

# LOOP TILING FOR PARALLELISM

by  
Jingling Xue

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# Loop Tiling For Parallelism

**David Padua**



## **Loop Tiling For Parallelism:**

**Loop Tiling for Parallelism** Jingling Xue, 2000-08-31 Loop tiling as one of the most important compiler optimizations is beneficial for both parallel machines and uniprocessors with a memory hierarchy This book explores the use of loop tiling for reducing communication cost and improving parallelism for distributed memory machines The author provides mathematical foundations investigates loop permutability in the framework of nonsingular loop transformations discusses the necessary machineries required and presents state of the art results for finding communication and time minimal tiling choices Throughout the book theorems and algorithms are illustrated with numerous examples and diagrams The techniques presented in Loop Tiling for Parallelism can be adapted to work for a cluster of workstations and are also directly applicable to shared memory machines once the machines are modeled as BSP Bulk Synchronous Parallel machines Features and key topics Detailed review of the mathematical foundations including convex polyhedra and cones Self contained treatment of nonsingular loop transformations code generation and full loop permutability Tiling loop nests by rectangles and parallelepipeds including their mathematical definition dependence analysis legality test and code generation A complete suite of techniques for generating SPMD code for a tiled loop nest Up to date results on tile size and shape selection for reducing communication and improving parallelism End of chapter references for further reading Researchers and practitioners involved in optimizing compilers and students in advanced computer architecture studies will find this a lucid and well presented reference work with numerous citations to original sources

**Algorithms & Architectures For Parallel Processing, 4th Intl Conf** Andrzej Marian Goscinski, Horace Ho Shing Ip, Wei-jia Jia, Wan Lei Zhou, 2000-11-24 ICA3PP 2000 was an important conference that brought together researchers and practitioners from academia industry and governments to advance the knowledge of parallel and distributed computing The proceedings constitute a well defined set of innovative research papers in two broad areas of parallel and distributed computing 1 architectures algorithms and networks 2 systems and applications

*Parallel Programming* Thomas Rauber, Gudula Rünger, 2023-04-04 This textbook covers the new development in processor architecture and parallel hardware It provides 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 The 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 In particular this third edition includes an extended update of the chapter on computer architecture and performance analysis taking new developments such as the aspect of energy consumption into consideration The description of OpenMP has been extended and now also captures the task concept of OpenMP The chapter on message passing programming has been extended and updated to include new features of MPI such as extended reduction operations and non blocking collective communication

operations The chapter on GPU programming also has been updated All other chapters also have been revised carefully The main goal of this book is to present parallel programming techniques that can be used in many situations for many application areas and to enable the reader to develop correct and efficient parallel programs Many example programs and exercises are provided to support this goal and to show how the techniques can be applied to further applications The book can be used as a textbook for students as well as a reference book for professionals The material of the book has been used for courses in parallel programming at different universities for many years

**Symbolic Parallelization of Nested Loop Programs** Alexandru-Petru Tanase, Frank Hannig, Jürgen Teich, 2018-02-22 This book introduces new compilation techniques using the polyhedron model for the resource adaptive parallel execution of loop programs on massively parallel processor arrays The authors show how to compute optimal symbolic assignments and parallel schedules of loop iterations at compile time for cases where the number of available cores becomes known only at runtime The compile runtime symbolic parallelization approach the authors describe reduces significantly the runtime overhead compared to dynamic or just in time compilation The new on demand fault tolerant loop processing approach described in this book protects loop nests for parallel execution against soft errors

**Compiler Optimizations for Scalable Parallel Systems** Santosh Pande, Dharma P. Agrawal, 2003-06-29 Scalable parallel systems or more generally distributed memory systems offer a challenging model of computing and pose fascinating problems regarding compiler optimization ranging from language design to run time systems Research in this area is foundational to many challenges from memory hierarchy optimizations to communication optimization This unique handbook like monograph assesses the state of the art in the area in a systematic and comprehensive way The 21 coherent chapters by leading researchers provide complete and competent coverage of all relevant aspects of compiler optimization for scalable parallel systems The book is divided into five parts on languages analysis communication optimizations code generation and run time systems This book will serve as a landmark source for education information and reference to students practitioners professionals and researchers interested in updating their knowledge about or active in parallel computing

