



Chapter 1

Oblig 1

Course “Compiler Construction”

Martin Steffen

Spring 2021



Section

Compila 20

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Tools

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- material (also for oblig 2) based on previous years, including contributions from Eyvind W. Axelsen, Henning Berg, Fredrik Sørensen, and others
- see also the course web-page, containing links to “resources”

Goal (of oblig 1)



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Parsing

Determine if programs written in *Compila 20* are syntactically correct:

- scanner
 - parser
-
- first part of a compiler, oblig 2 will add to it
 - language spec provided separately

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Learning outcomes



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- using **tools** for parser/scanner generation
 - JFlex
 - CUP
- variants of a grammar for the same languages
 - **transforming** one form (EBNF) to another (compatible with the used tools)
 - controlling **precedence** and **associativity**
- designing and implementing an **AST** data structure
 - using the parsing tools to build such trees
 - pretty-printing such trees

Compila language at a glance



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```
program MyProgram  //
begin
    struct complex {    // record data type, but
        re: float;      // no subtyping, polymorphism ...
        im: float
    }
end;

procedure add (a: complex, b: complex) : complex
begin
    var retval : complex;
in
    retval := new complex;
    retval.re := a.re + b.re;
    retval.im := a.im + b.im;
    return retval
end;

procedure main()      // execution start here
begin
    var c1: complex;
    var c2: complex;
    result := add (c1, c2);
    ...
    return
end
end
```

Another glance

```
proc swap (a: ref(int), b: ref(int)) // passed as reference
begin
  var tmp: int;
  tmp := deref(a); // dereferencing
  deref(a) := deref(b); // deref can be used both
  deref(b) := tmp // left and right of
                  // an assignment.
end;
```

Grammar (1): declarations

PROGRAM "end"	→ "program" NAME "begin" [DECL { ";" DECL }]
DECL	→ VAR_DECL PROC_DECL REC_DECL
VAR_DECL "var" NAME "!=" EXP	→ "var" NAME ":" TYPE ["!=" EXP]
PROC_DECL	→ "procedure" NAME "(" [PARAMFIELD_DECL { ", " PARAMFIELD_DECL }] [":" TYPE] "begin" [[DECL { ";" DECL }] "in"] STMT_LIST "end"
REC_DECL	→ "struct" NAME "{ " [PARAMFIELD_DECL { ";" PARAMFIELD_DECL }] "} "
PARAMFIELD_DECL	→ NAME ":" TYPE

Grammar (2): expressions, statements, etc.

STMT_LIST → [STMT {";" STMT}]

EXP → EXP LOG_OP EXP
| "not" EXP
| EXP REL_OP EXP
| EXP ARITH_OP EXP
| LITERAL
| CALL_STMT
| "new" NAME
| VAR
| REF_VAR
| Deref_VAR
| "(" EXP ")"

REF_VAR → "ref" "(" VAR ")"

Deref_VAR → "deref" "(" VAR ")" | "deref" "(" Deref_VAR ")"

VAR → NAME | EXP "." NAME

LOG_OP → "&&" | "||"

REL_OP → "<" | "<=" | ">" | ">=" | "=" | "<>"

ARITH_OP → "+" | "-" | "*" | "/" | "^"

Grammar (3): statements and types

LITERAL	→ FLOAT_LITERAL INT_LITERAL STRING_LITERAL BOOL_LITERAL "null"
BOOL_LITERAL	→ "true" "false"
STMT	→ ASSIGN_STMT IF_STMT WHILE_STMT RETURN_STMT CALL_STMT
ASSIGN_STMT	→ VAR ":"=" EXP Deref_VAR ":"=" EXP
IF_STMT	→ "if" EXP "then" { STMT_LIST } ["else" { STMT_LIST }] "fi"
WHILE_STMT	→ "while" EXP "do" { STMT_LIST } "od"
RETURN_STMT	→ "return" [EXP]
CALL_STMT	→ NAME "(" [EXP { "," EXP }] ")"
TYPE	→ "float" "int" "string" "bool" NAME "ref" "(" TYPE ")"



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- scanner generator (or lexer generator) tool
 - **input**: lexical specification
 - **output**: scanner program in Java
- lexical spec written as `.lex` file
- consists of **3 parts**
 - user code
 - options and macros
 - lexical rules

Sample lex code



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User code

```
package oblig1parser;  
import java_cup.runtime.*;
```

Copied to the generated class, before
the class definition

```
%%
```

Options/
macros

```
%class Lexer Options (class name, unicode support,  
%unicode CUP integration)  
%cup
```

```
%{  
    private Symbol symbol(int type) {  
        return new Symbol(type, yyline, yycolumn);  
    }  
%}  
LineTerminator = \r|\n|\r\n
```

Defined in package
java_cup.runtime.

Inserted into
generated class

Variables holding
current line/column

Macros, defined as
regular expressions

