Section

Compila 19

Chapter 0 “”
Course “Compiler Construction”
Martin Steffen
Spring 2019

Oblig 1

- 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)

Parsing

Determine if programs written in *Compila 19* are syntactically correct:

- scanner
- parser

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

Learning outcomes

- 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

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

proc 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;
proc 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          -> "program" NAME "begin" [ DECL {";" DECL}]
"end"

DECL             -> VAR_DECL | PROC_DECL | REC_DECL

VAR_DECL         -> "var" NAME ":" TYPE

PROC_DECL        -> "proc" NAME
                    "(" [ PARAMFIELD_DECL { "," PARAMFIELD_DECL } ]
                    [ ":" TYPE ]
                    "begin" [DECL{";" DECL}] "in" [STMT {";" STMT}]

REC_DECL         -> "struct" NAME "{" [ PARAMFIELD_DECL {";" PARAM
"}"

PARAMFIELD_DECL   -> NAME ":" TYPE
```

Grammar (2): declarations

```
EXP             -> EXP LOG_OP EXP
                 | "not" EXP
                 | EXP REL_OP EXP
                 | EXP ARIT_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          -> "<" | "<=" | ">" | ">=" | "=" | "<>"

ARIT_OP         -> "+" | "-" | "*" | "/" | "^"

LITERAL         -> FLOAT_LITERAL | INT_LITERAL | STRING_LITERAL
```

Grammar (3): statements and types

```
                    | "true" | "false" | "null"

STMT                -> ASSIGN_STMT
                     | IF_STMT
                     | WHILE_STMT
                     | RETURN_STMT
                     | CALL_STMT

ASSIGN_STMT         -> VAR ":=" EXP | DEREF_VAR ":=" EXP

IF_STMT             -> "if" EXP "then" { STMT ";" } "fi"
                       [ "else" { STMT ";" } "fi" ]
WHILE_STMT          -> "while" EXP "do" { STMT ";" } "od"

RETURN_STMT         -> "return" [ EXP ]

CALL_STMT           -> NAME "(" [ EXP { "," EXP } ] ")"

