][j] += A[i][k] B[k][j]; } } } ``` Designing Efficient Parallel Solutions Pacheco highlights several best practices for designing effective parallel programs. 1. Minimize Data Dependencies - Structure algorithms

to reduce synchronization points. - Use data partitioning techniques to avoid contention. 2. Balance the Load - Distribute work evenly to prevent processors from idling. - Use dynamic scheduling where appropriate. 3. Avoid Overheads - Limit the number of synchronization points. - Use coarse-grained parallelism to reduce communication costs. 4. Test and Profile - Use profiling tools to identify bottlenecks. - Benchmark different parallelization strategies for performance gains. Tools and Libraries in Pacheco's Solutions Several tools and libraries facilitate parallel programming, many of which are highlighted in Pacheco's solutions: - OpenMP: For shared memory parallelism. - MPI: For distributed memory systems. - Cilk Plus: For task-based parallelism (supported in some compilers). - 4 TBB (Threading Building Blocks): For scalable parallel algorithms. Choosing the right tool depends on the application's nature, system architecture, and performance goals. Challenges and Considerations in Parallel Programming While parallel programming offers significant benefits, it also introduces challenges: - Race Conditions: When multiple threads access shared data without proper synchronization. - Deadlocks: When threads wait indefinitely for resources. - Non- determinism: Harder to reproduce bugs due to concurrent execution. - Complex Debugging: Parallel code is more difficult to test and debug. Pacheco's solutions advocate for careful design, thorough testing, and understanding of underlying hardware to mitigate these issues. Conclusion: Embracing Parallel Programming with Pacheco's Solutions Mastering parallel programming is essential for modern software development, especially in data-intensive and performance-critical applications. Barry Pacheco's solutions provide a clear, practical, and effective pathway to understanding and implementing parallel algorithms. By focusing on core concepts like task decomposition, data parallelism, synchronization, and load balancing, developers can design scalable and efficient solutions suited to contemporary multi-core and distributed systems. Whether through leveraging OpenMP, MPI, or hybrid models, the principles outlined in Pacheco's work serve as a solid foundation for tackling the complexities of parallel programming. As systems continue to evolve, the ability to write optimized parallel code will remain a vital skill for developers aiming to push the boundaries of computational performance. Further Resources - Parallel Programming: Concepts and Practice by Barry Wilkinson and Michael Allen Pacheco. - Official OpenMP documentation and tutorials. - MPI (Message Passing Interface) official resources. - Online courses and tutorials on parallel algorithm design. - Profiling tools like Intel VTune, Valgrind, and GNU Profiler. By embracing these solutions and best practices, you can unlock the full potential of modern computing architectures and contribute to innovative, high-performance applications. QuestionAnswer What are the main concepts introduced in Pacheco's 'Introduction to Parallel Programming'? Pacheco's book covers fundamental concepts such as parallelism models, thread management, synchronization, data sharing, and performance considerations to help readers understand how to design efficient parallel programs. 5 How does Pacheco suggest handling thread synchronization in parallel programs? Pacheco emphasizes using synchronization primitives like mutexes, barriers, and condition variables to manage data consistency and coordinate thread execution effectively. What are the common parallel programming patterns discussed in Pacheco's solutions? The book discusses patterns such as data parallelism, task parallelism, divide-and-conquer, and pipeline parallelism, providing examples and solutions for each. How does Pacheco address performance optimization in parallel programs? Pacheco highlights techniques like minimizing synchronization overhead, balancing workload, optimizing memory access patterns, and understanding hardware architecture to improve performance. What tools and APIs does Pacheco recommend for implementing parallel programming solutions? Pacheco primarily discusses the use of POSIX threads (pthreads), OpenMP, and MPI, providing solutions and best practices for each to facilitate parallel programming. Are there example problems with solutions in Pacheco's 'Introduction to Parallel Programming'? Yes, the book includes numerous example problems with detailed solutions demonstrating how to implement parallel algorithms and solve common challenges. How does Pacheco address debugging and testing parallel programs? Pacheco discusses the importance of debugging tools, detecting race conditions, deadlocks, and using performance analyzers to ensure correctness and efficiency of parallel applications. What prerequisites are recommended before studying Pacheco's solutions for parallel programming? A basic understanding of programming in C or C++, familiarity with algorithms and data structures, and some knowledge of serial programming are recommended prerequisites. Introduction to Parallel Programming Pacheco Solutions: An In-Depth Analysis Parallel programming has become an essential paradigm in the realm of high-performance computing, enabling developers and researchers to harness the power of multi-core processors, clusters, and distributed systems. Among the many resources available for mastering parallel programming, "Introduction to Parallel Programming" by David B. Pacheco stands out as a comprehensive guide, offering practical insights and solutions tailored to both novices and seasoned practitioners. This article aims to provide an investigative review of Pacheco's solutions, emphasizing their applicability, strengths, limitations, and relevance in today's computational landscape. --- The Significance of Pacheco's Approach in Parallel Programming Background and Context David B. Pacheco's Introduction to Parallel Programming is widely regarded as a seminal textbook that bridges theoretical concepts with hands-on implementation strategies. Published in 2011, the book addresses the increasing demand for accessible yet rigorous explanations of