OpenMP Shared Memory Parallel Programming Matthias S. Müller, Barbara Chapman, Bronis R. de Supinski, Allen D. Malony, Michael Voss, 2008-05-23 This book constitutes the thoroughly refereed post workshop proceedings of the First and the Second International Workshop on OpenMP IWOMP 2005 and IWOMP 2006 held in Eugene OR USA and in Reims France in June 2005 and 2006 respectively The first part of the book presents 16 revised full papers carefully reviewed and selected from the IWOMP 2005 program and organized in topical sections on performance tools compiler technology run time environment applications as well as the OpenMP language and its evaluation In the second part there are 19 papers of IWOMP 2006 fully revised and grouped thematically in sections on advanced performance tuning aspects of code development applications and proposed extensions to OpenMP

**Parallel and Distributed Processing and Applications** Yi Pan, 2005-10-21 This book constitutes the refereed proceedings of the

Third International Symposium on Parallel and Distributed Processing and Applications ISPA 2005 held in Nanjing China in November 2005 The 90 revised full papers and 19 revised short papers presented together with 3 keynote speeches and 2 tutorials were carefully reviewed and selected from 645 submissions The papers are organized in topical sections on cluster systems and applications performance evaluation and measurements distributed algorithms and systems fault tolerance and reliability high performance computing and architecture parallel algorithms and systems network routing and communication algorithms security algorithms and systems grid applications and systems database applications and data mining distributed processing and architecture sensor networks and protocols peer to peer algorithms and systems internet computing and Web technologies network protocols and switching and ad hoc and wireless networks **Parallel Processing and Applied**

**Mathematics** Roman Wyrzykowski,Ewa Deelman,Jack Dongarra,Konrad Karczewski,Jacek Kitowski,Kazimierz

Wiatr,2016-04-05 This two volume set LNCS 9573 and 9574 constitutes the refereed proceedings of the 11th International Conference of Parallel Processing and Applied Mathematics PPAM 2015 held in Krakow Poland in September 2015 The 111 revised full papers presented in both volumes were carefully reviewed and selected from 196 submissions The focus of PPAM 2015 was on models algorithms and software tools which facilitate efficient and convenient utilization of modern parallel and distributed computing architectures as well as on large scale applications including big data problems **Advances in Grid**

**and Pervasive Computing** Yeh-Ching Chung,2006-04-21 This book constitutes the proceedings of the First International Conference on Grid and Pervasive Computing GPC 2006 The 64 revised full papers were carefully reviewed The papers are organized in topical sections on grid scheduling peer to peer computing Web grid services high performance computing ad hoc networks wireless sensor networks grid applications data grid pervasive applications semantic Web semantic grid grid load balancing wireless ad hoc sensor networks and mobile computing Languages and Compilers for Parallel Computing

Chen Ding,John Criswell,Peng Wu,2017-01-20 This book constitutes the thoroughly refereed post conference proceedings of the 29th International Workshop on Languages and Compilers for Parallel Computing LCPC 2016 held in Rochester NY USA in September 2016 The 20 revised full papers presented together with 4 short papers were carefully reviewed The papers are organized in topical sections on large scale parallelism resilience and persistence compiler analysis and optimization dynamic computation and languages GPUs and private memory and run time and performance analysis Smart Sensors and

Systems Yongpan Liu,Youn-Long Lin,Chong-Min Kyung,Hiroto Yasuura,2020-06-10 This book describes for readers technology used for effective sensing of our physical world and intelligent processing techniques for sensed information which are essential to the success of Internet of Things IoTs The authors provide a multidisciplinary view of sensor technology from materials process circuits and big data domains and showcase smart sensor systems in real applications including smart home transportation medical environmental agricultural etc Unlike earlier books on sensors this book will provide a global view on smart sensors covering abstraction levels from device circuit systems and algorithms Profiles active

research on smart sensors based on CMOS microelectronics Describes applications of sensors and sensor systems in cyber physical systems the social information infrastructure in our modern world Includes coverage of a variety of related information technologies supporting the application of sensors Discusses the integration of computation networking actuation databases and various sensors in order to embed smart sensor systems into actual social systems *Compiler Construction* ,

**Languages and Compilers for Parallel Computing** Eduard Ayguadé,2006-12-22 This book constitutes the thoroughly refereed post proceedings of the 18th International Workshop on Languages and Compilers for Parallel Computing LCPC 2005 held in Hawthorne NY USA in October 2005 The 26 revised full papers and eight short papers presented were carefully selected during two rounds of reviewing and improvement The papers are organized in topical sections

**Encyclopedia of Parallel Computing** David Padua,2011-09-08 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 searchers 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 coherency machine classes such as clusters shared memory multiprocessors special purpose machines and dataflow machines specific machines such as Cray supercomputers IBM s cell 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 Amdahls law Computer Architecture Concepts Parallel Machine Designs Benmarks 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 **Compilation Techniques for Reconfigurable Architectures** João M.P.

