

# Implementing a VSOP Compiler

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## Part II

# Syntax Analysis

## 1 Introduction

In this assignment, you will implement a parser for the VSOP language, according to the syntactic rules described in the VSOP manual. You will reuse the lexer developed for the previous assignment (you can of course improve it if needed). You can use the parser generator of your choice, or write the parser yourself.

To enable easy testing of your generated parser, your program will dump the *abstract syntax tree* (AST) corresponding to the given input VSOP source file on standard output, in the format described in section 2.

As VSOP source code files can contain syntax errors, you will need to detect those and print error messages when they occur. The way syntax errors should be handled is not precisely described in the VSOP manual. This document gives some more information about the way your compiler should handle those errors in section 3.

Some guidance regarding how you should test your parser is given in section 4.

Finally, the way you should submit your work for evaluation is described in section 5.

This assignment is due at the latest for Tuesday the **15<sup>th</sup> of March 2022** (23:59 CET).

## 2 Output Format

You are free to use the structure of your choice to represent your AST, but your parser output should be structured as follows.

### 2.1 Preliminaries

You can use spaces and line feeds for legibility in your output, if you want.

To improve output legibility, you will not print AST node positions, but it is a good idea to keep them in your AST data structure, for semantic error messages and debugging.

Lists will be enclosed in square brackets (`[]`), with items separated by commas (`,`).

The following of this section describes how the different elements of the AST should be printed, referring to them in the same way as in the grammar in the VSOP manual.

It concludes with an example output.

## 2.2 Program

```
program = class { class };
```

Print the list of classes, in the same order as in the input file.

## 2.3 Class

```
class = "class" type-identifier [ "extends" type-identifier ] class-body;  
class-body = "{" { field | method } "}";
```

Each *class* will be printed as

Class(<name>, <parent>, <fields>, <methods>)

where <name> is the class name, <parent> its parent class, or Object if none was provided<sup>1</sup>, <fields> is the list of class fields, and <methods> the list of class methods. Both fields and methods will be listed in the same order as in the input file (but separately).

## 2.4 Field

```
field = object-identifier ":" type [ "<-> expr ] ";";
```

Each *field* will be printed as one of

Field(<name>, <type>)

Field(<name>, <type>, <init-expr>)

depending on whether or not a field initializer was provided.

## 2.5 Method

```
method = object-identifier "(" formals ")" ":" type block;
```

Each *method* will be printed as

Method(<name>, <formals>, <ret-type>, <block>)

where <formals> is the list of formal parameters, <ret-type> the method's return type, and <block> the method body.

## 2.6 Types

```
type = type-identifier | "int32" | "bool" | "string" | "unit";
```

*Types* should be printed literally, as they would appear in the VSOP source code.

## 2.7 Formals

```
formals = [ formal { "," formal } ];  
formal = object-identifier ":" type;
```

Each *formal* argument will be printed as

<name> : <type>

---

<sup>1</sup>Object is the ancestor of all classes in VSOP.

## 2.8 Blocks

```
block = "{ expr { ";" expr } }";
```

A block will be printed as

```
<expr-list>
```

## 2.9 Expressions

```
expr = "if" expr "then" expr [ "else" expr ]
```

If(<cond-expr>, <then-expr>)

If(<cond-expr>, <then-expr>, <else-expr>)

```
expr = "while" expr "do" expr
```

While(<cond-expr>, <body-expr>)

```
expr = "let" object-identifier ":" type [ "<-" expr ] "in" expr
```

Let(<name>, <type>, <scope-expr>)

Let(<name>, <type>, <init-expr>, <scope-expr>)

```
expr = object-identifier "<-" expr
```

Assign(<name>, <expr>)

```
expr = "not" expr
```

```
      | "-" expr
```

```
      | "isnull" expr
```

UnOp(not, <expr>)

UnOp(-, <expr>)

UnOp(isnull, <expr>)

```
expr = expr ("=" | "<" | "<=") expr
```

```
      | expr ("+" | "-") expr
```

```
      | expr ("*" | "/" ) expr
```

```
      | expr "^" expr
```

```
      | expr "and" expr
```

