Symbolic Analysis for Parallelizing Compilers

Mohammad R. Haghighat

foreword by
Constantine D. Polychronopoulos

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Larry Carter,Jeanne Ferrante

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   Symbolic Analysis for Parallelizing Compilers Mohammad R. Haghighat,1995-09-30 In Symbolic Analysis for Parallelizing Compilers the author presents an excellent demonstration of the effectiveness of symbolic analysis in tackling important optimization problems some of which inhibit loop parallelization The framework that Haghighat presents has proved extremely successful in induction and wraparound variable analysis strength reduction dead code elimination and symbolic constant propagation The approach can be applied to any program transformation or optimization problem that uses properties and value ranges of program names Symbolic analysis can be used on any transformational system or optimization problem that relies on compile time information about program variables This covers the majority of if not all optimization and parallelization techniques The book makes a compelling case for the potential of symbolic analysis applying it for the first time and with remarkable results to a number of classical optimization problems loop scheduling static timing or size analysis and dependence analysis It demonstrates how symbolic analysis can solve these problems faster and more accurately than existing hybrid techniques   *Symbolic Analysis for Parallelizing Compilers* Mohammad Reza Haghighat,1994 Abstract The notion of dependence captures the most important properties of a program for efficient execution on parallel computers The dependence structure of a program defines the necessary constraints of the order of execution of the program components and provides sufficient information for the exploitation of the available parallelism Static discovery and management of the dependence structure of programs saves a tremendous amount of execution time and dynamic utilization of dependence information results in a significant performance gain on parallel computers However experiments with supercomputers indicate that existing multiprocessing environments are unable to deliver the desired performance over a wide range of real applications mainly due to lack of precision of their dependence information This calls for an effective compilation scheme capable of understanding the dependence structure of complicated application programs This thesis describes a methodology for capturing and analyzing program properties that are essential in the effective detection and efficient exploitation of parallelism on parallel computers Based on this methodology a symbolic analysis framework is developed for the Parafrase 2 parallelizing compiler This framework extends the scope of a variety of important program analysis problems and solves them in a unified way The attained solution space of these problems is much larger than that handled by existing compiler technology Such a powerful approach is required for the effective compilation of a large class of application programs   Symbolic Analysis for Parallelizing Compilers Mohammad R. Haghighat,2007-08-19 In Symbolic Analysis for Parallelizing Compilers the author presents an excellent demonstration of the effectiveness of symbolic analysis in tackling important optimization problems some of which inhibit loop parallelization The framework that Haghighat presents has proved extremely successful in induction and wraparound variable analysis strength reduction dead code elimination and symbolic constant propagation The approach can be applied to any program transformation or

optimization problem that uses properties and value ranges of program names Symbolic analysis can be used on any transformational system or optimization problem that relies on compile time information about program variables This covers the majority of if not all optimization and parallelization techniques The book makes a compelling case for the potential of symbolic analysis applying it for the first time and with remarkable results to a number of classical optimization problems loop scheduling static timing or size analysis and dependence analysis It demonstrates how symbolic analysis can solve these problems faster and more accurately than existing hybrid techniques **Advanced Symbolic Analysis for Compilers** Thomas Fahringer,Bernhard Scholz,2003-08-03 The objective of program analysis is to automatically determine the p perties of a program Tools of software development such as compilers p formance estimators debuggers reverse engineering tools program veri tion testing proving systems program comprehension systems and program specializationtoolsarelargelydependentonprogramanalysis Advancedp gram analysis can help to nd program errors detect and tune performan critical code regions ensure assumed constraints on data are not violated tailor a generic program to suit a speci c application reverse engineer so ware modules etc A prominent program analysis technique is symbolic a lysis which has attracted substantial attention for many years as it is not dependent on executing a program to examine the semantics of a program and it can yield very elegant formulations of many analyses Moreover the complexity of symbolic analysis can be largely independent of the input data size of a program and of the size of the machine on which the program is being executed In this book we present novel symbolic control and data ow repres tation techniques as well as symbolic techniques and algorithms to analyze and optimize programs Program contexts which de ne a new symbolic scription of program semantics for control and data ow analysis are at the center of our approach We have solved a number of problems encountered in program analysis by using program contexts Our solution methods are e cient versatile uni ed and more general they cope with regular and irregular codes than most existing methods **Symbolic Program Analysis and Optimization for Parallelizing Compilers** University of Illinois at Urbana-Champaign. Center for Supercomputing Research and Development,M. R. Haghighat,C. D. Polychronopoulos,1992 A systematic method for generalized strength reduction based on this representation is also presented This results in an effective scheme for exploitation of parallelism and optimization of the code Symbolic analysis also serves as a basis for other code generation optimizations such as elimination of redundant computations Languages and Compilers for Parallel Computing Utpal Banerjee,1993-12-08 The articles in this volume are revised versions of the best papers presented at the Fifth Workshop on Languages and Compilers for Parallel Computing held at Yale University August 1992 The previous workshops in this series were held in Santa Clara 1991 Irvine 1990 Urbana 1989 and Ithaca 1988 As in previous years a reasonable cross section of some of the best work in the field is presented The volume contains 35 papers mostly by authors working in the U S or Canada but also by authors from Austria Denmark Israel Italy Japan and the U K **Languages and Compilers for Parallel Computing** Larry Carter,Jeanne

