On Modular Termination Proofs of General Logic Programs

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Abstract

We propose a modular method for proving termination of general logic programs (i.e., logic programs with negation). It is based on the notion of acceptable programs, but it allows us to prove termination in a truly modular way. We consider programs consisting of a hierarchy of modules and supply a general result for proving termination by dealing with each module separately. For programs which are in a certain sense well-behaved, namely well-moded or well-typed programs, we derive both a simple verification technique and an iterative proof method. Some examples show how our system allows for greatly simplified proofs.

1 Introduction

It is standard practice to tackle a large proof by decomposing it into more manageable pieces (lemmata or modules) and proving them separately. By composing appropriately these simpler results, one can then obtain the final proof. This methodology has been recognized an important one also when proving termination of logic programs. Moreover most practical logic programs are engineered by assembling different modules and libraries, some of which might be pre-compiled or written in a different programming language. In such a situation, a compositional methodology for proving termination is of crucial importance.

The first approach to modular termination proofs of logic programs has been proposed by Apt and Pedreschi in (Apt and Pedreschi 1994). It extends the seminal work on *acceptable* programs (Apt and Pedreschi 1993) which provides an algebraic characterization of programs terminating under Prolog left-to-right selection rule. The class of acceptable programs contains programs which terminate on ground queries. To prove acceptability one needs to determine a measure on literals (*level mapping*) such that, in any clause, the measure of the head is greater than the measure of each body literal. This implies the decreasing of the measure of the

Termination Proofs For Logic Programs

Manuel Hermenegildo,German Puebla

Termination Proofs For Logic Programs:

Termination Proofs for Logic Programs Lutz Plümer,1990 Termination proofs constitute a crucial part of program verification Much research about termination has been done in the context of term rewriting systems But until now there was little hope that termination proofs for nontrivial programs could be achieved automatically This book gives a comprehensive discussion of the termination problem in the context of logic programming Although logic programs pose special difficulties for termination proofs it turns out that automation of this task is obtainable to a much larger degree than for programs in imperative languages A technique for the automatic derivation of termination proofs is presented in detail The discussion of several nontrivial examples illustrates its range of applicability The approach is based on the concept of declarative semantics and thus makes use of an important feature of logic programming PUBLISHER S WEBSITE **TERMINATION PROOFS FOR LOGIC PROGRAMS** Lutz Plumer,1990 **Termination proofs for logic programs based on predicate inequalities** Lutz Plümer,1990 **Deriving Termination Proofs for Logic Programs, Using Abstract Procedures** K. Verschaetse,D. De Schreye,1991 **Logic Programming** Lee Naish,1997 Covers the latest research in areas such as theoretical foundations constraints concurrency and parallelism deductive databases language design and implementation non monotonic reasoning and logicprogramming and the Internet 8 12 July 1997 Leuven Belgium The International Conference on Logic Programming is the main annual conference sponsored by the Association for Logic Programming It covers the latest research in areas such as theoretical foundations constraints concurrency and parallelism deductive databases language design and implementation non monotonic reasoning and logic programming and the Internet Logic Program Synthesis and Transformation Maurizio Proietti,1996-03-06 This book constitutes the refereed proceedings of the 5th International Workshop on Logic Program Synthesis and Transformation LOPSTR 95 held in Utrecht The Netherlands in September 1995 The 19 papers included were selected from 40 workshop submissions they offer a unique up to date account of the use of formal synthesis and transformation techniques for computer aided development of logic programs Among the topics addressed are deductive and inductive program synthesis synthesis models based on constructive type theory program specification program analysis theorem proving and applications to various types of programs *Logic Programming* Michael Maher,1996 Includes tutorials invited lectures and refereed papers on all aspects of logic programming including Constraints Concurrency and Parallelism Deductive Databases Implementations Meta and Higher order Programming Theory and Semantic Analysis September 2 6 1996 Bonn Germany Every four years the two major international scientific conferences on logic programming merge in one joint event JICSLP 96 is the thirteenth in the two series of annual conferences sponsored by The Association for Logic Programming It includes tutorials invited lectures and refereed papers on all aspects of logic programming including Constraints Concurrency and Parallelism Deductive Databases Implementations Meta and Higher order Programming Theory and Semantic Analysis The contributors are international with