BinOp(<op>, <left-expr>, <right-expr>)

where <op> is represented literally as it would appear in the VSOP source code.

```
expr = object-identifier "(" args ")"
```

```
      | expr "." object-identifier "(" args ")"
```

Call(<obj-expr>, <method-name>, <expr-list>)

A call of the form `someFunc(arg1, arg2)` is just *syntactic sugar* for `self.someFunc(arg1, arg2)`. `self` denotes the current object in VSOP. Print them using the explicit version, e.g.

```
Call(self, someFunc, [arg1, arg2])
```

```
expr = "new" type-identifier
```

New(<type-name>)

```
expr = object-identifier
```

```
expr = "self"
```

Print *variable names* literally, as they would appear in the VSOP source code.

```

expr = literal;
literal = integer-literal | string-literal | boolean-literal;
boolean-literal = "true" | "false";

```

String literals should be escaped as in your lexer output, i.e. enclosed in double quotes ("), escaping non-printable characters, " and \ as \xhh where hh is the numerical value of the byte in hexadecimal.

Integer literals should be represented in decimal, and Booleans will be denoted by `true` and `false` as in the VSOP source code.

```
expr = "(" ")"
```

"()" is a value of type `unit`, that is itself called *unit*. We will further discuss unit in the future. For now, all you have to know is that it should appear as () in the parser output.

```
expr = "(" expr ")"
```

Simply print the expression, as described above. There is no need for the parentheses, which are now implicitly conveyed by the structure of the tree, e.g.

```
(a + b) * c
```

will give

```
BinOp(*, BinOp(+, a, b), c)
```

correctly conveying the fact that a and b should be added first, and then only multiplied with c.

## 2.10 Example

Figure 1 is an example of VSOP source file (taken from the manual) that implements a linked list. For this source code your parser should output (except for whitespace differences):

```

[Class(List, Object, [],
  [Method(isNil, [], bool, [true]), Method(length, [], int32, [0])]),
 Class(Nil, List, [], []),
 Class(Cons, List, [Field(head, int32), Field(tail, List)],
  [Method(init, [hd : int32, tl : List], Cons,
    [Assign(head, hd), Assign(tail, tl), self]),
   Method(head, [], int32, [head]), Method(isNil, [], bool, [false]),
   Method(length, [], int32, [BinOp(+, 1, Call(tail, length, [])])])]),
 Class(Main, Object, [],
  [Method(main, [], int32,
    [Let(xs, List,
      Call(New(Cons), init,
        [0,
         Call(New(Cons), init,
           [1, Call(New(Cons), init, [2, New(Nil)])])]),
      Call(self, print, ["List has length "]),
      Call(self, printInt32, [Call(xs, length, [])]),
      Call(self, print, ["\x0a"]), 0])])])])

```

## 3 Error Handling

Your parser should detect and report syntax errors in the input VSOP source file. Error reporting is part science, and part *black magic*. You are free to implement it as you see fit (or as you can). The only constraint is that error messages should begin with

```

class List {
  isNil() : bool { true }
  length() : int32 { 0 }
}

(* Nil is nothing more than a glorified alias to List *)
class Nil extends List { }

class Cons extends List {
  head : int32;
  tail : List;

  init(hd : int32, tl : List) : Cons {
    head <- hd;
    tail <- tl;
    self
  }

  head() : int32 { head }
  isNil() : bool { false }
  length() : int32 { 1 + tail.length() }
}

class Main {
  main() : int32 {
    let xs : List <- (new Cons).init(0, (new Cons).init(
      1, (new Cons).init(
        2, new Nil))) in {
      print("List has length ");
      printInt32(xs.length());
      print("\n");
    }
  }
}

```

Figure 1: VSOP source code of a linked list

<filename>:<line>:<col>: syntax error

Generally the reported position should be the one of the first token that cannot be part of a valid grammar production, but this may be hard to do depending on which parser generator you use. In some cases, it might also be more interesting to report the error elsewhere, if it is more likely to be the error position. *E.g.* in code

```
{ if cond then e1; else e2 } // Parsed as { (if cond then e1); else e2 }
```

the first token in error is the `else` (which cannot be part of previous *if-then* which is ended by the semicolon), but reporting the error at the semicolon could arguably be more likely to help the developer.

