EDAN65: Compilers, Lecture 14

Review of important concepts
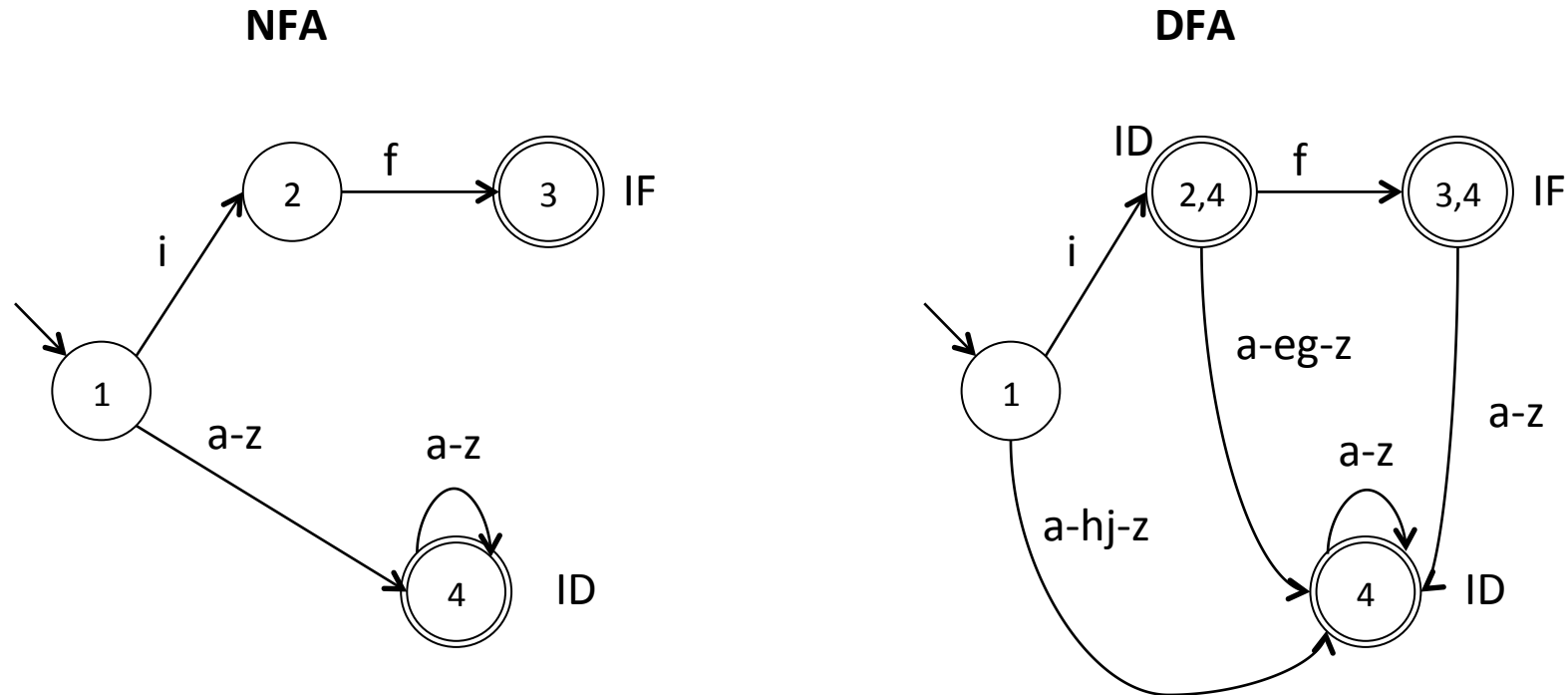
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Course overview

source code (text)

| Regular expressions | **A1** → | Lexical analyzer (scanner) |

tokens

| Context-free grammar | **A1, A2** → | Syntactic analyzer (parser) |

AST (Abstract syntax tree)

| Attribute grammar | **A3, A4** → | Semantic analyzer |

Attributed AST

Intermediate code generator ----**A5**---- Interpreter

intermediate code

Optimizer

intermediate code

Target code generator ----**A6**---- machine

target code

runtime system

- *activation records* — stack
- *objects* — garbage collection / heap
- Interpreter
- Virtual machine — code and data

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Regular expressions and scanning

NFA

DFA

Given some informal description, formulate a regular expression or automaton.
Translate between regular expressions, NFAs, DFAs.
Know how to combine automata representing tokens.
Know how to handle rule priority and longest match.

