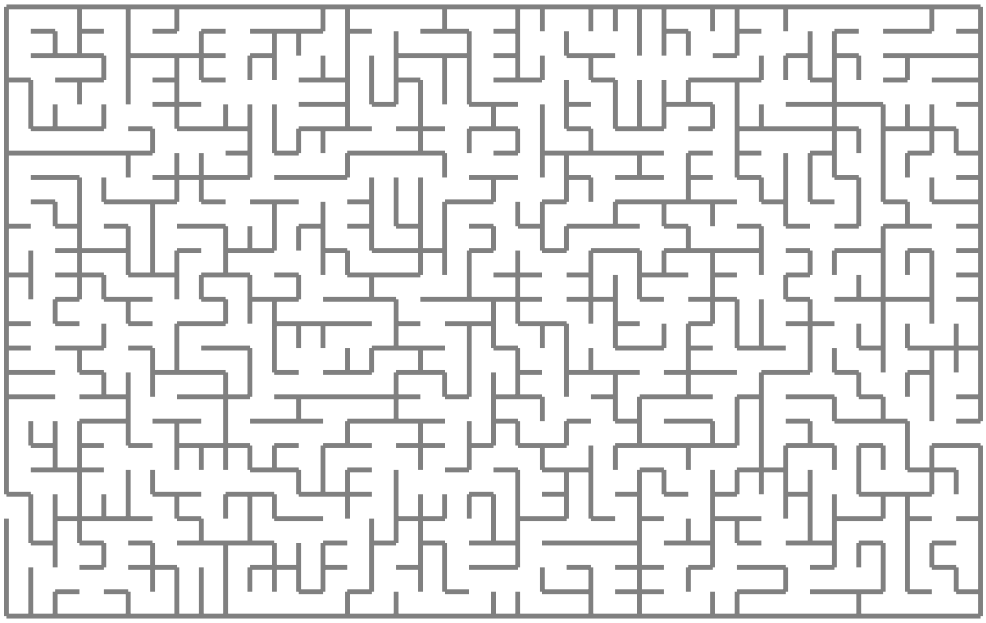
Dependently Typed Languages in Statix

Version of September 25, 2022



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Chapter 1

Introduction

Spoofax is a textual language workbench: a collection of tools that enable the development of textual languages. When working with the Spoofax workbench, the Statix meta-language can be used for the specification of static semantics.

Dependently typed languages are different from other languages because they allow types to be parameterized by values. This allows more rigorous reasoning over types and the values that are inhabited by a type. This expressiveness also makes dependent type systems more complicated to implement. Especially, deciding equality of types requires evaluation of the terms they are parameterized by.

This goal of this paper is to investigate how well Statix is fit for the task of defining a simple dependently-typed language. We want to investigate whether typical features of dependently typed language can be encoded concisely in Statix. The goal is not to show that Statix can implement it, but that implementing it is easier in Statix than in a general-purpose programming language.

We will first show the base language and explain the way that Statix was used to implement this language. Next, we will explore several features and see how well they can be expressed in Statix.

Features - Base language (sec 2) - Name collision avoidance (sec 3) - Language parametric services (sec 4) - Inference (sec 5) - Data types (sec 6)

Chapter 2

Base Language

The base language that was implemented is the Calculus of Constructions [1], with a syntax somewhat similar to that of Haskell. One extra feature was added that is not present in the Calculus of Constructions, that is, let bindings.

2.1 Syntax

The syntax of the base language is defined in SDF3, the syntax definition language of Spoofax. The definition is very similar to that of a simply typed lambda calculus, except that types and expressions are a single sort.

```
context-free sorts
        Expr

context-free syntax
        Expr.Let = [let [ID] = [Expr]; [Expr]]
        Expr.Type = "Type"
        Expr.Var = ID
        Expr.FnType = ID ":" Expr "->" Expr {right}
        Expr.FnConstruct = "\\" ID ":" Expr "." Expr
        Expr.FnDestruct = Expr Expr {left}
        Expr = "(" Expr ")" {bracket}

context-free priorities
        Expr.Type > Expr.Var > Expr.FnType > Expr.FnDestruct
                > Expr.FnConstruct > Expr.Let
```

2.2 Static Analysis

2.3 How scope graphs are used

To type-check the base language, we need to scope graphs. This section describes how scope graphs are used.

The scope graph only has a single type of edge, called `P` (parent) edges. It also only has a single relation, called `name`. This name stores a `NameEntry`, which can be either a `NameType`, which stores the type of a name, or a `NameSubst`, which stores a substitution corresponding to a name.

```
signature sorts
```

```
        NameEntry
constructors
        NameType : Expr -> NameEntry
        NameSubst : scope * Expr -> NameEntry
relations
        name : ID -> NameEntry
name-resolution labels P
```

These are all the definitions we will need to type-check programs.

2.4 Typechecking programs

We will define a statix relation `typeOfExpr` that takes a scope and an expression and type-checks the scope in the expression. It returns two expressions, the first being the expression that was input (this will be changed when we add inference), and the second being the type of the input expression.

```
typeOfExpr : scope * Expr -> (Expr * Expr)
```

2.4.1 Let bindings and variables

Let bindings are typechecked by first typechecking the value that was bound, and then putting this as a substitution in the scope graph. This new scope is then used to typecheck the body.

```
typeOfExpr_(s, l@Let(n, v, b)) = (Let(n, v', b'), b_type) :- {s'}
        typeOfExpr(s, v) == (v', _),
        scopePutSubst(s, n, (s, v')) == s',
        typeOfExpr(s', b) == (b', b_type).
```

We can then

2.5 Garbage

- Base language is calculus of constructions with lets + type assertions (move type assertions to sec 5?) - Describe syntax of the base language? - Describe rules of base language (statix syntax or mathy?) - Scope graphs for substitutions + scopes

Chapter 3

Solving Name Collisions

3.1 Garbage

Ways: - Uniquify at the start, doesn't work (example) - Rename terms using statix rules (works, complex) - Using scope graphs

Chapter 4

Related work

- Scopes as types - Krivine machines - JEspers lijstje

Bibliography

[1] Thierry Coquand and Gérard Huet. “The calculus of constructions”. en. In: *Information and Computation* 76.2–3 (Feb. 1988), pp. 95–120. ISSN: 08905401. DOI: 10.1016/0890-5401(88)90005-3. URL: https://linkinghub.elsevier.com/retrieve/pii/0890540188900053.