Universitetet i Oslo
Institutt for Informatikk

Reliable Systems
Martin Steffen

# INF 5110: Compiler construction

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## Series 3

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**Topic: Chapter 4: grammars**

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**Exercise 1 (LL(1))** Check if the following grammar is LL(1)?

$$S \;\rightarrow\; (\,S\,)\,S \;\mid\; \epsilon$$

**Exercise 2 (Ambiguity)** Given the following grammar.

$$\begin{array}{lcl} \mathit{exp} & \rightarrow & \mathit{exp} + \mathit{exp} \;\mid\; (\,\mathit{exp}\,) \;\mid\; \textbf{if}\ \mathit{exp}\ \textbf{then}\ \mathit{exp}\ \textbf{else}\ \mathit{exp} \;\mid\; \mathit{var} \\ \mathit{var} & \rightarrow & \ldots \end{array}$$

1. Try to come up with an *unambiguous* grammar for the language of the given grammar, where
   (a) addition is left-associative, and where
   (b) **if** $x$ **then** $y$ **else** $z \;+\; y$ is meant to mean **if** $x$ **then** $y$ **else** $(z + y)$ .
2. Why don't we have a dangling else problem here?

**Exercise 3 (Ambiguity)** Given the following grammar.

$$\begin{array}{rcl} \mathit{exp} & \rightarrow & \mathit{exp}\ \mathit{op}\ \mathit{exp} \;\mid\; (\,\mathit{exp}\,) \;\mid\; \textbf{number} \\ \mathit{op} & \rightarrow & + \;\mid\; - \;\mid\; * \;\mid\; / \;\mid\; \uparrow \;\mid\; < \;\mid\; = \end{array}$$

Do the following things.[1]

1. The grammar is pretty ambiguous. Make an unambiguous grammar capturing the same language, under the following side conditions

| | precedence | assoc |
|---|---|---|
| $\uparrow$ | highest (3) | right |
| $*$, $/$ | level 2 | left |
| $+$, $-$ | level 1 | left |
| $<$, $=$ | 0 | non-associative |

[1] There's a certain amount of repetition here, we won't go through everything during class-time, but a proposal for solution will be available.

2. Give recursive-descent procedures for each non-terminal to check the grammar (using also loops, if advisable). Divide the terminals representing *op* in an appropriate manner

3. Based on the previous point: add tree-building code into the procedures in such a way that sequences of exponentiations $\uparrow$ are treated appropriately in the sense that the tree reflects the intended right-associativity.

4. Take the unambiguous grammar done in the first point, remove left-recursion, and do left-factorization (without destroying unambiguity).

5. Check whether the resulting grammar is LL(1).