strong contingents from the United States United Kingdom France and Japan Logic Programming series Research Reports and Notes Program Development in Computational Logic Maurice Bruynooghe,Kung-Kiu Lau,2004-06-17 1 The tenth anniversary of the LOPSTR symposium provided the incentive for this volume LOPSTR started in 1991 as a workshop on logic program synthesis and transformation but later it broadened its scope to logic based program development in general that is program development in computational logic and hence the title of this volume The motivating force behind LOPSTR has been the belief that declarative paradigms such as logic programming are better suited to program development tasks than traditional non declarative ones such as the imperative paradigm Speci cation synthesis transformation or specialization analysis debugging and veri cation can all be given logical foundations thus providing a unifying framework for the whole development process In the past 10 years or so such a theoretical framework has indeed begun to emerge Even tools have been implemented for analysis veri cation and speci ization However itisfairtosaythatsofarthefocushaslargelybeenonprogrammi in the small So the future challenge is to apply or extend these techniques to programming in the large in order to tackle software engineering in the real world Returning to this volume our aim is to present a collection of papers that re ect signi cant research e orts over the past 10 years These papers cover the wholedevelopmentprocess speci cation synthesis analysis transformationand specialization as well as semantics and systems Logic Programming John Lloyd,1995 The International Logic Programming Symposium is one of two major international conferences sponsored by the Association of Logic Programming Both conferences are held annually The theme for the 1995 conference was Declarative Systems particularly the integration of the logic programming functional programming and object oriented programming paradigms **Rules on the Web: From Theory to Applications** Antonis Bikakis,Paul Fodor,Dumitru Roman,2014-07-21 This book constitutes the refereed proceedings of the 8th International RuleML Symposium RuleML 2014 co located with the 21st European Conference on Artificial Intelligence ECAI 2014 held in Prague Czech Republic in August 2014 The 17 full and 6 short papers presented together with 3 keynote talks were carefully reviewed and selected from 48 submissions The papers cover the following topics semantic web rule languages and standards rule engines formal and operational semantics and rule based systems the relation between natural language and rules automation of business rules generation from existing data and aspects related to legal rules and norms for web and corporate environments **Logic Program Synthesis and Transformation - Meta-Programming in Logic** Laurent Fribourg,Franco Turini,1994-11-30 This volume constitutes the combined proceedings of the 4th International Workshops on Logic Program Synthesis and Transformation LOPSTR 94 and on Meta Programming META 94 held jointly in Pisa Italy in June 1994 This book includes thoroughly revised versions of the best papers presented at both workshops The main topics addressed by the META papers are language extensions in support of meta logic semantics of meta logic implementation of meta logic features performance of meta logic and several applicational aspects The LOPSTR papers are devoted to unfolding

folding partial deduction proofs as programs inductive logic programming automated program verification specification and programming methodologies **Static Analysis** Patrick Cousot,2001-07-04 In this edited book various novel approaches to problems of current interest in civil engineering are demonstrated The topics range from dynamic band seismic problems to the analysis of long span structures and ancient buildings Experts associated within the Lagrange Laboratory present recent research results on functionally graded or composite materials granular materials geotechnics as well as frictional or adhesive contact problems FME '93: Industrial-Strength Formal Methods Jim Woodcock,James C.P. Woodcock,Peter G. Larsen,1993 The last few years have borne witness to a remarkable diversity of formal methods with applications to sequential and concurrent software to real time and reactive systems and to hardware design In that time many theoretical problems have been tackled and solved and many continue to be worked upon Yet it is by the suitability of their industrial application and the extent of their usage that formal methods will ultimately be judged This volume presents the proceedings of the first international symposium of Formal Methods Europe FME 93 The symposium focuses on the application of industrial strength formal methods Authors address the difficulties of scaling their techniques up to industrial sized problems and their suitability in the workplace and discuss techniques that are formal that is they have a mathematical basis and that are industrially applicable The volume has four parts Invited lectures containing a lecture by Cliff B Jones and a lecture by Antonio Cau and Willem Paul de Roever Industrial usage reports containing 6 reports Papers containing 32 selected and refereedpapers Tool descriptions containing 11 descriptions **Logics of Programs** Rohit Parikh,1985-06 **Principles and Practice of Declarative Programming** Gopalan Nadathur,2006-12-29 This book constitutes the refereed proceedings of the International Conference on Principles and Practice of Declarative Programming PPDP 99 held in Paris France in September October 1999 The 22 revised full papers presented together with three invited contributions were carefully reviewed and selected from a total of 52 full length papers submitted Among the topics covered are type theory logics and logical methods in understanding defining integrating and extending programming paradigms such as functional logic object oriented constraint and concurrent programming support for modularity the use of logics in the design of program development tools and development and implementation methods Static Analysis Manuel Hermenegildo,German Puebla,2002-09-06 This book constitutes the refereed proceedings of the 9th International Static Analysis Symposium SAS 2002 held in Madrid Spain in September 2002 The 32 revised full papers presented were carefully reviewed and selected from 86 submissions The papers are organized in topical sections on theory data structure analysis type inference analysis of numerical problems implementation data flow analysis compiler optimizations security analyses abstract model checking semantics and abstract verification and termination analysis *Conditional Term Rewriting Systems* Michael Rusinowitch,Jean-Luc Remy,1993-01-29 This volume contains the papers preesented at the Third International Workshop on Conditional Term Rewriting Systems held in Pont Mousson France July 8 10 1992 Topics covered include conditional