Context-free grammars

```
Exp -> Exp "+" Exp
Exp -> Exp "*" Exp
Exp -> INT
```

Given some informal description, formulate a language as a context-free grammar.

The elements of a context-free grammar G=(N, T, P, S):
nonterminal symbols, terminal symbols, productions, start symbol

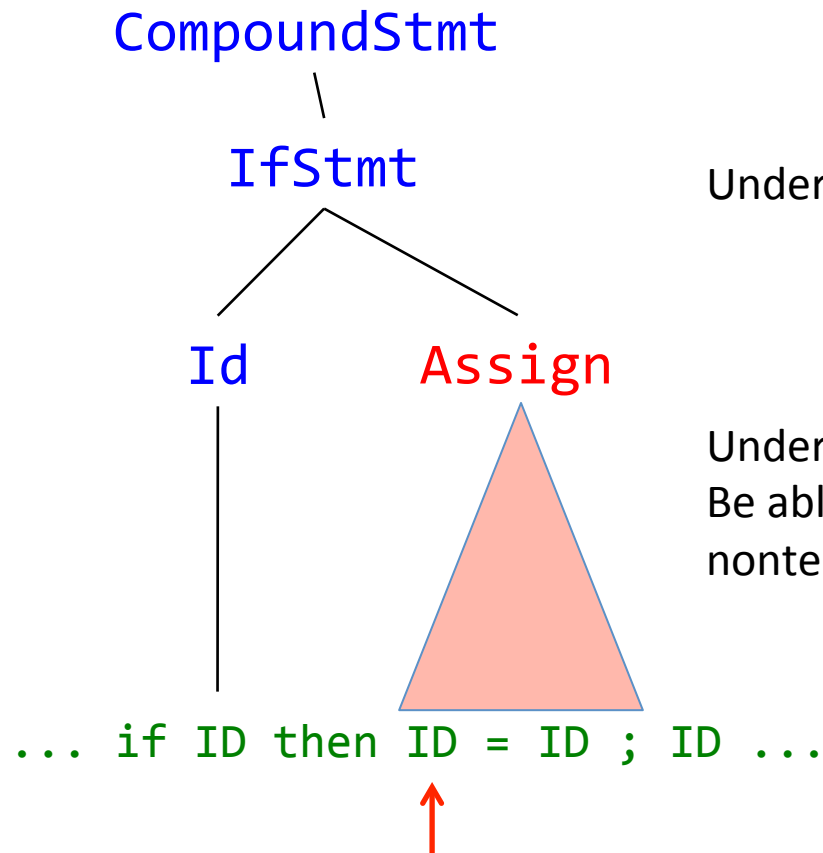Understand what the language defined by a grammar is.
Understand the difference between regular expressions and context-free grammars.

```
Exp
=> Exp "+" Exp
=> INT "+" Exp
...
```

Derivations. How to prove that a sentence belongs to a language.
Parse trees. How a parse tree corresponds to a derivation.

