

ORBIT: An Optimizing Compiler for Scheme

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1. Introduction

In this paper we describe an optimizing compiler for Scheme [3, 13] called *Orbit* that incorporates our experience with an earlier Scheme compiler called *TC* [10, 11], together with some ideas from Steele's *Rabbit* compiler [1-4]. The three main design goals have been correctness, generating very efficient compiled code, and portability.

In spirit, *Orbit* is similar to the *Rabbit* compiler in that it depends on a translation of source code into "continuation-passing style" (CPS), a convenient intermediate form that makes control-flow explicit. After CPS conversion, procedures take an extra argument called a *continuation* (another procedure) that represents the next logical execution point after execution of the procedure body. Thus procedures do not "return," but rather "continue into" the code represented by the continuation. This permits, for example, a general but simple way to optimize tail-recursions into loops.

Steele's seminal work on *Rabbit* demonstrated the general benefits of this approach to compiler design. However, this work was primarily research oriented, and *Rabbit* was essentially a prototype compiler (consider, for example, that it generated MACLISP code). *TC*, on the other hand, was one of the first practical compilers for a Scheme dialect, and much was learned through its design and construction.² *Orbit* now represents a culmination of that learning process, in which CPS conversion has been implemented thoroughly, extended in critical ways, and set in a framework of other important compiler innovations to yield a practical compiler that generates production-quality code competitive with the best compilers for LISP as well as non-LISP languages.³ The new ideas in *Orbit* include:

1. An extension to CPS conversion called *assignment conversion* that facilitates treatment of assigned variables. (See section 3.)
2. Compact and efficient runtime data representations, the most important being those for lexical closures, which are represented in different ways depending on information gleaned from a static analysis of their use. (See sections 4 and 5.)
3. A register allocation strategy based on *trace scheduling* that optimizes register usage across forks and joins (and which, because of CPS conversion, includes procedure calls). (See section 6.)
4. An integral table-driven assembler that uses hints from the code generator to order blocks so as to minimize the number and size of jumps. (See section 7.)
5. A technique for defining the behavior of primitive operations in Scheme source modules rather than in the internal logic of the compiler. (See section 9.1.)
6. Flexibility in configuring the runtime support system for user programs. (See section 9.2.)

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²Both *TC* and the S-1 Common LISP compiler described in [2] have as a common ancestor a LISP compiler which Steele wrote during the summer of 1979. From this compiler *TC* was derived by making modifications for compilation of a different source language for different target machines, and adding the logic necessary for compiling lexical closures moderately well.

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Proceedings of the 1986 SIGPLAN Symposium on Compiler Construction ,1986 *Proceedings of the SIGPLAN '84 Symposium on Compiler Construction ,1984* **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 Link ping 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 **Compiler Construction** Peter A. Fritzson,1994-03-23 The International Conference on Compiler Construction provides a forum for presentation and discussion of recent developments in the area of compiler construction language implementation and language design Its scope ranges from compilation methods and tools to implementation techniques for specific requirements on languages and target architectures It also includes language design and programming environment issues which are related to language translation There is an emphasis on practical and efficient techniques This volume contains the papers selected for presentation at CC 94 the fifth International Conference on Compiler Construction held in Edinburgh U K in April 1994 **A Practical Approach to Compiler Construction** Des Watson,2017-03-22 This book provides a practically oriented introduction to high level programming language implementation It demystifies what goes on within a compiler and stimulates the reader s interest in compiler design an essential aspect of computer science Programming language analysis and translation techniques are used in many software application areas A Practical Approach to Compiler Construction covers the fundamental principles of the subject in an accessible way It presents the necessary background theory and shows how it can be applied to implement complete compilers A step by step approach based on a standard compiler structure is adopted presenting up to date techniques and examples Strategies and designs are described in detail to guide the reader in implementing a translator for a programming language A simple high level language loosely based on C is used to illustrate aspects of the compilation process Code examples in C are included together with discussion and illustration of how this code can be extended to cover the compilation of more complex languages Examples are also given of the use of the flex and bison compiler construction tools Lexical and syntax analysis is covered in detail together with a comprehensive coverage of semantic analysis intermediate representations optimisation and code generation Introductory material on parallelisation is also included Designed for personal study as well as for use in introductory undergraduate and postgraduate courses in compiler design the author assumes that readers have a reasonable competence in programming in any high level language **Compiler Compilers and High Speed Compilation** Dieter Hammer,1989 Advances and problems in the field of compiler compilers are the subject of

