

# Specification and Verification of Compiler Frontend Tasks: Semantic Analysis

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## Abstract

We describe a methodology for the specification and verification of the tasks of compiler frontends. The semantics of the language to be compiled is specified with Evolving Algebras. With respect to the semantics of the language we define the static semantics. The semantical analysis checks whether a program satisfies the static semantics. We introduce a notion of correctness of semantic analysis and show how it can be proven. The technique will be demonstrated for a subset of real life imperative programming languages.

Keywords: Compiler specification, Compiler Verification, Evolving Algebra, Semantic Analysis

## 1 Introduction

Compiler correctness is essential for correct software development. If the compiler that transforms high level language programs (source programs) to machine code (target programs) is erroneous, it can not be assured that the application works correctly.

In [GDG<sup>+</sup>96] we described our notion of compiler correctness. We distinguish between the correctness of the specification of the mapping from source to target programs (the *compiling verification*) and the correctness of the implementation (on a real machine) of the compiling specification (the *compiler implementation verification*). In this paper we focus on one part of the frontend of a compiler, the semantic analysis and show how specification and its compiling verification can be performed. The compiler verification can be performed with standard proof techniques and is not further mentioned in this paper. We start from programs represented as abstract syntax trees. Thus we do not consider lexical and syntax analysis.

The semantics of a program are determined by the description of the programming language. For formal reasoning about programs, it is necessary that this description is clean and unambiguous. Operational semantics are adequate for this purpose, because the view of states and state transitions support the intuitive understanding of compiler designers. Evolving Algebras, [Gur91, Gur95], are one formal approach to define semantics operationally. Their applicability for specifying semantics of existing programming languages is shown by several semantics specifications, e.g [GH93], [Wal95] or [BDR94]. We use evolving algebra specifications as starting point for our technique. But, in contrast to the specifications above, we define abstract machines that can handle semantically incorrect programs as well.

Though semantics of programming languages are usually defined mostly dynamic, it is possible to check parts statically. We examine what semantic properties of programming languages can be checked statically and how they can be determined by considering the evolving algebra specification. Then we define a notion of correctness with respect to the abstract machine representing the

# Compiler Specification And Verification

**G Thomas**



## **Compiler Specification And Verification:**

Compiler Specification and Verification Wolfgang Polak,1981-10      *Compiler Specification and Verification* W. Polak,2014-01-15      **Compiler Construction** Uwe Kastens,Peter Pfahler,1992-09-23 The International Workshop on Compiler Construction provides a forum for the presentation and discussion of recent developments in the area of compiler construction Its scope ranges from compilation methods and tools to implementation techniques for specific requirements of languages and target architectures This volume contains the papers selected for presentation at the 4th International Workshop on Compiler Construction CC 92 held in Paderborn Germany October 5 7 1992 The papers present recent developments on such topics as structural and semantic analysis code generation and optimization and compilation for parallel architectures and for functional logical and application languages      **Collaboration between Human and Artificial Societies** Julian A. Padget,2006-12-31 The full title of the HCM network project behind this volume is VIM A virtual multicomputer for symbolic applications The three strands which bound the network together were parallel systems advanced compilation techniques and artificial intelligence with a common substrate in the programming language Lisp The initial aim of the project was to demonstrate how the combination of these three technologies could be used to build a virtual multicomputer an ephemeral persistent machine of available heterogeneous computing resources for large scale symbolic applications The system would support a virtual processor abstraction to distribute data and tasks across the multicomputer the actual physical composition of which may change dynamically Our practical objective was to assist in the prototyping of dynamic distributed symbolic applications in artificial intelligence using whatever resources are available probably networked workstations so that the developed program could also be run on more exotic hardware without reprogramming What we had not foreseen at the outset of the project was how agents would unify the strands at the application level as distinct from the system level outlined above It was as a result of the agent in unience that we held two workshops in May and December 1997 with the title Collaboration between human and artificial societies The papers collected in this volume are a selection from presentations made at those two workshops In each case the format consisted of a number of invited speakers plus presentations from the network partners      **Compiler Construction** ,1992      **Piton** J Strother Moore,2007-08-28 Mountaineers use pitons to protect themselves from falls The lead climber wears a harness to which a rope is tied As the climber ascends the rope is paid out by a partner on the ground As described thus far the climber receives no protection from the rope or the partner However the climber generally carries several spike like pitons and stops when possible to drive one into a small crack or crevice in the rock face After climbing just above the piton the climber clips the rope to the piton using slings and carabiners A subsequent fall would result in the climber hanging from the piton if the piton stays in the rock the slings and carabiners do not fail the rope does not break the partner is holding the rope taut and secure and the climber had not climbed too high above the piton before falling The climber's safety clearly depends on all of the components of the

system But the piton is distinguished because it connects the natural to the artificial In 1987 I designed an assembly level language for Warren Hunt s FM8501 verified microprocessor I wanted the language to be conveniently used as the object code produced by verified compilers Thus I envisioned the language as the first software link in a trusted chain from verified hardware to verified applications programs Thinking of the hardware as the rock I named the language Piton Of what Use is a Verified Compiler Specification? Paul Curzon,1992 FME '97 Industrial Applications and Strengthened Foundations of Formal Methods John Fitzgerald,Cliff B. Jones,Peter Lucas,1997-09-03 This book constitutes the refereed proceedings of FME 97 the 4th International Symposium of Formal Methods Europe devoted to Industrial Applications and Strengthened Foundations of Formal Methods held in Graz Austria in September 1997 The 35 revised full papers presented in the volume were selected from a total of 94 submissions Formal methods and mathematically based techniques are increasingly recognized as a viable technology for the development and engineering of computing systems The majority of the papers in this volume describe industrial applications extensions to existing techniques or case studies papers on theoretical aspects show clear potential applicability **GWAI ...** ,1981 **Foundations of Software Technology and Theoretical Computer Science** ,2001 **Design and Implementation of Symbolic Computation Systems** ,1993 A *Verified Compiler for a Verified Microprocessor* Jeffrey J. Joyce,1989 *Higher Order Logic Theorem Proving and Its Applications* Jeffrey J. Joyce,Carl-Johan H. Seger,1994-04-28 This volume constitutes the refereed proceedings of the 1993 Higher Order Logic User s Group Workshop held at the University of British Columbia in August 1993 The workshop was sponsored by the Centre for Integrated Computer System Research It was the sixth in the series of annual international workshops dedicated to the topic of Higher Order Logic theorem proving its usage in the HOL system and its applications The volume contains 40 papers including an invited paper by David Parnas McMaster University Canada entitled Some theorems we should prove **A Verified Vista Implementation** Paul Curzon,1993 Abstract We describe the formal verification of a simple compiler using the HOL theorem proving system The language and microprocessor considered are a subset of the structured assembly language Vista and the VIPER microprocessor respectively We describe how our work is directly applicable to a family of languages and compilers and discuss how the correctness theorem and verified compiler fit into a wider context of ensuring that object code is correct We first show how the compiler correctness result can be formally combined with a proof system for application programs We then show how our verified compiler despite not being written in a traditional programming language can be used to produce compiled code We also discuss how a dependable implementation might be obtained *Dissertation Abstracts International* ,1993 **Proceedings** ,1987 Proceedings of the ... IEEE Symposium on Security and Privacy ,1987 *Comprehensive Dissertation Index* ,1984 Computers, Control & Information Theory ,1981 *Abstract State Machines* ,2000

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