LL Parsing

CompoundStmt

IfStmt

Id   Assign

```
... if ID then ID = ID ; ID ...
```

Understand the main idea of how LL parsing works

Understand the concepts of FIRST, Nullable, and FOLLOW. Be able to compute them for a given nonterminal in a grammar.
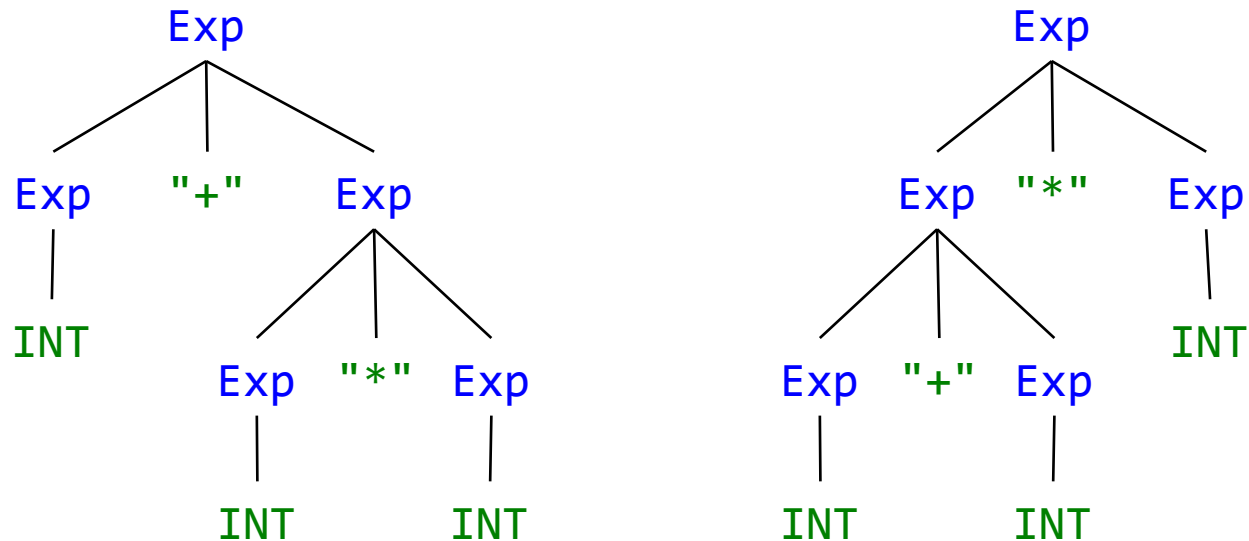
Be able to construct a recursive-descent parser for a given LL(1) grammar.

Understand what left recursion and common prefix mean.
Understand why grammars with these properties are not LL(1).
Be able to transform such a grammar to an equivalent LL(1) grammar.

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Ambiguities in context-free grammars

Understand what it means for a grammar to be ambiguous.
Understand what it means for two grammars to be equivalent.

Be able to prove that a grammar is ambiguous for common ambiguities (expressions and dangling else).

Be able to transform an ambiguous grammar to an equivalent unambiguous grammar, for common ambiguities.

Notations for context-free grammars

```
A -> B d e C f
A -> g A
```
Canonical form

```
C -> D a b | b E F | a C
```
BNF

```
G -> H* i | (d E)+ F | [d C]
```
EBNF

Be able to formulate grammars on canonical form, as BNF, and EBNF
Be able to translate between these forms.

Abstract grammars

Abstract grammar

abstract Stmt;
IfStmt : Stmt ::= Expr Stmt;
Assignment : Stmt ::= IdUse Expr;
IdUse : Expr ::= <ID:String>;

Understand the difference between an abstract grammar and a context-free grammar.

Understand how an abstract grammar corresponds to an object-oriented model.
Be able to design an abstract grammar for a simple language, corresponding to a good object-oriented model.

Be able to design a high-level (possibly ambiguous) concrete grammar that is very close to an abstract grammar.

LR parsing

Id   Assign

IdId

... if ID then ID = ID ; ID ...