Introduction To Parallel Programming Pacheco Solutions 6 parallel computing principles, making it a cornerstone resource in academic and professional settings. Why Focus on Pacheco's Solutions? The solutions presented in Pacheco's work are notable because they: - Emphasize clarity and pedagogical effectiveness - Incorporate real-world examples and code snippets - Cover a range of parallel programming models, including shared memory, message passing, and hybrid approaches - Offer practical exercises to reinforce understanding Given these qualities, an investigative review of Pacheco's solutions provides valuable insights into their effectiveness and adaptability in modern computational challenges. --- Core Concepts and Methodologies in Pacheco's Solutions Parallel Computing Models Covered Pacheco's solutions encompass several foundational models: - Data Parallelism: Distributing data across multiple processors - Task Parallelism: Executing different tasks simultaneously - Hybrid Models: Combining data and task parallelism for complex applications These models serve as the building blocks for understanding and implementing parallel algorithms. Programming Languages and Tools The solutions leverage: - C and C++: For performance-critical implementations - OpenMP: For shared-memory parallelism - MPI (Message Passing Interface): For distributed systems - Pthreads: For low-level thread management Pacheco's emphasis on these tools reflects their relevance and widespread adoption in the industry. --- Deep Dive into Pacheco's Solutions: An Investigative Perspective 1. Implementing Parallel Algorithms: Strategies and Best Practices Pacheco advocates for a structured approach to parallel algorithm design: - Analyze the problem to identify potential parallelism - Choose appropriate programming models - Design algorithms to minimize synchronization and contention - Validate correctness and performance Key Solutions Include: - Parallel matrix multiplication - Summation and reduction operations - Sorting algorithms adapted for parallel execution Investigation Point: While these solutions demonstrate optimal strategies for common problems, their efficacy depends heavily on the underlying hardware architecture. For instance, algorithms optimized for shared-memory systems may underperform in distributed environments, highlighting the importance of context-aware implementation. 2. Synchronization and Data Sharing Challenges Pacheco addresses critical issues like race conditions, deadlocks, and data consistency. His solutions include: - Use of critical sections and atomic operations in OpenMP - Message passing synchronization via MPI barriers - Strategies for minimizing synchronization overhead Investigation Point: The solutions effectively illustrate synchronization techniques, but as systems scale, synchronization costs can become prohibitive. Pacheco's solutions provide a foundation, but practitioners must adapt these strategies for large-scale applications, possibly integrating more advanced synchronization primitives or lock-free algorithms. 3. Performance Optimization Techniques Pacheco emphasizes profiling and iterative optimization: - Load balancing - Minimizing communication overhead - Exploiting data locality Investigation Point: While these solutions are instructive, they assume a certain Introduction To Parallel Programming Pacheco Solutions 7 level of hardware homogeneity. Real-world systems often involve heterogeneous architectures (CPUs with GPUs, FPGA accelerators), requiring further adaptation of these solutions. --- Critical Evaluation of Pacheco's Solutions in Contemporary Context Strengths - Educational Clarity: The explanations are accessible, with diagrams and annotated code snippets. - Practical Focus: Solutions are directly implementable, bridging theory and practice. - Coverage: A broad spectrum of topics, from basic concepts to advanced algorithms. Limitations - Hardware Evolution: The solutions are primarily based on systems available around 2010-2011. Modern hardware features like many-core GPUs, tensor processing units, and high-speed interconnects are not extensively covered. - Scalability: As parallel systems grow in size and complexity, some solutions may not scale efficiently without additional refinements. - Emerging Paradigms: New models like task- based parallelism, asynchronous programming, and heterogeneous computing frameworks are less emphasized. Relevance Today Despite limitations, Pacheco's solutions remain foundational. They serve as a starting point for understanding core principles before delving into more advanced or specialized frameworks. Moreover, many concepts—such as synchronization, load balancing, and algorithm design—are timeless, with adaptations needed for modern architectures. --- Practical Applications and Case Studies Academic and Educational Use Pacheco's solutions are widely used in university courses, providing students with concrete examples and exercises that reinforce theoretical understanding. Industry Adoption Organizations leverage solutions based on Pacheco's principles for: - Scientific simulations - Data analytics - Real-time processing Case Study: Parallel Matrix Multiplication A typical implementation involves distributing matrix rows across processors, performing local multiplications, and aggregating results. Pacheco's approach emphasizes minimizing communication and synchronization, principles still relevant in optimized GPU-accelerated libraries. --- Future Directions and Open Challenges Integration with Modern Frameworks Adapting Pacheco's solutions to frameworks like CUDA, OpenCL, or TensorFlow can enhance their applicability in heterogeneous environments. Scalability and Fault Tolerance Addressing issues like scalability bottlenecks, fault tolerance, and energy efficiency remains an ongoing challenge. Education and Training Developing interactive tutorials and visualization tools based on Pacheco's solutions can aid in demystifying complex parallel concepts. --- Conclusion Introduction to Parallel Programming Pacheco solutions offers a robust foundation for understanding the fundamental principles of parallel computing. Its solutions are characterized by clarity, practicality, and pedagogical