TYPE                -> "float" | "int" | "string" | "bool" | NAME
                     | "ref" "(" TYPE ")"
```

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Tools

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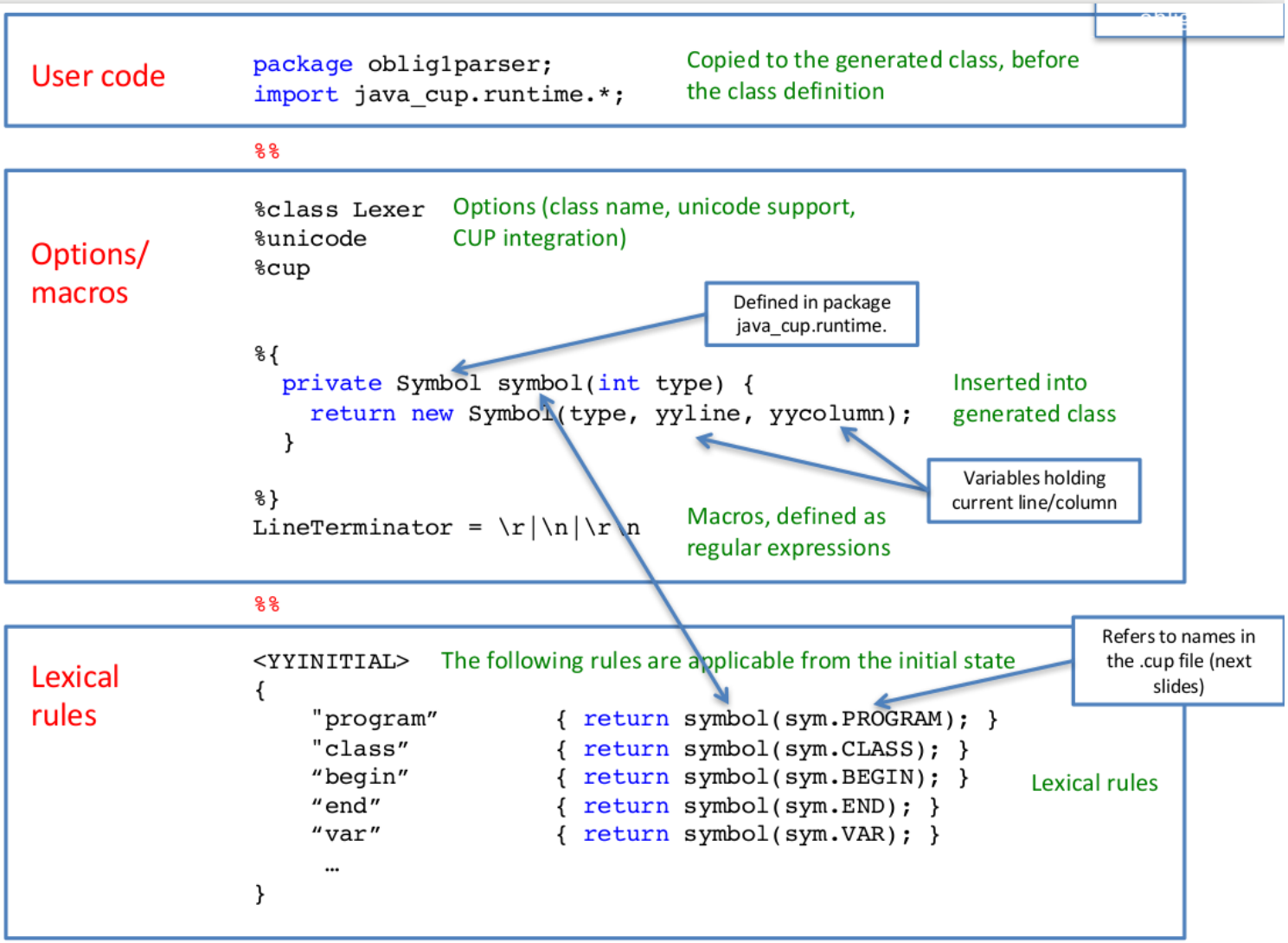
Tools: JFlex

- 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



CUP: Construction of useful parsers (for Java)

- a tool to easily (ymmv) generate *parsers*
- reads tokes 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)

Sample CUP code

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

```
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;
```

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;
```

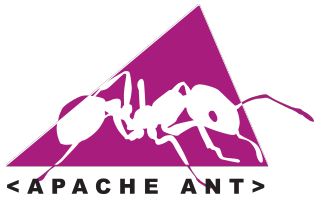
Precedence declarations are listed in ascending order, last = highest

Grammar

```
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); :}   ;
```

AST is built during parsing. The left hand side of each production is implicitly labeled RESULT.

