

Semantics-Directed Compiler Generation*

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July 21, 2005

Abstract

This dissertation concerns the design and implementation of SEMCOM, an interpreter generator for arbitrary languages, which compiles a two-level operational semantics (in either big- or small-step style). Input to SEMCOM is expressed in a purpose-designed Semantic Description Language (SDL). An SDL file contains the definition of an evaluation and typing relation, and can express type systems up to polymorphism. The SEMCOM compiler performs a sequence of analyses on this input, and generates a lexer, parser, and interpreter (in both OCaml and F#) for the user's language. SDL itself is typed, and a number of consistency checks are performed, producing comprehensive debugging output and useful error messages. Non-deterministic semantics are supported.

1 Introduction

In essence, computation has always been concerned with automation, and this takes place at many different levels. Rather than building systems directly in hardware, we have a processor that provides a convenient *abstraction* – that is to say, we can concern ourselves with the movement and processing of binary data, rather than the control of electrical signals. Furthermore, we do not write general purpose programs in assembler, but use an *abstracted* language in which we can talk about more meaningful concepts, such as objects, functions, and so forth.

The concept of abstraction does not end here, however. A programming language is not just a shorthand for sequences of assembler instructions – it has an underlying meaning, which is in some sense separate from the implementation. Over the course of time, our concept of the *semantics* of a language has developed, so that we now have an underlying mathematical framework with which to describe the execution of a program. In particular, an *operational* semantics is a specification of an abstract machine (an inductively defined transition relation), that explains the execution of a program as a sequence of syntactic transformations. Given this formal description of a programming language, is it not natural to ask whether a compiler could be generated automatically?

This is not as far-fetched as it sounds. Consider the humble parser. Before the theory of formal context-free grammars was understood, the programmer had to code their lexing and parsing routines by hand. Now, we have tools such as yacc, which will generate an efficient parser from a BNF-style description of a grammar. Although this is a considerably more constrained problem than the one just posed, it shows that useful tools can arise from the

*In this document, the term *compiler generator* is used to refer more generally to the automated generation of compilers, interpreters and abstract machines.

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