Understand the main idea of how LR parsing works with shift, reduce, and accept actions.
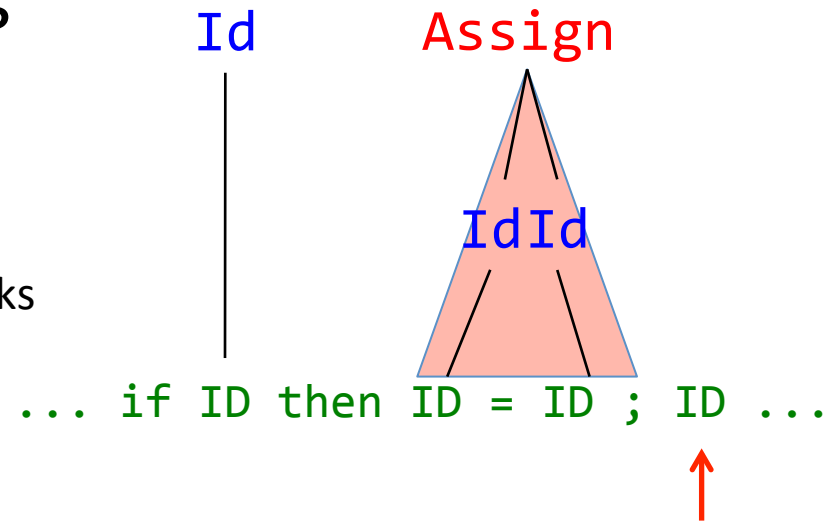
Understand why LR is more powerful than LL.

Understand what an LR item is.
Understand what an LR state is.

```
E -> E • "+" E        ?
E -> E "*" E •       "+"
```

Understand what an LR conflict is.
For a given LR conflict, be able to construct a program that would expose the conflict (for a simple case).

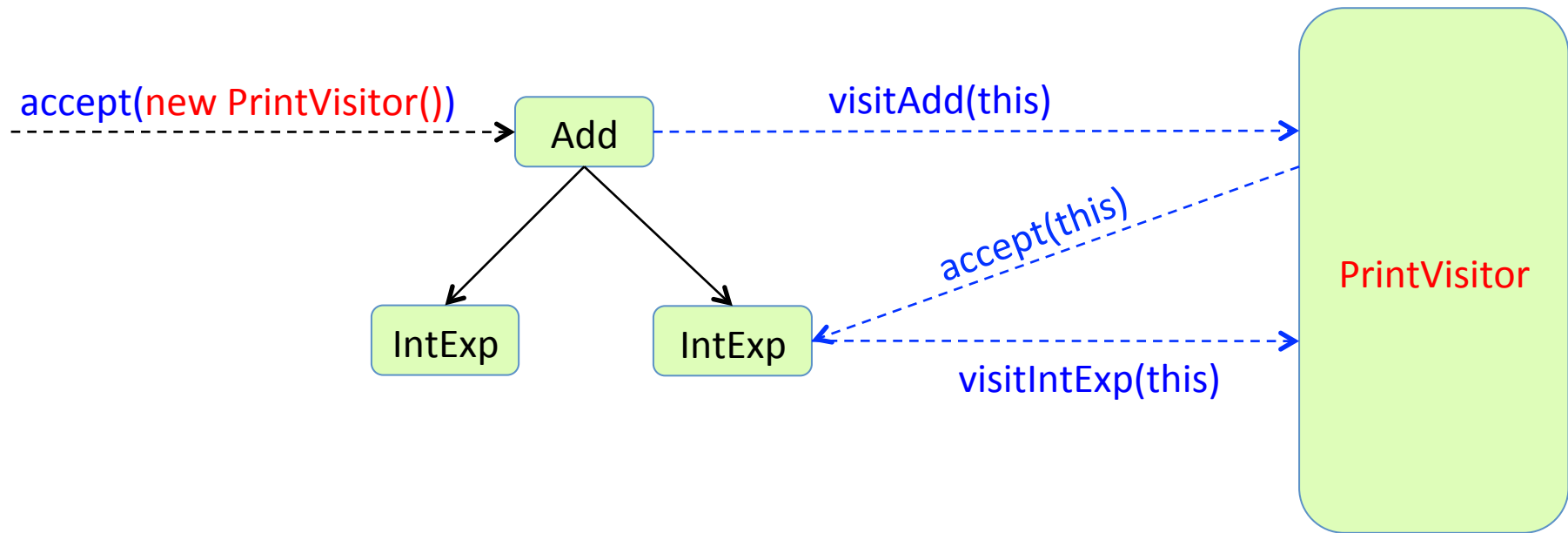I will **not** ask you to construct an LR DFA or an LR parsing table on the exam.