It is generally nice when a compiler can report several errors in the same execution. However, this generally requires to discard some tokens after a syntax error, in order to resynchronize in some sensible place. If not done smartly, it results in a great number of spurious error messages after an error, greatly diminishing the advantage of reporting several errors at once. Finally, this may be more or less difficult to do depending on your parser generator and/or AST structure.

Don't forget that lexical errors can still happen. When a lexical error occurs, you can either stop processing, or try to recover in one way or another to try detect some more potential lexical and/or syntax errors.

Finally, you can do what you want with the standard output in case of errors. You can print a partial AST up to the error, print a full AST with some dummy values in the areas of errors, or print nothing at all (which has the merit of making clear that an error occurred).

Due to the great freedom left in error reporting, the testing script will be quite lax, and only check that your parser exits with non-zero status and prints some error message in case of error. However, we will check your parser manually to see how good your error messages are.

## 4 Testing Your Parser

You are expected to test your parser by writing some VSOP input files, and calling your parser on them. Use both *valid* input files, which are syntactically correct, and *invalid* ones, that should trigger errors. Try to test all language features, and all specific errors you should detect. Don't forget to try a few nested constructs, like a while loop inside an if-then-else branch, or *vice versa*. Also mix and match some operations to ensure that precedence and associativity rules are respected.

When building your parser, you might have to face grammar ambiguities, as you have seen during the theory courses. For instance, the *bison* parser generator creates bottom-up parsers. Therefore, there may be shift/reduce or reduce/reduce conflicts. When it is the case, bison will tell you so. It is better to fix all conflicts, but sometimes they can be difficult to fix, while not being dangerous. We simply ask you to analyze the conflicts if you have any, to determine why they could cause problems or why not. For instance, when a shift/reduce conflict occurs, bison chooses by default the shift operation. If this is the correct operation, then this conflict is not dangerous. We will ask you to write a short section in your final report about the possible conflicts that your parser may encounter.

Don't assume your lexer is bug-free. If you encounter some strange parsing errors, or if the output is different from what you expect, it may be worth calling `vsopc` again with the `-l` argument to check if generated tokens are correct.

Finally, check your parser generator documentation to see if it comes with built-in support for debugging. With most parser generators, the parser can report a lot of information such as read tokens, content of the parsing stack, transitions between states, *etc.*

## 5 How to Submit your Work?

To submit your work for evaluation, use the [submission platform](#).

You can provide your test VSOP input files in a `vsopcompiler/tests` sub-folder. Any file with `.vsop` extension in that folder will be tested against the reference parser by the testing script.

Your code will be executed as follows. Your built `vsopc` executable will be called with the arguments `-p <SOURCE-FILE>` where `<SOURCE-FILE>` is the path to the input VSOP source code.

Your program should then output the parsed AST on standard output, and error messages (if any) on standard error, as described above. Your program should still handle argument `-l <SOURCE-FILE>` as in the previous assignment.

The submission platform will check that your submission is in the right format, and test your parser. If you want to be able to use that feedback, don't wait until the last minute to submit your parser (you can submit up to 40 times, only the last submission will be taken into account).

Also note that **5% of your final grade** will be determined directly by the automated tests for this assignment. It is thus doubly in your interest to ensure that your code passes all the tests (and early enough).

**Plagiarism.** Cooperation (even between groups) is allowed, but all cooperation must be clearly referred to in the final report, and we will have **no tolerance at all for plagiarism** (writing together, reusing/sharing code or text). Code available on the web that serves as a source of inspiration must also be properly referred in the report.

**Participation.** **Each student has to participate** in the project, and do her/his fair share of work. Letting others in the group do all work will be considered as plagiarism.