Section

Compila 22

Chapter 0 “”
Course “Compiler Construction”
Martin Steffen
Spring 2022

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 22* are syntactically correct:

- scanner
- parser

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

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;

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

DECL                 -> VAR_DECL | PROC_DECL | REC_DECL

VAR_DECL             -> "var" NAME ":" TYPE [ ":=" EXP ] |
"var" NAME ":="   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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Tools

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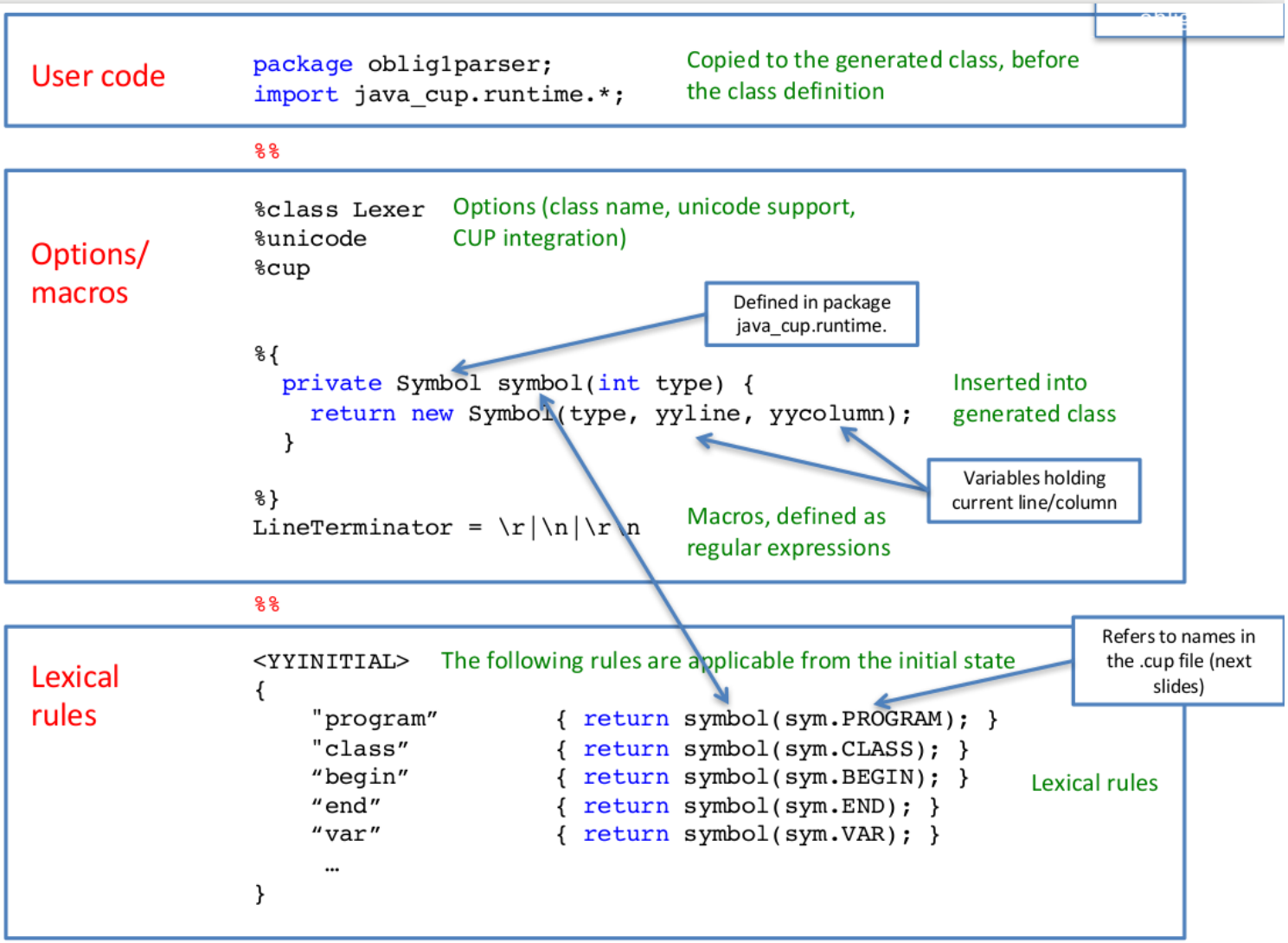
Tools: JFlex