Static aspects with intertype declarations

```
aspect Evaluator {
 abstract int Expr.value();
 int Add.value() { return getLeft().value() + getRight().value(); }
 int Sub.value() { return getLeft().value() – getRight().value(); }
 int IntExpr.value() { return String.parseInt(getINT()); }
}
```

Understand how static aspect-oriented programming with
inter-type declarations works.

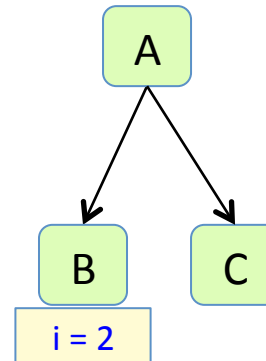Be able to program problems using methods declared in aspects.

Visitors

accept(new PrintVisitor())

visitAdd(this)

Add

IntExp

IntExp

accept(this)

PrintVisitor

visitIntExp(this)

Understand how the visitor pattern works.

Be able to program problems using visitors.

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Reference attribute grammars

```
inh int B.i();
eq  A.getB().i() = 2;
```

A

B   C

i = 2

Understand how reference attribute grammars work, with different kinds of attributes: synthesized, inherited, parameterized, NTAs, circular, and collection attributes.

Be able to program problems using reference attribute grammars.

You **don't** have to memorize details in the JastAdd syntax –
copies of the JastAdd reference manual will be available at the exam.