the 2nd CCHSC Workshop which took place in Berlin GDR in October 1988 The 18 papers which were selected for the workshop are now included in this volume among them three invited papers They discuss the requirements properties and theoretical aspects of compiler compilers as well as tools and metatools for software engineering The papers cover a wide spectrum in the field of compiler compilers ranging from overviews of existing compiler compilers and engineering of compiler compilers to special problems of attribute evaluation generation and code generation In connection with compiler compiler projects means of supporting high speed compilation are pointed out Special attention is given to problems of incremental compilation *Compiler Construction* Görel Hedin,2003-07-01 This book constitutes the refereed proceedings of the 12th International Conference on Compiler Construction CC 2003 held in Warsaw Poland in April 2003 The 20 revised full regular papers and one tool demonstration paper presented together with two invited papers were carefully reviewed and selected from 83 submissions The papers are organized in topical sections on register allocation language constructs and their implementation type analysis Java pot pourri and optimization **Qualified Types** Mark P. Jones,2003-10-16 Qualified types can be viewed as a generalization of type classes in the functional language Haskell and the theorem prover Isabelle These in turn are extensions of equality types in Standard ML Other applications of qualified types include extensible records and subtyping This book describes the use of qualified types to provide a general framework for the combination of polymorphism and overloading Using a general formulation of qualified types the author extends the Damas Milner type inference algorithm to support qualified types In addition he describes a new technique for establishing suitable coherence conditions that guarantee the same semantics for all possible translations of a given term Practical issues that arise in concrete implementations are also discussed concentrating in particular on the implementation of overloading in Haskell and Gofer a small functional programming system developed by the author This book will be suitable for advanced graduate students and researchers in computer science

Multithreaded Computer Architecture: A Summary of the State of the ART Robert A. Iannucci,Guang R. Gao,Robert H. Halstead Jr.,Burton Smith,2012-12-06 Multithreaded computer architecture has emerged as one of the most promising and exciting avenues for the exploitation of parallelism This new field represents the confluence of several independent research directions which have united over a common set of issues and techniques Multithreading draws on recent advances in dataflow RISC compiling for fine grained parallel execution and dynamic resource management It offers the hope of dramatic performance increases through parallel execution for a broad spectrum of significant applications based on extensions to traditional approaches Multithreaded Computer Architecture is divided into four parts reflecting four major perspectives on the topic Part I provides the reader with basic background information definitions and surveys of work which have in one way or another been pivotal in defining and shaping multithreading as an architectural discipline Part II examines key elements of multithreading highlighting the fundamental nature of latency and synchronization This section presents clever techniques for hiding latency and supporting large

synchronization name spaces Part III looks at three major multithreaded systems considering issues of machine organization and compilation strategy Part IV concludes the volume with an analysis of multithreaded architectures showcasing methodologies and actual measurements Multithreaded Computer Architecture A Summary of the State of the Art is an excellent reference source and may be used as a text for advanced courses on the subject

Functional Programming Languages and Computer Architecture Jean-Pierre Jouannaud,1985-09

Parle '91 Parallel Architectures and Languages Europe Emile H.L. Aarts,Jan van Leeuwen,Martin Rem,2013-11-11

The innovative progress in the development of large and small scale parallel computing systems and their increasing availability have caused a sharp rise in interest in the scientific principles that underlie parallel computation and parallel programming The biannual Parallel Architectures and Languages Europe PARLE conferences aim at presenting current research material on all aspects of the theory design and application of parallel computing systems and parallel processing At the same time the goal of the PARLE conferences is to provide a forum for researchers and practitioners to exchange ideas on recent developments and trends in the field of parallel computing and parallel programming The first two conferences PARLE 87 and PARLE 89 have succeeded in meeting this goal and made PARLE a conference that is recognized worldwide in the field of parallel computation PARLE 91 again offers a wealth of high quality research material for the benefit of the scientific community Compared to its predecessors the scope of PARLE 91 has been broadened so as to cover the area of parallel algorithms and complexity in addition to the central themes of parallel architectures and languages The proceedings of the PARLE 91 conference contain the text of all contributed papers that were selected for the programme and of the invited papers by leading experts in the field