Cardoso,Pedro C. Diniz,2011-04-02 The extreme exibility of recon gurable architectures and their performance pot tial have made them a vehicle of choice in a wide range of computing domains from rapid circuit prototyping to high performance computing The increasing availab ity of transistors on a die has allowed the emergence of recon gurable architectures with a large number of computing resources and interconnection topologies To ploit the potential of these recon gurable

architectures programmers are forced to map their applications typically written in high level imperative programming languages such as C or MATLAB to hardware oriented languages such as VHDL or Verilog In this process they must assume the role of hardware designers and software programmers and navigate a maze of program transformations mapping and synthesis steps to produce efficient reconfigurable computing implementations The richness and sophistication of any of these application mapping steps make the mapping of computations to these architectures an increasingly daunting process It is thus widely believed that automatic compilation from high level programming languages is the key to the success of reconfigurable computing This book describes a wide range of code transformations and mapping techniques for programs described in high level programming languages most notably imperative languages to reconfigurable architectures *Languages and Compilers for Parallel Computing* Siddharta Chatterjee, 1999-09-24 This book constitutes the thoroughly refereed post workshop proceedings of the 11th International Workshop on Languages and Compilers for Parallel Computing LCPC 98 held in Chapel Hill North Carolina USA in August 1998 The 24 revised full papers presented have gone through two rounds of selection and reviewing The volume is divided in topical sections on Java locality network computing Fortran irregular applications instructions scheduling and dependence analysis *Artificial Intelligence and Soft Computing* Leszek Rutkowski, Rafał Scherer, Marcin Korytkowski, Witold Pedrycz, Ryszard Tadeusiewicz, Jacek M. Zurada, 2019-05-27 The two volume set LNCS 11508 and 11509 constitutes the refereed proceedings of the 18th International Conference on Artificial Intelligence and Soft Computing ICAISC 2019 held in Zakopane Poland in June 2019 The 122 revised full papers presented were carefully reviewed and selected from 333 submissions The papers included in the first volume are organized in the following five parts neural networks and their applications fuzzy systems and their applications evolutionary algorithms and their applications pattern classification artificial intelligence in modeling and simulation The papers included in the second volume are organized in the following five parts computer vision image and speech analysis bioinformatics biometrics and medical applications data mining various problems of artificial intelligence agent systems robotics and control **STACS 2002** Helmut Alt, Afonso Ferreira, 2003-08-03 This book constitutes the refereed proceedings of the 19th Annual Symposium on Theoretical Aspects of Computer Science STACS 2002 held in Antibes Juan les Pins France in March 2002 The 50 revised full papers presented together with three invited papers were carefully reviewed and selected from a total of 209 submissions The book offers topical sections on algorithms current challenges computational and structural complexity automata and formal languages and logic in computer science **Embedded Computer Systems: Architectures, Modeling, and Simulation** Alex Orailoglu, Matthias Jung, Marc Reichenbach, 2022-04-26 This book constitutes the proceedings of the 21st International Conference on Embedded Computer Systems Architectures Modeling and Simulation SAMOS 2021 which took place in July 2021 Due to COVID 19 pandemic the conference was held virtually The 17 full papers presented in this volume were carefully reviewed and selected from 45 submissions The papers are organized in topics as

follows simulation and design space exploration the 3Cs Cache Cluster and Cloud heterogeneous SoC novel CPU architectures and applications dataflow innovative architectures and tools for security next generation computing insights from negative results      Compiler Construction Tibor Gyimothy, 1996-04-03 This book presents the refereed proceedings of the Sixth International Conference on Compiler Construction CC 96 held in Linköping Sweden in April 1996 The 23 revised full papers included were selected from a total of 57 submissions also included is an invited paper by William Waite entitled Compiler Construction Craftsmanship or Engineering The book reports the state of the art in the area of theoretical foundations and design of compilers among the topics addressed are program transformation software pipelining compiler optimization program analysis program inference partial evaluation implementational aspects and object oriented compilers



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