effectiveness, making them invaluable for learners and practitioners. While the rapid evolution of hardware and programming paradigms necessitates continual adaptation, the core concepts elucidated in Pacheco's work continue to underpin modern parallel programming strategies. Investigation into these solutions reveals their strengths in teaching and implementation, as well as areas where modern enhancements are necessary. For anyone venturing into Introduction To Parallel Programming Pacheco Solutions 8 high-performance computing, Pacheco's solutions serve as a vital stepping stone, fostering a deeper comprehension of parallel algorithms and their applications in an increasingly data-driven world. parallel programming, Pacheco solutions, parallel algorithms, MPI, OpenMP, concurrency, parallel computation, shared memory, message passing, multi-threading

Introduction to Parallel ProgrammingParallel ProgrammingIntroduction to Parallel ComputingStructured Parallel ProgrammingUsing OpenMPUsing MPI, third editionParallel and High Performance ComputingParallel Programming with PythonMastering Parallel Programming with RParallel Programming with Co-arraysProgramming Massively Parallel ProcessorsIntroduction to Parallel ProgrammingParallel Programming with MPIINTRODUCTION TO PARALLEL PROCESSINGParallel ProgrammingParallel Programming for Modern High Performance Computing SystemsIntroduction to Parallel ProgrammingParallel ProgrammingParallel Programming Using C++Parallel Programming Subodh Kumar Bertil Schmidt Ananth Grama Michael McCool Barbara Chapman William Gropp Robert Robey Jan Palach Simon R. Chapple Robert W. Numrich David B. Kirk Tobias Wittwer Peter Pacheco M. Sasikumar Thomas Rauber Pawel Czarnul Steven Brawer Thomas Rauber Gregory V. Wilson Thomas Br□ unl
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in modern computer science there exists no truly sequential computing system and most advanced programming is parallel programming this is particularly evident in modern application domains like scientific computation data science machine intelligence etc this lucid introductory textbook will be invaluable to students of computer science and technology acting as a self contained primer to parallel programming it takes the reader from introduction to expertise addressing a broad gamut of issues it covers different parallel programming styles describes parallel architecture includes parallel programming frameworks and techniques presents algorithmic and analysis techniques and discusses parallel design and performance issues with its broad coverage the book can be useful in a wide range of courses and can also prove useful as a ready reckoner for professionals in the field

