

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⁺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

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