Automatic Parallelization An Overview Of Fundamental Compiler Techniques Samuel P Midkiff

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Compiling for parallelism is a longstanding topic of compiler research. This book describes the fundamental principles of compiling "regular" numerical programs for parallelism. We begin with an explanation of analyses that allow a compiler to understand the interaction of data reads and writes in different statements and loop iterations during program execution. These analyses include dependence analysis, use-def analysis and pointer analysis. Next, we describe how the results of these analyses are used to enable transformations that make loops more amenable to parallelization, and discuss transformations that expose parallelism to target shared memory multicore and vector processors. We then discuss some problems that arise when parallelizing programs for execution on distributed memory machines. Finally, we conclude with an overview of solving Diophantine equations and suggestions for further readings in the topics of this book to enable the interested reader to delve deeper into the field. Table of Contents: Introduction and overview / Dependence analysis, dependence graphs and alias analysis / Program parallelization / Transformations to modify and eliminate dependences / Transformation of iterative and recursive constructs / Compiling for distributed memory machines / Solving Diophantine equations / A guide to further reading

I Unidimensional Problems.- 1 Scheduling DAGs without Communications.- 2 Scheduling DAGs with Communications.- 3 Cyclic Scheduling.- II Multidimensional Problems.- 4 Systems of Uniform Recurrence Equations.- 5 Parallelism Detection in Nested Loops.

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Distributed-memory multiprocessing systems (DMS), such as Intel's hypercubes, the Paragon, Thinking Machine's CM-5, and the Meiko Computing Surface, have rapidly gained user acceptance and promise to deliver the computing power required to solve the grand challenge problems of Science and Engineering. These machines are relatively inexpensive to build, and are potentially scalable to large numbers of processors. However, they are difficult to program: the non-uniformity of the memory which makes local accesses much faster than the transfer of non-local data via message-passing operations implies that the locality of algorithms must be exploited in order to achieve acceptable performance. The management of data, with the twin goals of both spreading the computational workload and minimizing the delays caused when a processor has to wait for non-local data, becomes of paramount importance. When a code is parallelized by hand, the programmer must distribute the program's work and data to the processors which will execute it. One of the common approaches to do so makes use of the regularity of most numerical computations. This is the so-called Single Program Multiple Data (SPMD) or data parallel model of computation. With this method, the data arrays in the original program are each distributed to the processors, establishing an ownership relation, and computations defining a data item are performed by the processors owning the data.

This book presents the refereed proceedings of the Eighth Annual Workshop on Languages and Compilers for Parallel Computing, held in Columbus, Ohio in August 1995. The 38 full revised papers presented were carefully selected for inclusion in the proceedings and reflect the state of the art of research and advanced applications in parallel languages, restructuring compilers, and runtime systems. The papers are organized in sections on fine-grain parallelism, interprocedural analysis, program analysis, Fortran 90 and HPF, loop parallelization for HPF compilers, tools and libraries, loop-level optimization, automatic data distribution, compiler models, irregular computation, object-oriented and functional parallelism.

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.

This historical survey of parallel processing from 1980 to 2020 is a follow-up to the authors’ 1981 Tutorial on Parallel Processing, which covered the state of the art in hardware, programming languages, and applications. Here, we cover the evolution of the field since 1980 in: parallel computers, ranging from the Cyber 205 to clusters now approaching an exaflop, to multicore microprocessors, and Graphic Processing Units (GPUs) in commodity personal devices; parallel programming notations such as OpenMP, MPI message passing, and CUDA streaming notation; and seven parallel applications, such as finite element analysis and computer vision. Some things that looked like they would be major trends in 1981, such as big Single Instruction Multiple Data arrays disappeared for some time but have been revived recently in deep neural network processors. There are now major trends that did not exist in 1980, such as GPUs, distributed memory machines, and parallel processing in nearly every commodity device. This book is intended for those that already have some knowledge of parallel processing today and want to learn about the history of the three areas. In parallel hardware, every major parallel architecture type from 1980 has scaled-up in

performance and scaled-out into commodity microprocessors and GPUs, so that every personal and embedded device is a parallel processor. There has been a confluence of parallel architecture types into hybrid parallel systems. Much of the impetus for change has been Moore’s Law, but as clock speed increases have stopped and feature size decreases have slowed down, there has been increased demand on parallel processing to continue performance gains. In programming notations and compilers, we observe that the roots of today’s programming notations existed before 1980. And that, through a great deal of research, the most widely used programming notations today, although the result of much broadening of these roots, remain close to target system architectures allowing the programmer to almost explicitly use the target’s parallelism to the best of their ability. The parallel versions of applications directly or indirectly impact nearly everyone, computer expert or not, and parallelism has brought about major breakthroughs in numerous application areas. Seven parallel applications are studied in this book.

With multicore processors now in every computer, server, and embedded device, the need for cost-effective, reliable parallel software has never been greater. By explaining key aspects of multicore programming, Fundamentals of Multicore Software Development helps software engineers understand parallel programming and master the multicore challenge. Accessible to newcomers to the field, the book captures the state of the art of multicore programming in computer science. It covers the fundamentals of multicore hardware, parallel design patterns, and parallel programming in C++, .NET, and Java. It also discusses manycore computing on graphics cards and heterogeneous multicore platforms, automatic parallelization, automatic performance tuning, transactional memory, and emerging applications. As computing power increasingly comes from parallelism, software developers must embrace parallel programming. Written by leaders in the field, this book provides an overview of the existing and up-and-coming programming choices for multicores. It addresses issues in systems architecture, operating systems, languages, and compilers.

This monograph-like book assembles the thorougly revised and cross-reviewed lectures given at the School on Data Parallelism, held in Les Menuires, France, in May 1996. The book is a unique survey on the current status and future perspectives of the currently very promising and popular data parallel programming model. Much attention is paid to the style of writing and complementary coverage of the relevant issues throughout the 12 chapters. Thus these lecture notes are ideally suited for advanced courses or self-instruction on data parallel programming. Furthermore, the book is indispensable reading for anybody doing research in data parallel programming and related areas.

This book constitutes the proceedings of the 33rd International Conference on Architecture of Computing Systems, ARCS 2020, held in Aachen, Germany, in May 2020.* The 12 full papers in this volume were carefully reviewed and selected from 33 submissions. 6 workshop papers are also included. ARCS has always been a conference attracting leading-edge research outcomes in Computer Architecture and Operating Systems, including a wide spectrum of topics ranging from embedded and real-time systems all the way to large-scale and parallel systems. The selected papers focus on concepts and tools for incorporating self-adaptation and self-organization mechanisms in high-performance computing systems. This includes upcoming approaches for runtime modifications at various abstraction levels, ranging from hardware changes to goal changes and their impact on architectures, technologies, and languages. *The conference was canceled due to the COVID-19 pandemic.