rewriting and its applications to programming languages specification languages automated deduction constrained rewriting typed rewriting higher order rewriting and graph rewriting The volume contains 40 papers including four invited talks Algebraic semantics of rewriting terms and types by K Meinke Generic induction proofs by P Padawitz Conditional term rewriting and first order theorem proving by D Plaisted and Decidability of finiteness properties abstract by L Pacholski The first CTRS workshop was held at the University of Paris in 1987 and the second at Concordia University Montreal in 1990 Their proceddings are published as Lecture Notes in Computer Science Volumes 308 and 516 respectively Advanced Topics in Term Rewriting Enno Ohlebusch,2013-04-17 Term rewriting techniques are applicable in various fields of computer sci ence in software engineering e g equationally specified abstract data types in programming languages e g functional logic programming in computer algebra e g symbolic computations Grabner bases in pro gram verification e g automatically proving termination of programs in automated theorem proving e g equational unification and in algebra e g Boolean algebra group theory In other words term rewriting has applications in practical computer science theoretical computer science and mathematics Roughly speaking term rewriting techniques can suc cessfully be applied in areas that demand efficient methods for reasoning with equations One of the major problems one encounters in the theory of term rewriting is the characterization of classes of rewrite systems that have a desirable property like confluence or termination If a term rewriting system is conflu ent then the normal form of a given term is unique A terminating rewrite system does not permit infinite computations that is every computation starting from a term must end in a normal form Therefore in a system that is both terminating and confluent every computation leads to a result that is unique regardless of the order in which the rewrite rules are applied This book provides a comprehensive study of termination and confluence as well as related properties

High Performance Computing for Computational Science - VECPAR 2002 José M.L.M. Palma,2003-04-07 This book constitutes the thoroughly refereed post proceedings of the 5th International Conference on High Performance Computing for Computational Science VECPAR 2002 held in Porto Portugal in June 2002 The 45 revised full papers presented together with 4 invited papers were carefully selected during two rounds of reviewing and improvement The papers are organized in topical sections on fluids and structures data mining computing in chemistry and biology problem solving environments computational linear and non linear algebra cluster computing imaging and software tools and environments Constraints and Databases Raghu Ramakrishnan,Peter Stuckey,1997-12-31 Constraints and Databases contains seven contributions on the rapidly evolving research area of constraints and databases This collection of original research articles has been compiled as a tribute to Paris C Kanellakis one of the pioneers in the field Constraints have long been used for maintaining the integrity of databases More recently constraint databases have emerged where databases store and manipulate data in the form of constraints The generality of constraint databases makes them highly attractive for many applications Constraints provide a uniform mechanism for describing heterogenous data and advanced constraint solving methods can be used for

efficient manipulation of constraint data The articles included in this book cover the range of topics involving constraints and databases join algorithms evaluation methods applications e g data mining and implementations of constraint databases as well as more traditional topics such as integrity constraint maintenance Constraints and Databases is an edited volume of original research comprising invited contributions by leading researchers

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