Section

Intro

Chapter 0 “”
Course “Compiler Construction”
Martin Steffen
Spring 2023

Goal

1. semantic analysis, as far as
   - typing is concerned ("static semantics")
   - other coditions (no duplicate declaration etc)
2. code generation for `compila23` (ish) programs

Last time (O1)

Syntactic analysis

- lexer (scanner)
- parser
- abstract syntax tree

this time: continue with your previous deliv. (and repos)

Learning outcome

- understand type checking, implementing a simple variant
- understand (simple form of) bytecode and how to generate it from “source code” (as AST)
- extend an existing compiler code base with new functionality

Section

Semantic analysis

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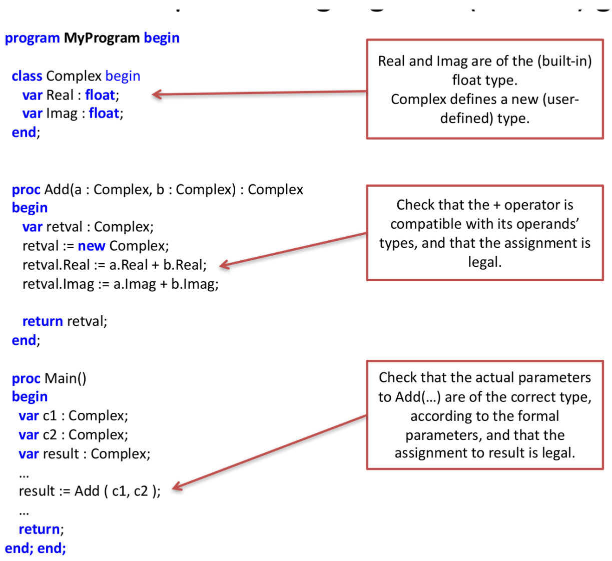
Semantic analysis & type checking

- parser / context-free grammars
  - not powerful enough
  - cannot check all (static) properties of a language spec
- => extend the front-end by a type checker
  - use the AST classes of last time
  - add type checking code
  - allowed to make changes or adaptations if advantagous.

Another glance at compila23



```
program MyProgram begin

 class Complex begin
   var Real : float;
   var Imag : float;
 end;


 proc Add(a : Complex, b : Complex) : Complex
 begin
   var retval : Complex;
   retval := new Complex;
   retval.Real := a.Real + b.Real;
   retval.Imag := a.Imag + b.Imag;

   return retval;
 end;

 proc Main()
 begin
  var c1 : Complex;
  var c2 : Complex;
  var result : Complex;
  …
  result := Add ( c1, c2 );
  …
  return;
end; end;
```

Real and Imag are of the (built-in) float type. Complex defines a new (user-defined) type.

Check that the + operator is compatible with its operands' types, and that the assignment is legal.

Check that the actual parameters to Add(…) are of the correct type, according to the formal parameters, and that the assignment to result is legal.

NB: 2023: structs, not classes

Type checking for conditionals

- as “inspiration”, details may vary

```
  class IfStatement extends Statement {
  ...
    public void typeCheck(){
      String condType = condition.get.Type ();
      if (condType != "bool") {
         throw new TypeException("condition in an if
           statement must be of type bool")
      }
}
```

Type checking: assignments

```
class Assignment extends Statement {
...
  public void typeCheck() {
    String varType = var.getType();
    String expType = exp.getType();
    if (varType != expType &&
       !isAssigmentCompatible(varType,expType){
                 throw new TypeException("Cannot assig
                 " from " + expType);
  }
}
```

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Code generation

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Code generation

- byte code API and operations are described in the document “Interpreter and bytecode for INF5110”
- Task: add bytecode generation methods to your AST classes for instance

```
Ast.Node.GenerateCode(...)
```

- again: if adaptations of the AST are called for or useful, go for it...
- some people did visitors for ast-printing, one can also (re-)use the visitor pattern

Code generation: limitations

- interpreter and byte code library somewhat limited
    - cannot express full compila 23
    - no block structure
    - no reference types
- your delivery should support generating correct bytecode for the `compila` 23 source code file `runme.cmp`