Build tool: ant



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

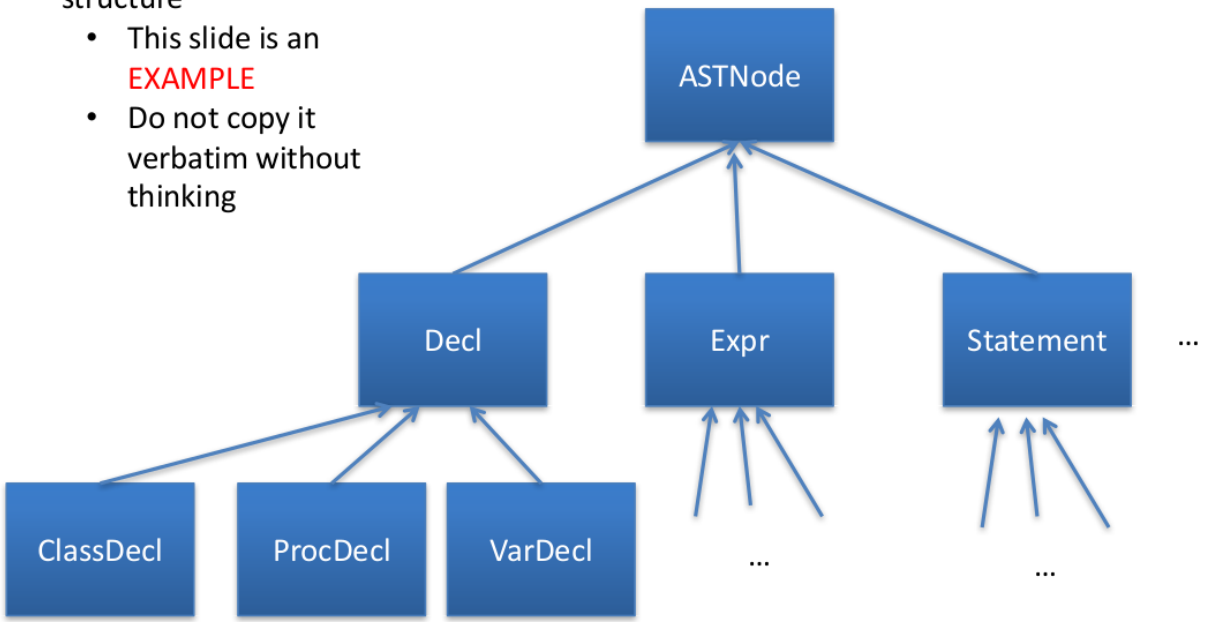
typical general targets

- test
- clean
- build
- run

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

AST data structure

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

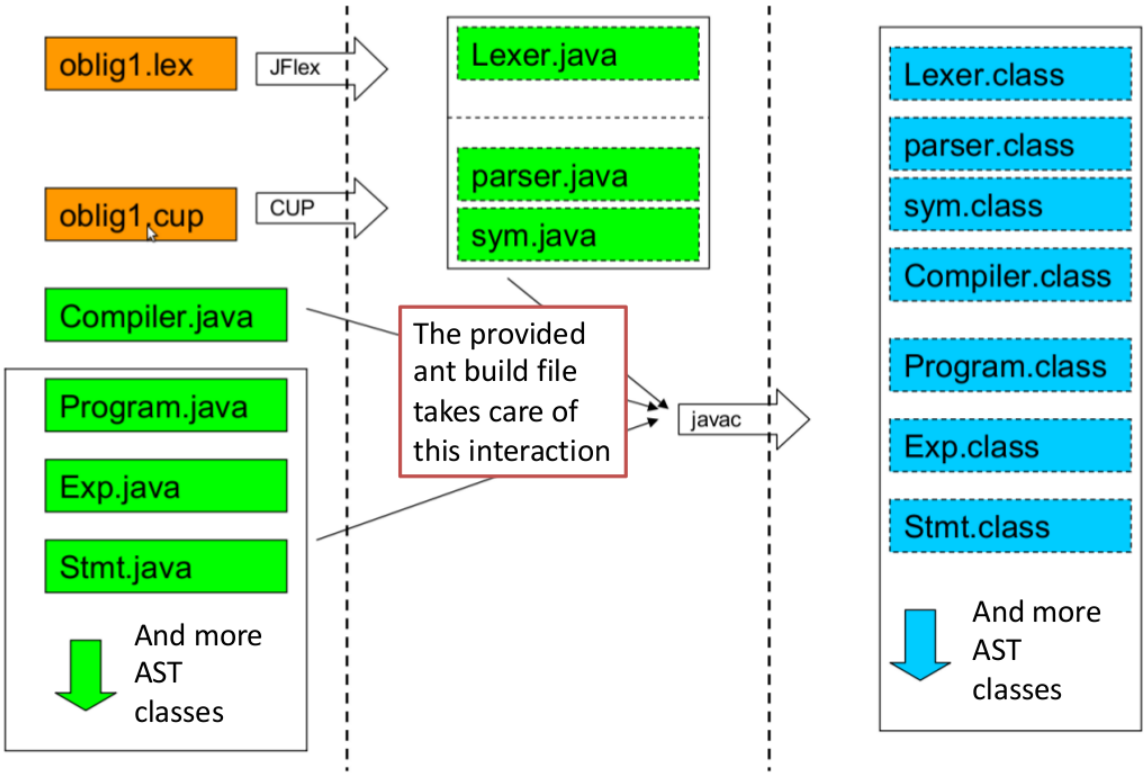


Overview over the directory + first steps

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

```
/uio/kant/ifi-ansatt-u00/msteffen/TMP/compila:
total used in directory 60 available 52814464
drwxrwxr-x. 11 msteffen ifi 2048 Feb 18 08:04 .
drwxrwxr-x.  3 msteffen ifi 2048 Feb 18 08:04 ..
drwxrwxr-x.  8 msteffen ifi 2048 Feb 18 08:04 .git
-rw-rw-r--.  1 msteffen ifi   66 Feb 18 08:04 .gitignore
-rw-rw-r--.  1 msteffen ifi 5267 Feb 18 08:04 Readme.org
drwxrwxr-x.  3 msteffen ifi 2048 Feb 18 08:05 build
-rwxrwxr-x.  1 msteffen ifi 3231 Feb 18 08:04 build.xml
drwxrwxr-x.  5 msteffen ifi 2048 Feb 18 08:04 doc
drwxrwxr-x.  2 msteffen ifi 2048 Feb 18 08:04 lib
drwxrwxr-x.  5 msteffen ifi 2048 Feb 18 08:04 material
drwxrwxr-x.  4 msteffen ifi 2048 Feb 18 08:04 previoussemesters
drwxrwxr-x.  8 msteffen ifi 2048 Feb 18 08:04 src
drwxrwxr-x.  3 msteffen ifi 2048 Feb 18 08:05 src-gen
drwxrwxr-x.  3 msteffen ifi 2048 Feb 18 08:04 tmp

/uio/kant/ifi-ansatt-u00/msteffen/TMP/compila/lib:
total used in directory 280 available 52814464
drwxrwxr-x.  2 msteffen ifi   2048 Feb 18 08:04 .
drwxrwxr-x. 11 msteffen ifi   2048 Feb 18 08:04 ..
-rwxrwxr-x.  1 msteffen ifi 179102 Feb 18 08:04 JFlex.jar