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

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

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 CONSTRUCTS 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

THE THOROUGHLY UPDATED EDITION OF A GUIDE TO PARALLEL PROGRAMMING WITH MPI REFLECTING THE LATEST SPECIFICATIONS WITH MANY DETAILED EXAMPLES THIS BOOK OFFERS A THOROUGHLY UPDATED GUIDE TO THE MPI MESSAGE PASSING INTERFACE STANDARD LIBRARY FOR WRITING PROGRAMS FOR PARALLEL COMPUTERS SINCE THE PUBLICATION OF THE PREVIOUS EDITION OF USING MPI PARALLEL COMPUTING HAS BECOME MAINSTREAM TODAY APPLICATIONS RUN ON COMPUTERS WITH MILLIONS OF PROCESSORS MULTIPLE PROCESSORS SHARING MEMORY AND MULTICORE PROCESSORS WITH MULTIPLE HARDWARE THREADS PER CORE ARE COMMON THE MPI 3 FORUM RECENTLY BROUGHT THE MPI STANDARD UP TO DATE WITH RESPECT TO DEVELOPMENTS IN HARDWARE CAPABILITIES CORE LANGUAGE EVOLUTION THE NEEDS OF APPLICATIONS AND EXPERIENCE GAINED OVER THE YEARS BY VENDORS IMPLEMENTERS AND USERS THIS THIRD EDITION OF USING MPI REFLECTS THESE CHANGES IN BOTH TEXT AND EXAMPLE CODE THE BOOK TAKES AN INFORMAL TUTORIAL APPROACH INTRODUCING EACH CONCEPT THROUGH EASY TO UNDERSTAND EXAMPLES INCLUDING ACTUAL CODE IN C AND FORTRAN TOPICS INCLUDE USING MPI IN SIMPLE PROGRAMS VIRTUAL TOPOLOGIES MPI DATATYPES PARALLEL LIBRARIES AND A COMPARISON OF MPI WITH SOCKETS FOR THE THIRD EDITION EXAMPLE CODE HAS BEEN BROUGHT UP TO DATE APPLICATIONS HAVE BEEN UPDATED AND REFERENCES REFLECT THE RECENT ATTENTION MPI HAS RECEIVED IN THE LITERATURE A COMPANION VOLUME USING ADVANCED MPI COVERS MORE ADVANCED TOPICS INCLUDING HYBRID PROGRAMMING AND COPING WITH LARGE DATA