Runtime systems and code generation
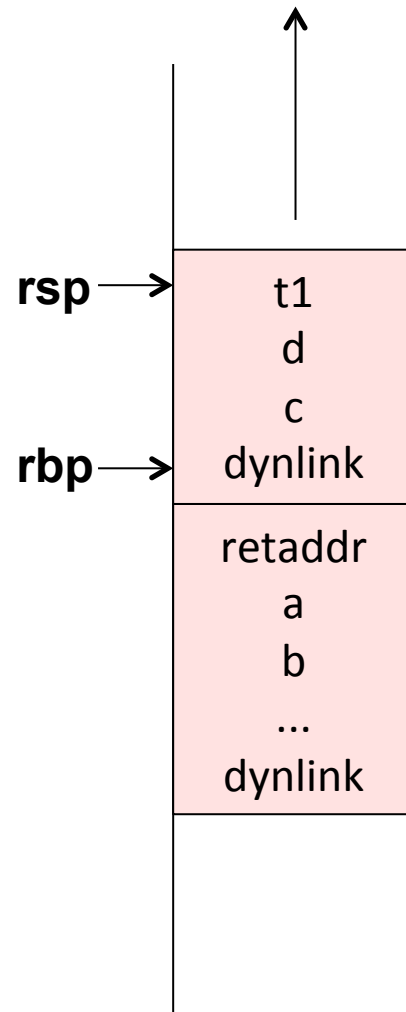
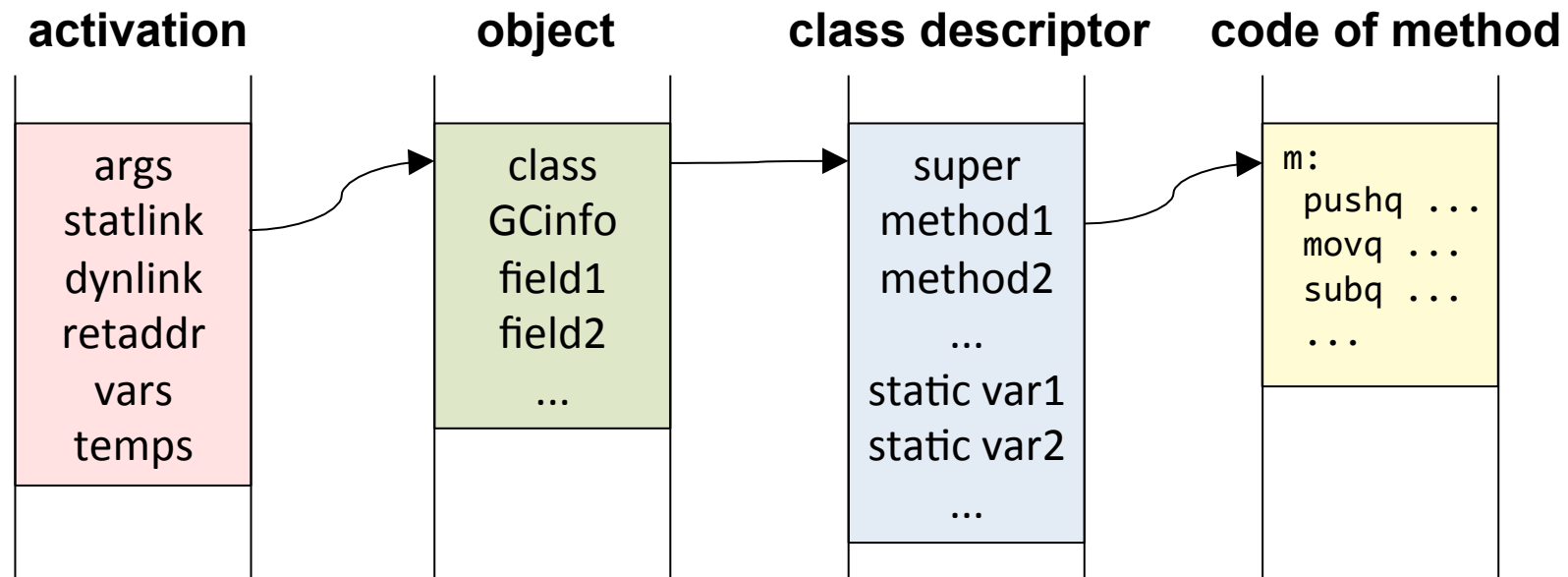Understand how an activation stack works, with frame pointer, stack pointer, and dynamic link.

Understand simple calling conventions, like passing arguments on the stack and the return value in a register.

Be able to write down pseudo assembly code for procedure calls, procedure activation and returns, and simple computations like loops, assignments, expression evaluation, etc.

Be able to draw the contents of the stack for a given execution point in a program.

You **don't** have to memorize x86 instructions.

Runtime systems for object-oriented languages

activation **object** **class descriptor** **code of method**

activation	object	class descriptor	code of method

args
statlink
dynlink
retaddr
vars
temps
	class
	GCinfo
	field1
	field2
	...
		super
		method1
		method2
		...
		static var1
		static var2
		...
			`m:`
			`  pushq ...`
			`  movq ...`
			`  subq ...`
			`  ...`

Understand the role of the static link ("this" pointer).
Understand how prefixing works for single inheritance of fields.
Understand how vtables work for single inheritance dynamic dispatch.
Have an overall idea about how dynamic adaptive compilation works.

You **don't** have to memorize how to handle multiple inheritance.

Preparing for the exam

Read slides, book, papers, lab descriptions.
Do the exercises and the quizzes.
Study old exams.

See http://cs.lth.se/edan65/material/

Ask at the forum if you have questions!

Don't forget to sign up for the exam by 2015-Oct-18, at student.lu.se
(Because of the new procedure for anonymized exam assessment)