-rwxrwxr-x.  1 msteffen ifi  96121 Feb 18 08:04 java-cup-11a.jar

/uio/kant/ifi-ansatt-u00/msteffen/TMP/compila/src:
total used in directory 32 available 52814464
drwxrwxr-x.  8 msteffen ifi 2048 Feb 18 08:04 .
drwxrwxr-x. 11 msteffen ifi 2048 Feb 18 08:04 ..
drwxrwxr-x.  2 msteffen ifi 2048 Feb 18 08:04 compiler
drwxrwxr-x.  6 msteffen ifi 2048 Feb 18 08:04 doc
drwxrwxr-x.  2 msteffen ifi 2048 Feb 18 08:04 grammars
drwxrwxr-x.  2 msteffen ifi 2048 Feb 18 08:04 org
drwxrwxr-x.  2 msteffen ifi 2048 Feb 18 08:04 syntaxtree
drwxrwxr-x.  6 msteffen ifi 2048 Feb 18 08:04 tests

/uio/kant/ifi-ansatt-u00/msteffen/TMP/compila/src-gen:
total used in directory 16 available 52814464
drwxrwxr-x.  3 msteffen ifi 2048 Feb 18 08:05 .
drwxrwxr-x. 11 msteffen ifi 2048 Feb 18 08:04 ..
-rw-rw-r--.  1 msteffen ifi   13 Feb 18 08:04 .gitignore
drwxrwxr-x.  2 msteffen ifi 2048 Feb 18 08:05 parser
```

Building: putting it together



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Official

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Deadline

Deadline

Friday 15. 03. 2019, 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

Deliverables

- see also the “handout”

Deliverables (1)

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

```
precendence left AND;
```

Deliverables

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

- 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) ⇒ I tell you group number
  - create a project `compila<n>` (n = group number)
  - add collaborator + (at some point me)
- see also the handout