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 MODERN COMPUTING HARDWARE COMES EQUIPPED WITH MULTICORE CPUS AND GPUS THAT CAN PROCESS NUMEROUS INSTRUCTION SETS SIMULTANEOUSLY PARALLEL COMPUTING TAKES ADVANTAGE OF THIS NOW STANDARD COMPUTER ARCHITECTURE TO EXECUTE MULTIPLE OPERATIONS AT THE SAME TIME OFFERING THE POTENTIAL FOR APPLICATIONS THAT RUN FASTER ARE MORE ENERGY EFFICIENT AND CAN BE SCALED TO TACKLE PROBLEMS THAT DEMAND LARGE COMPUTATIONAL CAPABILITIES BUT TO GET THESE BENEFITS YOU MUST CHANGE THE WAY YOU DESIGN AND WRITE SOFTWARE TAKING ADVANTAGE OF THE TOOLS ALGORITHMS AND DESIGN PATTERNS CREATED SPECIFICALLY FOR PARALLEL PROCESSING IS ESSENTIAL TO CREATING TOP PERFORMING APPLICATIONS ABOUT THE BOOK PARALLEL AND HIGH PERFORMANCE COMPUTING IS AN IRREPLACEABLE GUIDE FOR ANYONE WHO NEEDS TO MAXIMIZE APPLICATION PERFORMANCE AND REDUCE EXECUTION TIME PARALLEL COMPUTING EXPERTS ROBERT ROBEY AND YULIANA ZAMORA TAKE A FUNDAMENTAL APPROACH TO PARALLEL PROGRAMMING PROVIDING NOVICE PRACTITIONERS THE SKILLS NEEDED TO TACKLE ANY HIGH PERFORMANCE COMPUTING PROJECT WITH MODERN CPU AND GPU HARDWARE GET UNDER THE HOOD OF PARALLEL COMPUTING ARCHITECTURE AND LEARN TO EVALUATE HARDWARE PERFORMANCE SCALE UP YOUR RESOURCES TO TACKLE LARGER PROBLEM SIZES AND DELIVER A LEVEL OF ENERGY EFFICIENCY THAT MAKES HIGH PERFORMANCE POSSIBLE ON HAND HELD DEVICES WHEN YOU RE DONE YOU LL BE ABLE TO BUILD PARALLEL PROGRAMS THAT ARE RELIABLE ROBUST AND REQUIRE MINIMAL CODE MAINTENANCE THIS BOOK IS UNIQUE IN ITS BREADTH WITH DISCUSSIONS OF PARALLEL ALGORITHMS TECHNIQUES TO SUCCESSFULLY DEVELOP PARALLEL PROGRAMS AND WIDE COVERAGE OF THE MOST EFFECTIVE LANGUAGES FOR THE CPU AND GPU THE PROGRAMMING PARADIGMS INCLUDE MPI OPENMP THREADING AND VECTORIZATION FOR THE CPU FOR THE GPU THE BOOK COVERS OPENMP AND OPENACC DIRECTIVE BASED APPROACHES AND THE NATIVE BASED CUDA AND OPENCL LANGUAGES WHAT S INSIDE STEPS FOR PLANNING A NEW PARALLEL PROJECT CHOOSING THE RIGHT DATA STRUCTURES AND ALGORITHMS ADDRESSING UNDERPERFORMING KERNELS AND LOOPS THE DIFFERENCES IN CPU AND GPU ARCHITECTURE ABOUT THE READER FOR EXPERIENCED PROGRAMMERS WITH PROFICIENCY IN A HIGH PERFORMANCE COMPUTING LANGUAGE SUCH AS C C OR FORTRAN ABOUT THE AUTHORS ROBERT ROBEY HAS BEEN ACTIVE IN THE FIELD OF PARALLEL COMPUTING FOR OVER 30 YEARS HE WORKS AT LOS ALAMOS NATIONAL LABORATORY AND HAS PREVIOUSLY WORKED AT THE UNIVERSITY OF NEW MEXICO WHERE HE STARTED UP THE ALBUQUERQUE HIGH PERFORMANCE COMPUTING CENTER YULIANA ZAMORA HAS LECTURED ON EFFICIENT PROGRAMMING OF MODERN HARDWARE AT NATIONAL CONFERENCES BASED ON HER WORK DEVELOPING APPLICATIONS RUNNING ON TENS OF THOUSANDS OF PROCESSING CORES AND THE LATEST GPU ARCHITECTURES

A FAST EASY TO FOLLOW AND CLEAR TUTORIAL TO HELP YOU DEVELOP PARALLEL COMPUTING SYSTEMS USING PYTHON ALONG WITH EXPLAINING THE FUNDAMENTALS THE BOOK WILL ALSO INTRODUCE YOU TO SLIGHTLY ADVANCED CONCEPTS AND WILL HELP YOU IN IMPLEMENTING THESE TECHNIQUES IN THE REAL WORLD IF YOU ARE AN EXPERIENCED PYTHON PROGRAMMER AND ARE WILLING TO UTILIZE THE AVAILABLE COMPUTING RESOURCES BY PARALLELIZING APPLICATIONS IN A SIMPLE WAY THEN THIS BOOK IS FOR YOU YOU ARE REQUIRED TO HAVE A BASIC KNOWLEDGE OF PYTHON DEVELOPMENT TO GET THE MOST OF THIS BOOK