Generative Programming and Component Engineering Don Batory,Charles Consel,Walid Taha,2003-06-30 This volume constitutes the proceedings of the first ACM SIGPLAN SIGSOFT International Conference on Generative Programming and Component Engineering GPCE 2002 held October 6-8 2002 in Pittsburgh PA USA as part of the PLI 2002 event which also included ICFP PPDP and affiliated workshops

The future of Software Engineering lies in the automation of tasks that are performed manually today Generative Programming developing programs that synthesize other programs Component Engineering raising the level of modularization and analysis in application design and Domain Specific Languages elevating program specifications to compact domain specific notations that are easier to write and maintain are key technologies for automating program development In a time of conference and workshop proliferation GPCE represents a counter trend in the merging of two distinct communities with strongly overlapping interests the Generative and Component Based Software Engineering Conference GCSE and the International Workshop on the Semantics Applications and Implementation of Program Generation SAIG Researchers in the GCSE community address the topic of program automation from a contemporary software engineering viewpoint SAIG correspondingly represents a community attacking automation from a more formal programming languages viewpoint Together their combination provides the depth of theory and practice that one would expect in a premier research conference

Three prominent PLI invited speakers lectured at GPCE 2002 Neil Jones University of Copenhagen Catuscia Palamidessi Penn State University and Janos Sztipanovits Vanderbilt University GPCE 2002 received 39 submissions of which 18 were accepted

Conference Record of POPL '96 ,1996 Conditional and Typed Rewriting Systems Stephane

Kaplan,1991-08-07 In recent years extensions of rewriting techniques that go beyond the traditional untyped algebraic rewriting framework have been investigated and developed Among these extensions conditional and typed systems are particularly important as are higher order systems graph rewriting systems etc The international CTRS Conditional and Typed Rewriting Systems workshops are intended to offer a forum for researchers on such extensions of rewriting techniques This volume presents the proceedings of the second CTRS workshop which contributed to discussion and evaluation of new directions of research The proceedings of the first CTRS workshop are in Lecture Notes in Computer Science Vol 308 Several important directions for extensions of rewriting techniques were stressed which are reflected in the organization of the chapters in this volume Theory of conditional and Horn clause systems Infinite terms non terminating systems and termination Extension of Knuth Bendix completion Combined systems combined languages and modularity Architecture compilers and parallel computation Basic frameworks for typed and order sorted systems Extension of unification and narrowing techniques

ACM Transactions on Programming Languages and Systems Association for Computing

Machinery,1997 **Optimal Interprocedural Program Optimization** Jens Knoop,2003-06-26 Starting from the intraprocedural basic case this monograph focuses on interprocedural optimization It emphasizes the analogies and essential differences between intraprocedural and interprocedural optimization and offers cookbook style support for constructing the underlying algorithms It is aimed at compiler constructors and researchers interested in the systematic transfer of intraprocedural optimizations to the interprocedural setting as well as students seeking a gentle introduction to the field

The Synthesizer Generator Thomas W. Reps,Tim Teitelbaum,2012-12-06 This book is a detailed account of the Synthesizer Generator a system for creating specialized editors that are customized for editing particular languages The book is intended for those with an interest in software tools and in methods for building interactive systems It is a must for people who are using the Synthesizer Generator to build editors because it provides extensive discussions of how to write editor specifications The book should also be valuable for people who are building specialized editors by hand without using an editor generating tool The need to manage the development of large software systems is one of the most pressing problems faced by computer programmers An important aspect of this problem is the design of new tools to aid interactive program development The Synthesizer Generator permits one to create specialized editors that are tailored for editing a particular language In program editors built with the Synthesizer Generator knowledge about the language is used to continuously assess whether a program contains errors and to determine where such errors occur The information is then displayed on the terminal screen to provide feed back to the programmer as the program is developed and modified

