COMP 520 - Final Report (GoLite)

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1 Introduction

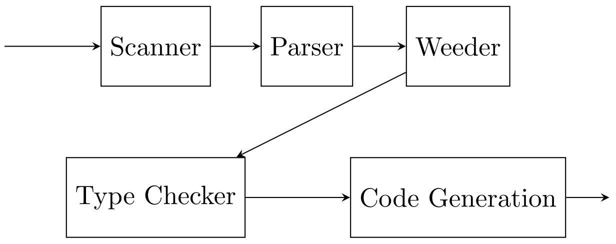
New programming languages are being conceived every other year to tackle various kinds of problems. The structure of a computer program are dependent on the syntax and semantics of a given programming language, and the correctness of the program has to be exact for a compiler to translate it to a machine language. Since the number of programming languages is on the rise, the study on compiler design is imperative to actually understand the tools and how the whole compilation process works. Our group decided to work on the GoLite project as the source-to-source compiler.

We chose OCaml [1] as our implementation language for compiler construction because the recursive nature of the language allows for easy manipulation of abstract syntax tree (AST). In addition, the pattern matching feature that OCaml provides is particularly helpful in constructing the compiler and has been applied to most parts of the compiler. The tools that we used for building the scanner and parser are `ocamllex` and `Menhir` [2,3,4]. The maturity of the parsing and scanning tools were another reason for the choice of OCaml. What's more, the lead TA had pointed out that OCaml is a good language for such a project.

As for the target language, we have chosen to generate WebAssembly (or `wasm`) [5], a low-level programming language that attempts to be more efficient than JavaScript for the web browser. In particular, our compiler generates WebAssembly TextFormat (`.wast`) code which uses an AST representation in S-expression syntax [6,7]. Since WebAssembly is currently in the experimental stage, only a handful of documentations about the language exist and even some of them are not complete. So far we have only encountered 2 compilers that translates a particular language to WebAssembly: emscripten [8] from LLVM to JavaScript (`asm.js`, the predecessor of `wasm`), and ilwasm [9] from C# to `wasm`. As such, our compiler that takes GoLite programs and generates WebAssembly TextFormat is a timely project.

The next section is about the design of the compiler structure and all its phases, followed by some examples comparing GoLite programs and the generated WebAssembly TextFormat code, and ended with a brief discussion and future work.

2 Compiler Structure



2.1 Scanner

2.2 Parser

2.3 Weeder

2.4 Symbol Table

2.5 Typechecker

2.6 Code Generation

2.7 Webassembly primer

2.7.1 Declaring locals

3 Examples

4 Conclusions

At the end of the project, we have come to know that building a compiler from scratch is no small feat. We have to devote our time in designing the architecture of the compiler from parsing to code generation, while maintaining the correctness of the syntax and semantics of the generated code. Even though it is a difficult process especially when dealing with a low-level programming language that has certain limitations over a high-level programming language, we have learned much from this project on what defines a computer program. We assert that the study of compiler design is crucial for programmers to understand the tools that they are using to build a computer program.

This project serves as an excellent example for the community at large to refer to a compiler that generates WebAssembly. There is still much work to be done if we were to extend GoLite to Go instead, but we hope to see that more such compilers exist so as to allow support for more programming languages to be compiled to WebAssembly code. This in turn will move the development of WebAssembly forward.

5 Contributions

Scanner Alexandre laid the ground work for defining the tokens. Cheuk Chuen and Alexandre defined the regular expressions for the literals.

Parser Cheuk Chuen laid the ground work for defining the grammar and AST. Alexandre made important changes and thorough bug checks.

Pretty printer Stefan worked extensively on the pretty printer.

Weeder Alexandre wrote the weeder.

AST Alexandre modified the AST so as to add annotations.

Symbol table Cheuk Chuen wrote the symbol table. Alexandre made changes according to the modified type checker.

Type checker Stefan laid the ground work for the type checker. Alexandre made changes according to the modified AST.

Pretty printer for type Stefan modified the pretty printer to work for the new AST and to print the types of typed expressions.

Testing Alexandre wrote shell scripts to automate testing of the existing valid and invalid programs. Cheuk Chuen wrote the majority of the tests for type checking.

Code generation All three of us contribute to various parts of the code generation.

6 References

1. `https://ocaml.org/`
2. `http://caml.inria.fr/pub/docs/manual-ocaml-4.00/manual026.html`
3. `https://realworldocaml.org/v1/en/html/parsing-with-ocamllex-and-menhir.html`
4. `http://pauillac.inria.fr/~fpottier/menhir/manual.pdf`
5. `https://webassembly.github.io/`
6. `https://github.com/WebAssembly/spec/blob/master/ml-proto/README.md`
7. `https://github.com/WebAssembly/design/blob/master/AstSemantics.md`
8. `https://github.com/kripken/emscripten`
9. `https://github.com/WebAssembly/ilwasm`