Code generation: creating a procedure

```
CodeFile codeFile = new CodeFile();
// add the procedure by name first
codeFile.addProcedure("Main")
// then define it
CodeProcedure main = new
   CodeProcedure("Main", VoidType,TYPE, codeFile);
main.addInstruction( new RETURN());
//then update it in the code file
codeFile.updateProcedure(main);
```

Code generation: assignment

```
//1: proc add(a: int, b : int ) : int {
//2: var res : int;
//3: res := a + b; // only bytecode for this line
//4: return res;
//5: }

// push a onto the stack
proc.addInstruction(new LOADLOCAL(proc.variableNumber("a")));
// push b onto the stack
proc.addInstruction(new LOADLOCAL(proc.variableNumber("b")));
// perform addition with arguments on the stack
proc.addInstruction(new ADD());
// pop result from stack, and store it in variable res
proc.addInstruction(new
        STORELOCAL(proc.variableNumber("res")));
```

Section

Testing

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Testing

- bunch of test files, for testing the *type checker*
- preferable: make `ant test` workable
- test files inside `./tests/semanticanalysis/errors/` (and with `fail` in the filename) contain a syntactically correct but erronous program (erroneous as the type system or generally the semantic phase is concerned)
- => compiler returns error code 2 for semantic failure

Section

Starting point and hand in

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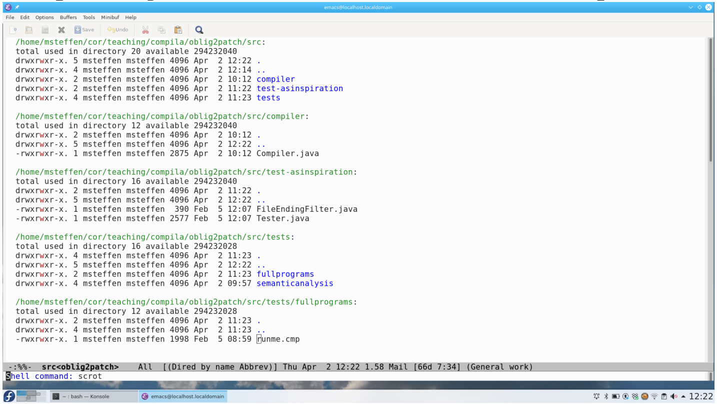
Provided source code (patch)

https://github.uio.no/msteffen/compila

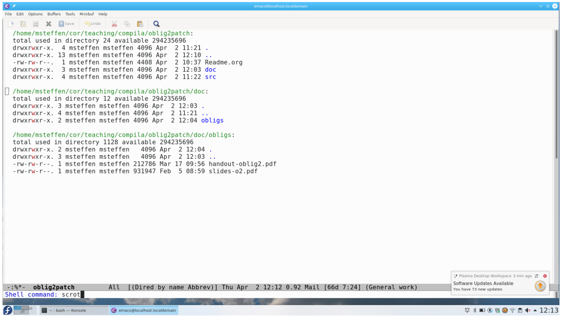


File Edit Options Buffers Tools Minibuf Help

```
/home/msteffen/cor/teaching/compila/oblig2patch/src:
total used in directory 20 available 294232040
drwxrwxr-x. 5 msteffen msteffen 4096 Apr  2 12:22 .
drwxrwxr-x. 4 msteffen msteffen 4096 Apr  2 12:14 ..
drwxrwxr-x. 2 msteffen msteffen 4096 Apr  2 10:12 compiler
drwxrwxr-x. 2 msteffen msteffen 4096 Apr  2 11:22 test-asinspiration
drwxrwxr-x. 4 msteffen msteffen 4096 Apr  2 11:23 tests

/home/msteffen/cor/teaching/compila/oblig2patch/src/compiler:
total used in directory 12 available 294232040
drwxrwxr-x. 2 msteffen msteffen 4096 Apr  2 10:12 .
drwxrwxr-x. 5 msteffen msteffen 4096 Apr  2 12:22 ..
-rwxrwxr-x. 1 msteffen msteffen 2875 Apr  2 10:12 Compiler.java

/home/msteffen/cor/teaching/compila/oblig2patch/src/test-asinspiration:
total used in directory 16 available 294232040
drwxrwxr-x. 2 msteffen msteffen 4096 Apr  2 11:22 .
drwxrwxr-x. 5 msteffen msteffen 4096 Apr  2 12:22 ..
-rwxrwxr-x. 1 msteffen msteffen  390 Feb  5 12:07 FileEndingFilter.java
-rwxrwxr-x. 1 msteffen msteffen 2577 Feb  5 12:07 Tester.java

/home/msteffen/cor/teaching/compila/oblig2patch/src/tests:
total used in directory 16 available 294232028
drwxrwxr-x. 4 msteffen msteffen 4096 Apr  2 11:23 .
drwxrwxr-x. 5 msteffen msteffen 4096 Apr  2 12:22 ..
drwxrwxr-x. 2 msteffen msteffen 4096 Apr  2 11:23 fullprograms
drwxrwxr-x. 4 msteffen msteffen 4096 Apr  2 09:57 semanticanalysis

/home/msteffen/cor/teaching/compila/oblig2patch/src/tests/fullprograms:
total used in directory 12 available 294232028
drwxrwxr-x. 2 msteffen msteffen 4096 Apr  2 11:23 .
drwxrwxr-x. 4 msteffen msteffen 4096 Apr  2 11:23 ..
-rwxrwxr-x. 1 msteffen msteffen 1998 Feb  5 08:59 runme.cmp

-:%%-  src<oblig2patch>    All  [(Dired by name Abbrev)] Thu Apr  2 12:22 1.58 Mail [66d 7:34] (General work)
Shell command: scrot
```