MASTER THE ROBUST FEATURES OF R PARALLEL PROGRAMMING TO ACCELERATE YOUR DATA SCIENCE COMPUTATIONS ABOUT THIS BOOK CREATE R PROGRAMS THAT EXPLOIT THE COMPUTATIONAL CAPABILITY OF YOUR CLOUD PLATFORMS AND COMPUTERS TO THE FULLEST BECOME AN EXPERT IN WRITING THE MOST EFFICIENT AND HIGHEST PERFORMANCE PARALLEL ALGORITHMS IN R GET TO GRIPS WITH THE CONCEPT OF PARALLELISM TO ACCELERATE YOUR EXISTING R PROGRAMS WHO THIS BOOK IS FOR THIS BOOK IS FOR R PROGRAMMERS WHO WANT TO STEP BEYOND ITS INHERENT SINGLE THREADED AND RESTRICTED MEMORY LIMITATIONS AND LEARN HOW TO IMPLEMENT HIGHLY ACCELERATED AND SCALABLE ALGORITHMS THAT ARE A NECESSITY FOR THE PERFORMANT PROCESSING OF BIG DATA NO PREVIOUS KNOWLEDGE OF PARALLELISM IS REQUIRED THIS BOOK ALSO PROVIDES FOR THE MORE ADVANCED TECHNICAL PROGRAMMER SEEKING TO GO BEYOND HIGH LEVEL PARALLEL FRAMEWORKS WHAT YOU WILL LEARN CREATE AND STRUCTURE EFFICIENT LOAD BALANCED PARALLEL COMPUTATION IN R USING R S BUILT IN PARALLEL PACKAGE DEPLOY AND UTILIZE CLOUD BASED PARALLEL INFRASTRUCTURE FROM R INCLUDING LAUNCHING A DISTRIBUTED COMPUTATION ON HADOOP RUNNING ON AMAZON SERVICES AWS GET ACCUSTOMED TO PARALLEL EFFICIENCY AND APPLY SIMPLE TECHNIQUES TO BENCHMARK MEASURE SPEED AND TARGET IMPROVEMENT IN YOUR OWN CODE DEVELOP COMPLEX PARALLEL PROCESSING ALGORITHMS WITH THE STANDARD MESSAGE PASSING INTERFACE MPI USING RMPI PBDMPI AND SPRINT PACKAGES BUILD AND EXTEND A PARALLEL R PACKAGE SPRINT WITH YOUR OWN MPI BASED ROUTINES IMPLEMENT ACCELERATED NUMERICAL FUNCTIONS IN R UTILIZING THE VECTOR PROCESSING CAPABILITY OF YOUR GRAPHICS PROCESSING UNIT GPU WITH OPENCL UNDERSTAND PARALLEL PROGRAMMING PITFALLS SUCH AS DEADLOCK AND NUMERICAL INSTABILITY AND THE APPROACHES TO HANDLE AND AVOID THEM BUILD A TASK FARM MASTER WORKER SPATIAL GRID AND HYBRID PARALLEL R PROGRAMS IN DETAIL R IS ONE OF THE MOST POPULAR PROGRAMMING LANGUAGES USED IN DATA SCIENCE APPLYING R TO BIG DATA AND COMPLEX ANALYTIC TASKS REQUIRES THE HARNESSING OF SCALABLE COMPUTE RESOURCES MASTERING PARALLEL PROGRAMMING WITH R PRESENTS A COMPREHENSIVE AND PRACTICAL TREATISE ON HOW TO BUILD HIGHLY SCALABLE AND EFFICIENT ALGORITHMS IN R IT WILL TEACH YOU A VARIETY OF PARALLELIZATION TECHNIQUES FROM SIMPLE USE OF R S BUILT IN PARALLEL PACKAGE VERSIONS OF LAPPLY TO HIGH LEVEL AWS CLOUD BASED HADOOP AND APACHE SPARK FRAMEWORKS IT WILL ALSO TEACH YOU LOW LEVEL SCALABLE PARALLEL PROGRAMMING USING RMPI AND PBDMPI FOR MESSAGE PASSING APPLICABLE