Ferrante,2003-06-29 In August 1999 the Twelfth Workshop on Languages and Compilers for P allel Computing LCPC was hosted by the Hierarchical Tiling Research group from the Computer Science and Engineering Department at the University of California San Diego UCSD The workshop is an annual international forum for leading research groups to present their current research activities and the latest results It has also been a place for researchers and practitioners to teract closely and exchange ideas about future directions Among the topics of interest to the workshop are language features code generation debugging timization communication and distributed shared memory libraries distributed object systems resource management systems integration of compiler and r time systems irregular and dynamic applications and performance evaluation In 1999 the workshop was held at the International Relations Paci c Studies Auditorium and the San Diego Supercomputer Center at UCSD Seventy seven researchers from Australia England France Germany Korea Spain and the United States attended the workshop an increase of over 50% from 1998 *Languages and Compilers for Parallel Computing* Chua-Huang Huang,1996-01-24 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 Languages and Compilers for Parallel Computing Bill Pugh,Chau-Wen Tseng,2005-12-13 This book constitutes the thoroughly refereed post proceedings of the 15th International Workshop on Languages and Compilers for Parallel Processing LCPC 2002 held in College Park MD USA in July 2002 The 26 revised full papers presented were carefully selected during two rounds of reviewing and improvement from 32 submissions All current issues in parallel processing are addressed in particular memory constrained computation compiler optimization performance studies high level languages programming language consistency models dynamic parallelization parallelization of data mining algorithms parallelizing compilers garbage collection algorithms and evaluation of iterative compilation **Languages and Compilers for Parallel Computing** Lawrence Rauchwerger,2004-02-25 This book constitutes the thoroughly refereed post proceedings of the 16th International Workshop on Languages and Compilers for Parallel Computing LCPC 2003 held in College Station Texas USA in October 2003 The 35 revised full papers presented were selected from 48 submissions during two rounds of reviewing and improvement upon presentation at the workshop The papers are organized in topical sections on adaptive optimization data locality parallel languages high level transformations embedded systems distributed systems software low level transformations compiling for novel architectures and optimization infrastructure Languages and Compilers for Parallel Computing Eduard Ayguadé,Gerald Baumgartner,J. Ramanujam,P. Sadayappan,2007-05-16 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 **Symbolic Dependence Analysis for High Performance Parallelizing Compilers** Mohammad Reza Haghighat,Constantine D. Polychronopoulos,1990 Abstract A framework is introduced to solve the dependence problem in the presence of unknown symbolic terms This framework uses the idea of abstract interpretation of programs and is based on lattice theoretical models Theories of dependence analysis flow analysis and approximate semantic analysis of programs are discussed The details of implementation of symbolic dependence analysis in Parafrase 21 PGH 89 is presented *Languages and Compilers for Parallel Computing* Samuel P. Midkiff,Jose E. Moreira,Manish Gupta,Siddhartha Chatterjee,Jeanne Ferrante,Jan Prins,William Pugh,Chau-Wen Tseng,2003-06-29 This volume contains the papers presented at the 13th International Workshop on Languages and Compilers for Parallel Computing It also contains extended abstracts of submissions that were accepted as posters The workshop was held at the IBM T J Watson Research Center in Yorktown Heights New York As in previous years the workshop focused on issues in optimizing compilers languages and software environments for high performance computing This continues a trend in which languages compilers and software environments for high performance computing and not strictly parallel computing has been the organizing topic As in past years participants came from Asia North America and Europe This workshop re ected the work of many people In particular the members of the steering committee David Padua Alex Nicolau Utpal Banerjee and David Gelernter have been instrumental in maintaining the focus and quality of the workshop since it was rst held in 1988 in Urbana Champaign The assistance of the other members of the program committee Larry Carter Sid Chatterjee Jeanne Ferrante Jans Prins Bill Pugh and Chau wen Tseng was crucial The infrastructure at the IBM T J Watson Research Center provided trouble free logistical support The IBM T J Watson Research Center also provided nancial support by underwriting much of the expense of the workshop Appreciation must also be extended to Marc Snir and Pratap Pattnaik of the IBM T J Watson Research Center for their support *Parallel Processing* Bruno Buchberger,Jens Volkert,1994-08-30 Proceedings Parallel Computing