- 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

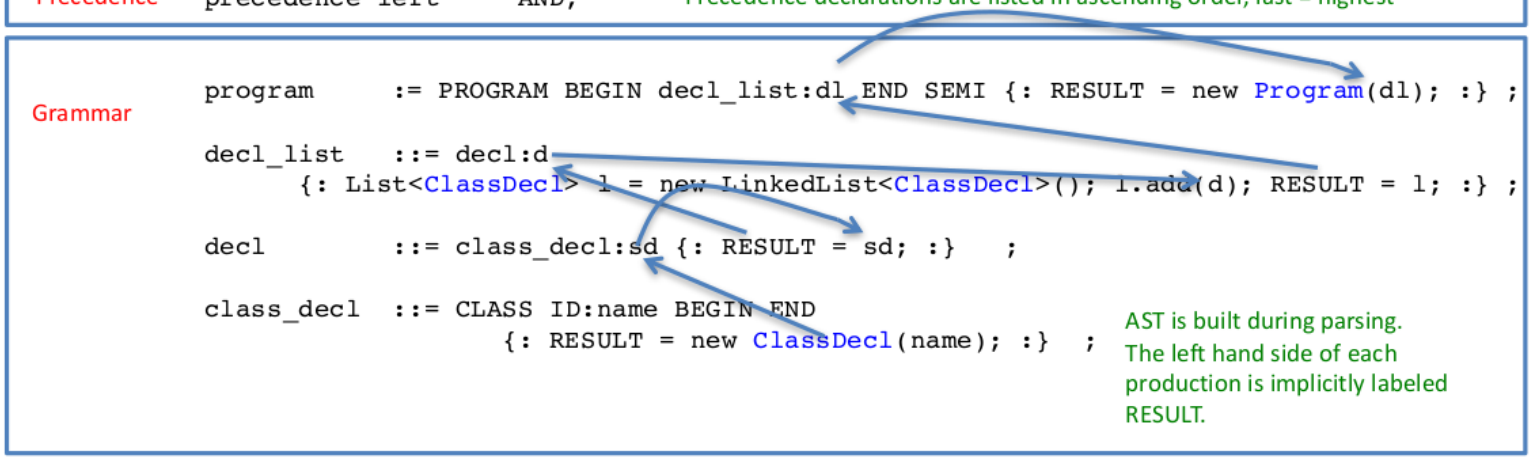
```
precedence left     AND;
```

Precedence declarations are listed in ascending order, last = highest

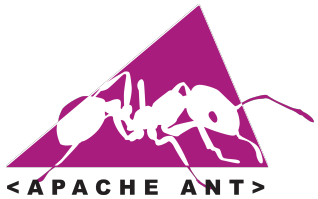
Grammar

```
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

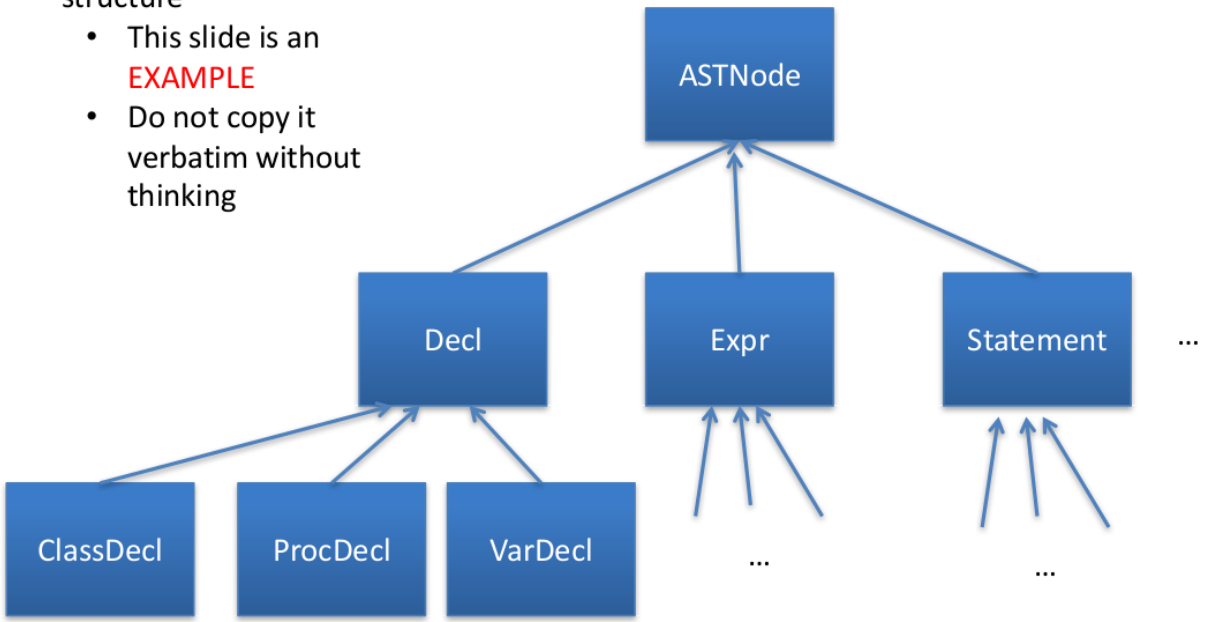
typical general targets

- 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

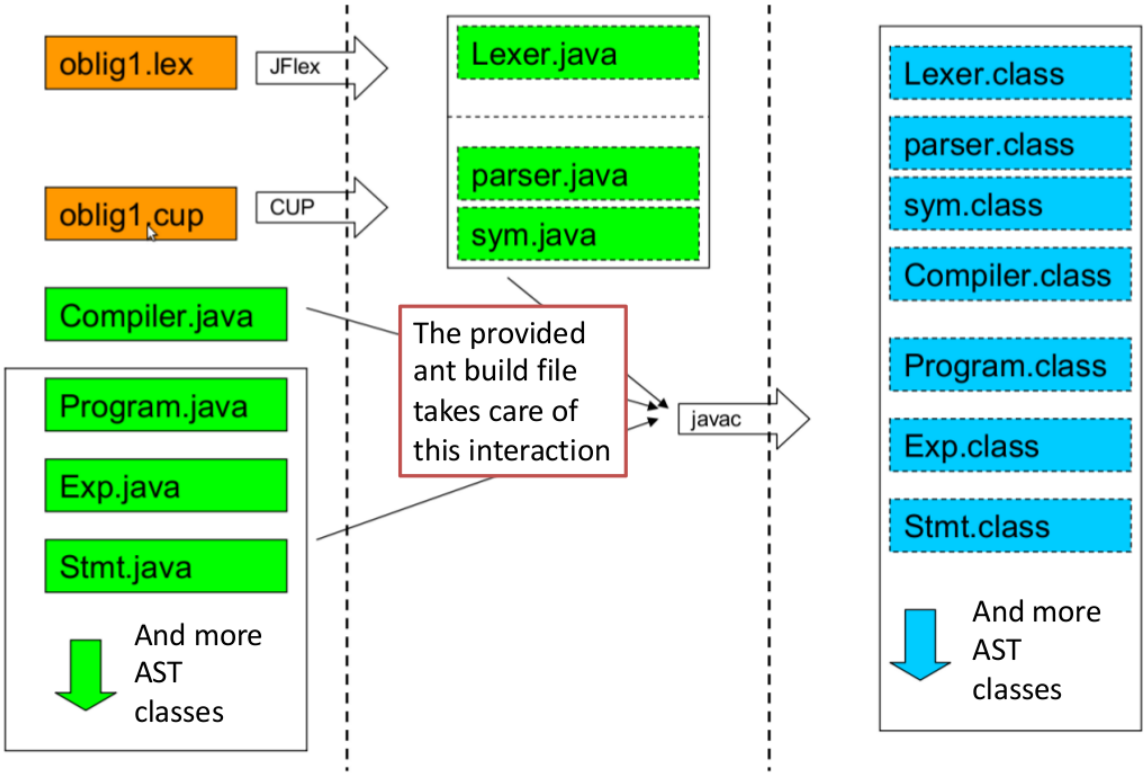


Overview over the directory + first steps

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

```
/uio/kant/ifi-ansatt-u00/msteffen/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
```

Building: putting it together



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Official

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Deadline

Deadline

Friday 11. 03. 2022, 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

- as the previous 2 or 3 years, we use *git*
- `https://github.uio.no` resp. https://github.uio.no/compilerconstruction-inf5110/compila22-<xx>
- you need
  - a login
  - send me emails that you want to do oblig (+ potential partner) ⇒ I tell you group number
- see also the handout and Readme