TO CLUSTERS AND SUPERCOMPUTERS AND HOW TO EXPLOIT THOUSAND FOLD SIMPLE PROCESSOR GPUS THROUGH ROPENCL BY THE END OF THE BOOK YOU WILL UNDERSTAND THE FACTORS THAT INFLUENCE PARALLEL EFFICIENCY INCLUDING ASSESSING CODE PERFORMANCE AND IMPLEMENTING LOAD BALANCING PITFALLS TO AVOID INCLUDING DEADLOCK AND NUMERICAL INSTABILITY ISSUES HOW TO STRUCTURE YOUR CODE AND DATA FOR THE MOST APPROPRIATE TYPE OF PARALLELISM FOR YOUR PROBLEM DOMAIN AND HOW TO EXTRACT THE MAXIMUM PERFORMANCE FROM YOUR R CODE RUNNING ON A VARIETY OF COMPUTER SYSTEMS STYLE AND APPROACH THIS BOOK LEADS YOU CHAPTER BY CHAPTER FROM THE EASY TO MORE COMPLEX FORMS OF PARALLELISM THE AUTHOR S INSIGHTS ARE PRESENTED THROUGH CLEAR PRACTICAL EXAMPLES APPLIED TO A RANGE OF DIFFERENT PROBLEMS WITH COMPREHENSIVE REFERENCE INFORMATION FOR EACH OF THE R PACKAGES EMPLOYED THE BOOK CAN BE READ FROM START TO FINISH OR BY DIPPING IN CHAPTER BY CHAPTER AS EACH CHAPTER DESCRIBES A SPECIFIC PARALLEL APPROACH AND TECHNOLOGY SO CAN BE READ AS A STANDALONE

PARALLEL PROGRAMMING WITH CO ARRAYS DESCRIBES THE BASIC TECHNIQUES USED TO DESIGN PARALLEL ALGORITHMS FOR HIGH PERFORMANCE SCIENTIFIC COMPUTING IT IS INTENDED FOR UPPER LEVEL UNDERGRADUATE STUDENTS AND GRADUATE STUDENTS WHO NEED TO DEVELOP PARALLEL CODES WITH LITTLE OR NO PREVIOUS INTRODUCTION TO PARALLEL COMPUTING IT IS ALSO INTENDED AS A REFERENCE MANUAL FOR RESEARCHERS ACTIVE IN THE FIELD OF SCIENTIFIC COMPUTING ALL THE ALGORITHMS IN THE BOOK ARE BASED ON PARTITION OPERATORS THESE OPERATORS PROVIDE A UNIFYING PRINCIPLE THAT FITS SEEMINGLY DISPARATE TECHNIQUES INTO AN OVERALL FRAMEWORK FOR ALGORITHM DESIGN THE BOOK USES THE CO ARRAY PROGRAMMING MODEL TO ILLUSTRATE HOW TO WRITE CODE FOR CONCRETE EXAMPLES BUT IT EMPHASIZES THAT THE IMPORTANT CONCEPTS FOR ALGORITHM DESIGN ARE INDEPENDENT OF THE PROGRAMMING MODEL WITH THESE CONCEPTS IN MIND THE READER CAN WRITE ALGORITHMS IN DIFFERENT PROGRAMMING MODELS BASED ON PERSONAL TASTE AND COMFORT

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 MRI 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

MATHEMATICS OF COMPUTING PARALLELISM

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 MAP REDUCE MODEL TOP 500 ORG INITIATIVE INDIAN EFFORTS IN SUPERCOMPUTING OPENMP SYSTEM FOR SHARED MEMORY PROGRAMMING ETC HAVE BEEN ADDED NUMEROUS

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

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 NGER 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 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