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 *Languages and Compilers for Parallel Computing* Henry Gordon Dietz,2003-08-03 This book constitutes the thoroughly refereed post proceedings of the 14th International Workshop on Languages and Compilers for Parallel Computing LCPC 2001 held in Lexington KY USA in August 1 3 2001 The 28 revised full papers presented were carefully selected during two rounds of reviewing and improvement All current issues in parallel processing are addressed in particular compiler optimization HP Java programming power aware parallel architectures high performance applications power management of mobile computers data distribution shared memory systems load balancing garbage collection parallel components job scheduling dynamic parallelization cache optimization specification and dataflow analysis **Languages and Compilers for Parallel Computing** ,2003 *Euro-Par 2001 Parallel Processing* Rizos Sakellariou,John Keane,John Gurd,Len Freeman,2003-06-30 Euro Par the European Conference on Parallel Computing is an international conference series dedicated to the promotion and advancement of all aspects of parallel computing The major themes can be divided into the broad categories of hardware software algorithms and applications for parallel computing The objective of Euro Par is to provide a forum within which to promote the dev opment of parallel computing both as an industrial technique and an academic discipline extending the frontiers of both the state of the art and the state of the practice This is particularlyimportant at a time when parallel computing is undergoing strong and sustained development and experiencing real ind trial take up The main audience for and participants in Euro Par are seen as researchers in academic departments government laboratories and industrial organisations Euro Par aims to become the primarychoice of such professionals for the presentation of new results in their speci c areas Euro Par is also int ested in applications that demonstrate the e ectiveness of the main Euro Par themes Euro Par has its own Internet domain with a permanent web site where the historyof the conference series is described http www euro par org The Euro Par conference series is sponsored bythe Association of Computer Machineryand the International Federation of Information Processing Euro Par 2001 Euro Par 2001 was organised bythe Universityof Manchester and UMIST *Automatic Parallelization* Samuel Midkiff,2022-06-01 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   <u>Proceedings of the 1995 International Conference on Parallel Processing</u> Constantine Polychronopoulos,1995-08-08 This set of technical books contains all the information presented at the 1995 International Conference on Parallel Processing This conference held August 14 18 featured over 100 lectures from more than 300 contributors and included three panel sessions and three keynote addresses The international authorship includes experts from around the globe from Texas to Tokyo from Leiden to London Compiled by faculty at the University of Illinois and sponsored by Penn State University these Proceedings are a comprehensive look at all that s new in the field of parallel processing

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