```
%%
```

Lexical
rules

```
<YYINITIAL> The following rules are applicable from the initial state  
{  
    "program" { return symbol(sym.PROGRAM); }  
    "class" { return symbol(sym.CLASS); }  
    "begin" { return symbol(sym.BEGIN); }  
    "end" { return symbol(sym.END); }  
    "var" { return symbol(sym.VAR); }  
    ""  
}
```

Refers to names in
the .cup file (next
slides)

Lexical rules

CUP: Construction of useful parsers (for Java)



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- a tool to easily (yymm) generate *parsers*
- reads tokens from the scanner using `next_token()`
- the `%cup` option (previous slide) makes that work

Input

grammar in BNF with **action** code

```
var_decl ::= VAR ID:name COLON type:vtype  
        { : RESULT = new VarDecl(name, vtype); : };
```

- **output:** parser program (in Java)

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Sample CUP code



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Package/ imports	package oblig1parser; import java_cup.runtime.*; import syntaxtree .*;	Package name for generated code and imports of packages we need The syntaxtree package contains our own AST classes
User code	parser code { : ; };	Code between { : and : } is inserted directly into the generated class (parser.java)
Symbol list	<pre> terminal PROGRAM, CLASS; terminal BEGIN, END; ... terminal String ID; terminal String STRING_LITERAL; non terminal Program program; non terminal List<ClassDecl> decl_list; non terminal ClassDecl class_decl, decl;</pre>	Terminals and non-terminals are defined here. They can also be given a Java type for the "value" that they carry, e.g. a node in the AST
Precedence	precedence left AND;	Precedence declarations are listed in ascending order, last = highest
Grammar	<pre> program := PROGRAM BEGIN decl_list:dl END SEMI { : RESULT = new Program(dl); : } ; decl_list := decl:d { : List<ClassDecl> l = new LinkedList<ClassDecl>(); l.add(d); RESULT = l; : } ; decl := class_decl:sd { : RESULT = sd; : } ; class_decl := CLASS ID:name BEGIN END { : RESULT = new ClassDecl(name); : } ;</pre>	<p>AST is built during parsing. The left hand side of each production is implicitly labeled RESULT.</p>

Build tool: ant



- Java-based build tool (think “make”)
- config in `build.xml`
- can contain different **targets**

typical general targets

- test
 - clean
 - build
 - run
-
- supplied configuration should take care of calling `jflex`, `cup`, and `javadoc` for you



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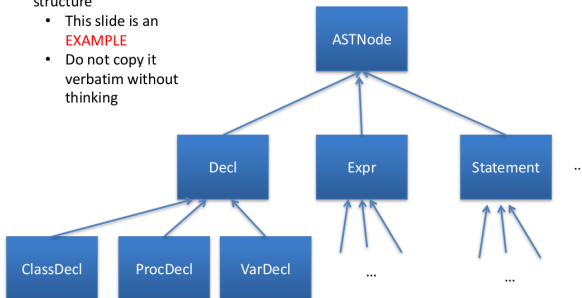
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AST data structure



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- Make a reasonable structure
 - This slide is an **EXAMPLE**
 - Do not copy it verbatim without thinking



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Overview over the directory + first steps

- see the Readme at/from the `github.uio.no`

```
/uio/kant/ifi-ansatt-u00/msteffen/cor/teaching/compila:
total used in directory 64 available 49217216
drwxrwxr-x. 12 msteffen ifi 2048 Feb 3 11:31 .
drwxrwxr-x. 11 msteffen ifi 2048 Jan 24 14:18 ..
drwxrwxr-x. 8 msteffen ifi 2048 Feb 3 11:31 .git
-rw-rw-r--. 1 msteffen ifi 77 Mar 23 2019 .gitignore
-rw-rw-r--. 1 msteffen ifi 5506 Jan 17 07:03 Readme.org
drwxrwxr-x. 3 msteffen ifi 2048 Feb 12 2019 build
-rwxrwxr-x. 1 msteffen ifi 3231 Feb 12 2019 build.xml
drwxrwxr-x. 5 msteffen ifi 2048 Feb 18 2019 doc
drwxrwxr-x. 2 msteffen ifi 2048 Jan 9 2017 lib
drwxrwxr-x. 4 msteffen ifi 2048 Feb 3 11:29 material
drwxrwxr-x. 5 msteffen ifi 2048 Feb 3 11:15 oblig2patch
drwxrwxr-x. 5 msteffen ifi 2048 Feb 3 11:28 previoussemesters
drwxrwxr-x. 12 msteffen ifi 2048 Feb 3 11:31 src
drwxrwxr-x. 3 msteffen ifi 2048 Feb 12 2019 src-gen
drwxrwxr-x. 3 msteffen ifi 2048 Feb 12 2019 tmp
```