Tests: already included in the oblig1 checkout, so left out in the zip-patch this year.

Provided documentation (patch)


emacs@localhost.localdomain
File Edit Options Buffers Tools Minibuf Help
Save
Undo

```
/home/msteffen/cor/teaching/compila/oblig2patch:
total used in directory 24 available 294235696
drwxrwxr-x.  4 msteffen msteffen 4096 Apr  2 11:21 .
drwxrwxr-x. 13 msteffen msteffen 4096 Apr  2 12:10 ..
-rw-rw-r--.  1 msteffen msteffen 4408 Apr  2 10:37 Readme.org
drwxrwxr-x.  3 msteffen msteffen 4096 Apr  2 12:03 doc
drwxrwxr-x.  4 msteffen msteffen 4096 Apr  2 11:22 src

/home/msteffen/cor/teaching/compila/oblig2patch/doc:
total used in directory 12 available 294235696
drwxrwxr-x. 3 msteffen msteffen 4096 Apr  2 12:03 .
drwxrwxr-x. 4 msteffen msteffen 4096 Apr  2 11:21 ..
drwxrwxr-x. 2 msteffen msteffen 4096 Apr  2 12:04 obligs

/home/msteffen/cor/teaching/compila/oblig2patch/doc/obligs:
total used in directory 1128 available 294235696
drwxrwxr-x. 2 msteffen msteffen   4096 Apr  2 12:04 .
drwxrwxr-x. 3 msteffen msteffen   4096 Apr  2 12:03 ..
-rw-rw-r--. 1 msteffen msteffen 212786 Mar 17 09:56 handout-oblig2.pdf
-rw-rw-r--. 1 msteffen msteffen 931947 Feb  5 08:59 slides-o2.pdf

-:%*-  oblig2patch        All  [(Dired by name Abbrev)] Thu Apr  2 12:12 0.92 Mail [66d 7:24] (General work)
Shell command: scrot
```

Plasma Desktop Workspace 3 min ago
Software Updates Available
You have 73 new updates
~ : bash — Konsole
emacs@localhost.localdomain
12:13

Relevant directories

- Java
  - `compiler`: updated compiler class (patch)
  - `test`: some code for performing tests (patch)
  - `bytecode`: classes for constructing bytecode (already there)
  - `runtime`: rte for executing the byte code (already there)
- Compila
  - `tests`: some test files (including `runme.cmp`)

Deadline

Deadline

(Friday, 12.05.2023)

Note: end of semester, and I need to report the ones passing the oblig some time before the exam.

delivs

- working type checker
- code generator (test with `runme.cmp`)
- report (including your name(s) etc.
  - discussion of your solution, choices you made, assumptions you rely on
  - printout of a test run (can be also checked in into the repos, but it needs to be mentioned where it is)
  - printout of the bytecode from `runme.cmp` (with a target like `ant list-runme`)
  - solution must "build" and be "testable" (typically via `ant`)