IN VIEW OF THE GROWING PRESENCE AND POPULARITY OF MULTICORE AND MANYCORE PROCESSORS ACCELERATORS AND COPROCESSORS AS WELL AS CLUSTERS USING SUCH COMPUTING DEVICES THE DEVELOPMENT OF EFFICIENT PARALLEL APPLICATIONS HAS BECOME A KEY CHALLENGE TO BE ABLE TO EXPLOIT THE PERFORMANCE OF SUCH SYSTEMS THIS BOOK COVERS THE SCOPE OF PARALLEL PROGRAMMING FOR MODERN HIGH PERFORMANCE COMPUTING SYSTEMS IT FIRST DISCUSSES SELECTED AND POPULAR STATE OF THE ART COMPUTING DEVICES AND SYSTEMS AVAILABLE TODAY THESE INCLUDE MULTICORE CPUS MANYCORE CO PROCESSORS SUCH AS INTEL XEON PHI ACCELERATORS SUCH AS GPUS AND CLUSTERS AS WELL AS PROGRAMMING MODELS SUPPORTED ON THESE PLATFORMS IT NEXT INTRODUCES PARALLELIZATION THROUGH IMPORTANT PROGRAMMING PARADIGMS SUCH AS MASTER SLAVE GEOMETRIC SINGLE PROGRAM MULTIPLE DATA SPMD AND DIVIDE AND CONQUER THE PRACTICAL AND USEFUL ELEMENTS OF THE MOST POPULAR AND IMPORTANT APIS FOR PROGRAMMING PARALLEL HPC SYSTEMS ARE DISCUSSED INCLUDING MPI OPENMP PTHREADS CUDA OPENCL AND OPENACC IT ALSO DEMONSTRATES THROUGH SELECTED CODE LISTINGS HOW SELECTED APIS CAN BE USED TO IMPLEMENT IMPORTANT PROGRAMMING PARADIGMS FURTHERMORE IT SHOWS HOW THE CODES CAN BE COMPILED AND EXECUTED IN A LINUX ENVIRONMENT THE BOOK ALSO PRESENTS HYBRID CODES THAT INTEGRATE SELECTED APIS FOR POTENTIALLY MULTI LEVEL PARALLELIZATION AND UTILIZATION OF HETEROGENEOUS RESOURCES AND IT SHOWS HOW TO USE MODERN ELEMENTS OF THESE APIS SELECTED OPTIMIZATION TECHNIQUES ARE ALSO INCLUDED SUCH AS OVERLAPPING COMMUNICATION AND COMPUTATIONS IMPLEMENTED USING VARIOUS APIS FEATURES DISCUSSES THE POPULAR AND CURRENTLY AVAILABLE COMPUTING DEVICES AND CLUSTER SYSTEMS INCLUDES TYPICAL PARADIGMS USED IN PARALLEL PROGRAMS EXPLORES POPULAR APIS FOR PROGRAMMING PARALLEL APPLICATIONS PROVIDES CODE TEMPLATES THAT CAN BE USED FOR IMPLEMENTATION OF PARADIGMS PROVIDES HYBRID CODE EXAMPLES ALLOWING MULTI LEVEL PARALLELIZATION COVERS THE OPTIMIZATION OF PARALLEL PROGRAMS

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 NGER 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 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 manyyears

foreword by bjarne stroustrup software is generally acknowledged to be the single greatest obstacle preventing mainstream adoption of massively parallel computing while sequential applications are routinely ported to platforms ranging from pcs to mainframes most parallel programs only ever run on one type of machine one reason for this is that most parallel programming systems have failed to insulate their users from the architectures of the machines on which they have run those that have been platform independent have usually also had poor performance many researchers now believe that object oriented languages may offer a solution by hiding the architecture specific constructs required for high performance inside platform independent abstractions parallel object oriented programming systems may be able to combine the speed of massively parallel computing with the comfort of sequential programming parallel programming using c describes fifteen parallel programming systems based on c the most popular object oriented language of today these systems cover the whole spectrum of parallel programming paradigms from data parallelism through dataflow and distributed shared memory to message passing control parallelism for the parallel programming community a common parallel application is discussed in each chapter as part of the description of the system itself by comparing the implementations of the polygon overlay problem in each system the reader can get a better sense of their expressiveness and functionality for a common problem for the systems community the chapters contain a discussion of the implementation of the various compilers and runtime systems in addition to discussing the performance of polygon overlay several of the contributors also discuss the performance of other more substantial applications for the research community the contributors discuss the motivations for and philosophy of their systems as well many of the chapters include critiques that complete the research arc by pointing out possible future research directions finally for the object oriented community there are many examples of how encapsulation inheritance and polymorphism can be used to control the complexity of developing debugging and tuning parallel software

this introduction to parallel programming explores the fundamentals of parallelism parallel system architecture mimd and simd and parallel programming languages and presents methods for designing parallel algorithms for writing efficient parallel programs and for computing performance data and judging it

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