```
/uio/kant/ifi-ansatt-u00/msteffen/cor/teaching/compila/lib:
total used in directory 280 available 49217216
drwxrwxr-x. 2 msteffen ifi 2048 Jan 9 2017 .
drwxrwxr-x. 12 msteffen ifi 2048 Feb 3 11:31 ..
-rwxrwxr-x. 1 msteffen ifi 179102 Jan 9 2017 JFlex.jar
-rwxrwxr-x. 1 msteffen ifi 96121 Jan 9 2017 java-cup-11a.jar
```

```
/uio/kant/ifi-ansatt-u00/msteffen/cor/teaching/compila/src:
total used in directory 48 available 49217216
drwxrwxr-x. 12 msteffen ifi 2048 Feb 3 11:31 .
drwxrwxr-x. 12 msteffen ifi 2048 Feb 3 11:31 ..
drwxr-xr-x. 4 msteffen ifi 2048 Mar 15 2017 bytecode
drwxrwxr-x. 2 msteffen ifi 2048 Feb 3 11:26 compiler
drwxrwxr-x. 6 msteffen ifi 2048 Feb 13 2019 doc
drwxrwxr-x. 2 msteffen ifi 2048 Feb 12 2019 grammars
drwxrwxr-x. 2 msteffen ifi 2048 Jan 16 09:13 org
drwxr-xr-x. 2 msteffen ifi 2048 Mar 16 2017 runtime
drwxrwxr-x. 2 msteffen ifi 2048 Feb 18 2019 src-gen
drwxrwxr-x. 2 msteffen ifi 2048 Feb 12 2019 syntaxtree
drwxr-xr-x. 2 msteffen ifi 2048 Feb 3 11:22 test
drwxrwxr-x. 8 msteffen ifi 2048 Feb 3 10:48 tests
```

```
/uio/kant/ifi-ansatt-u00/msteffen/cor/teaching/compila/src/compiler:
total used in directory 12 available 49217216
drwxrwxr-x. 2 msteffen ifi 2048 Feb 3 11:26 .
drwxrwxr-x. 12 msteffen ifi 2048 Feb 3 11:31 ..
-rwxrwxr-x. 1 msteffen ifi 981 Feb 3 11:26 Compiler.java
```

```
/uio/kant/ifi-ansatt-u00/msteffen/cor/teaching/compila/src/grammars:
total used in directory 16 available 49217216
drwxrwxr-x. 2 msteffen ifi 2048 Feb 12 2019 .
drwxrwxr-x. 12 msteffen ifi 2048 Feb 3 11:31 ..
-rwxrwxr-x. 1 msteffen ifi 1305 Feb 12 2019 Compila.cup
```



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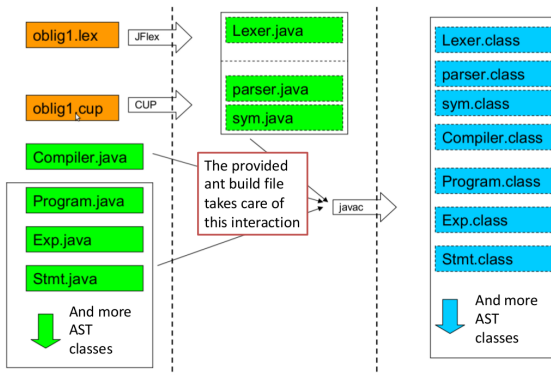
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Building: putting it together



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Deadline

Friday 06. 03. 2020, 23:59

- don't miss the deadline
- for extensions, administration needs to agree (studadm), contact them if sick etc
- even if not 100% finished
 - deliver what you have
 - contact early when problems arise

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- see also the “handout”

Deliverables (1)

- working **parser**
 - parse the supplied sample programs
 - printout the resulting AST
- **two** grammars (two `.cup`-files)
 - one unambiguous
 - one ambiguous, where ambiguities resolved through precedence declarations in *CUP*, e.g.

`precedence left AND;`

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Deliverables (2)

- report (with name(s) and UiO user name(s))
 - discussion of the solution (see handout for questions)
 - in particular: comparison of the two grammars
 - “Readme”
-
- the code must *build* (with ant) and run
 - test it on the UiO RHEL (linux) platform

Ask

If problems, **ask in time** (**NOT** Friday at the deadline)

Hand-in procedure



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- this year we try *git*
- `https://github.uio.no` resp.
`https://github.uio.no/msteffen/compila`
- you need
 - a login
 - send me emails that you want to do oblig (+ potential partner) \Rightarrow I tell you group number
 - create a project `compila<n>` (n = group number)
 - add collaborator + (at some point me)
- see also the handout

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