Programming Language Pragmatics Michael Scott, 2009-03-23 Programming Language Pragmatics Third Edition is the most comprehensive programming language book available today. Taking the perspective that language design and implementation are tightly interconnected and that neither can be fully understood in isolation, this critically acclaimed and bestselling book has been thoroughly updated to cover the most recent developments in programming language design, including Java 6 and 7, C, C++, C#, Fortran 2003 and 2008, Ada 2005, and Scheme R6RS. A new chapter on run time program management covers virtual machines, managed code, just-in-time and dynamic compilation, reflection, binary translation, and rewriting; mobile code, sandboxing, and debugging; and program analysis tools. Over 800 numbered examples are provided to help the reader quickly cross reference and access content. This text is designed for undergraduate Computer Science students, programmers, and systems and software engineers. Classic programming foundations text now updated to familiarize students with the languages they are most likely to encounter in the workforce, including Java, C, C++, C#, Fortran 2008, Ada 2005, Scheme R6RS, and Perl 6. New and expanded coverage of concurrency and run time systems ensures students and professionals understand the most important advances driving software today. Includes over 800 numbered examples to help the reader quickly cross reference and access content.

Languages and Compilers for Parallel Computing Utpal Banerjee, David Gelernter, Alex Nicolau, David A. Padua, 1992 This volume contains the proceedings of the Fourth Workshop on Languages and Compilers for Parallel Computing held in Santa Clara, California in August 1991. The purpose of the workshop held every year since 1988 is to bring together the leading researchers on parallel programming, language design, and compilation techniques for parallel computers. The papers in this book cover several important topics, including:

- 1. languages and structures to represent programs internally in the compiler
- 2. techniques to analyze and manipulate sequential loops in order to generate a parallel version
- 3. techniques to detect and extract fine grain parallelism
- 4. scheduling and memory management issues in automatically generated parallel programs
- 5. parallel programming language designs and
- 6. compilation of explicitly parallel programs.

Together the papers give a good overview of the research projects underway in 1991 in this field.

Programming Languages and System Architectures Jürg Gutknecht, 1994-02-22 Programming languages and system architectures are at the frontiers of two different worlds. The conference on which this book is based was an adventure in a land where the two worlds—the formal world of algorithms and the physical world of electronic circuits—interact. The participants explored this land under the guidance of internationally renowned researchers such as Butler W. Lampson, Susan Graham, Jan L. A. van de Snepscheut, and C. A. R. Hoare, all of whom gave invited papers. The volume includes these papers together with sixteen session papers. Subjects of special interest include programming language design and history, programming environments, programming methods, operating systems, compiler construction, and innovative system architectures.

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Table of Contents Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal

1. Understanding the eBook Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
 - The Rise of Digital Reading Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
 - Advantages of eBooks Over Traditional Books
2. Identifying Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
 - User-Friendly Interface
4. Exploring eBook Recommendations from Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
 - Personalized Recommendations

- Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal User Reviews and Ratings
 - Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal and Bestseller Lists
5. Accessing Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal Free and Paid eBooks
- Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal Public Domain eBooks
 - Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal eBook Subscription Services
 - Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal Budget-Friendly Options
6. Navigating Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal eBook Formats
- ePUB, PDF, MOBI, and More
 - Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal Compatibility with Devices
 - Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal Enhanced eBook Features
7. Enhancing Your Reading Experience
- Adjustable Fonts and Text Sizes of Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
 - Highlighting and Note-Taking Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
 - Interactive Elements Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
8. Staying Engaged with Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
- Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
9. Balancing eBooks and Physical Books Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
- Benefits of a Digital Library
 - Creating a Diverse Reading Collection Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
10. Overcoming Reading Challenges
- Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
- Setting Reading Goals Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
 - Carving Out Dedicated Reading Time

12. Sourcing Reliable Information of Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
 - Fact-Checking eBook Content of Proceedings Of The Sigplan 84 Symposium On Compiler Construction Montreal
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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