Exercises About LL(K) Grammars

Compilers course

Masters in Informatics and Computing Engineering (MIEIC), 3rd Year

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Exercise 1

$$E \rightarrow E + T \mid T$$
$$T \rightarrow T * F \mid F$$
$$F \rightarrow (E) \mid NUM$$

- **Group 1. *First*, *Follow* Sets and *Parsers* LL(k) (5 pts)**
- Consider the CFG1 in the left. **NUM** is a terminal symbol representing numbers.
- **1.a)** [1pt] Give the *First* and *Follow* sets for each grammar variable;
- **1.b)** [2pts] Is the grammar LL(1)? Show the table for the *parser* LL(1);
- **1.c)** [2pts] Modify the grammar in order it can be implemented as a top-down recursive parser with K=1 (*lookahead*).

Source: First midterm exam (MT1): April 6, 2017

Exercise 1

$E \rightarrow E + T \mid T$

$T \rightarrow T * F \mid F$

$F \rightarrow (E) \mid NUM$

- **1.a)** [1pt] Give the *First* and *Follow* sets for each grammar variable;
- First(E)={(,NUM}
- First(T)={(,NUM}
- First(F)={(,NUM}

- Follow(E)={+,)}
- Follow(T)={*,+,)}
- Follow(F)={*,+,)}

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Note that here you need to determine the First of each production (not the first of each variable) and the follow of the variables that have empty productions.

Exercise 1

- **1.b)** [2pts] Is the grammar LL(1)? Show the table for the *parser* LL(1);
  - The grammar is not LL(1), there are cases with more than one production for a given input symbol as can be seen below

$$E \rightarrow E + T \mid T$$
$$T \rightarrow T * F \mid F$$
$$F \rightarrow (E) \mid NUM$$

	+	*	(	)	NUM
E			E → E + T E → T		E → E + T E → T
T			T → T * F T → F		T → T * F T → F
F			F → (E)		F → NUM

Source: First midterm exam (MT1): April 6, 2016

What we need?

- Eliminate ambiguity
- Eliminate left recursion
- Do left factorization (may need to consider modifications of productions across different variables)

Exercise 1

- **1.c)** [2pts] Modify the grammar in order it can be implemented as a top-down recursive parser with K=1 (*lookahead*).

$$E \rightarrow E + T \mid T$$
$$T \rightarrow T * F \mid F$$
$$F \rightarrow (E) \mid NUM$$

The grammar is non-ambiguous

Source: First midterm exam (MT1): April 6, 2016

What we need?

- Eliminate ambiguity
- Eliminate left recursion
- Do left factorization (may need to consider modifications of productions across different variables)

Exercise 1

- **1.c)** [2pts] Modify the grammar in order it can be implemented as a top-down recursive parser with K=1 (*lookahead*).

$E \rightarrow E + T \mid T$

$T \rightarrow T * F \mid F$

$F \rightarrow (E) \mid NUM$

The grammar is non-ambiguous

1st: eliminate left recursion

$E \rightarrow T + E \mid T$

$T \rightarrow F * T \mid F$

$F \rightarrow (E) \mid NUM$

2nd: eliminate for each variable the existence of productions with First sets with one or more equal symbols

$E \rightarrow T\ E1$

$E1 \rightarrow + E \mid \varepsilon$

$T \rightarrow F\ T1$

$T1 \rightarrow * T \mid \varepsilon$

$F \rightarrow (E) \mid NUM$

$E \rightarrow T\ [+ E]$

$T \rightarrow F\ [* T\ ]$

$F \rightarrow (E) \mid NUM$

Source: First midterm exam (MT1): April 6, 2016

Exercise 2

- **1d)** Show the grammar is LL(1) by using the table for the *parser* LL(1)

E → T E1

E1 → + E | ε

T → F T1

*T1 → * T | ε*

F → (E) | NUM

Exercise 2

- **1d)** Show the grammar is LL(1) by using the table for the *parser* LL(1)
  - The table presented below has at most one production per cell and thus the grammar is LL(1)

E → T E1

E1 → + E | ε

T → F T1

*T1 → * T | ε*

F → (E) | NUM

	+	*****	**(**	**)**	**NUM**
E			E → T E1		E → T E1
E1	E1 → + E				
T			T → F T1		T → F T1
T1	T1 → ε	T1 → * T			
F			F → (E)		F → NUM

Source: First midterm exam (MT1): April 6, 2016

Exercise 2

E → T E1

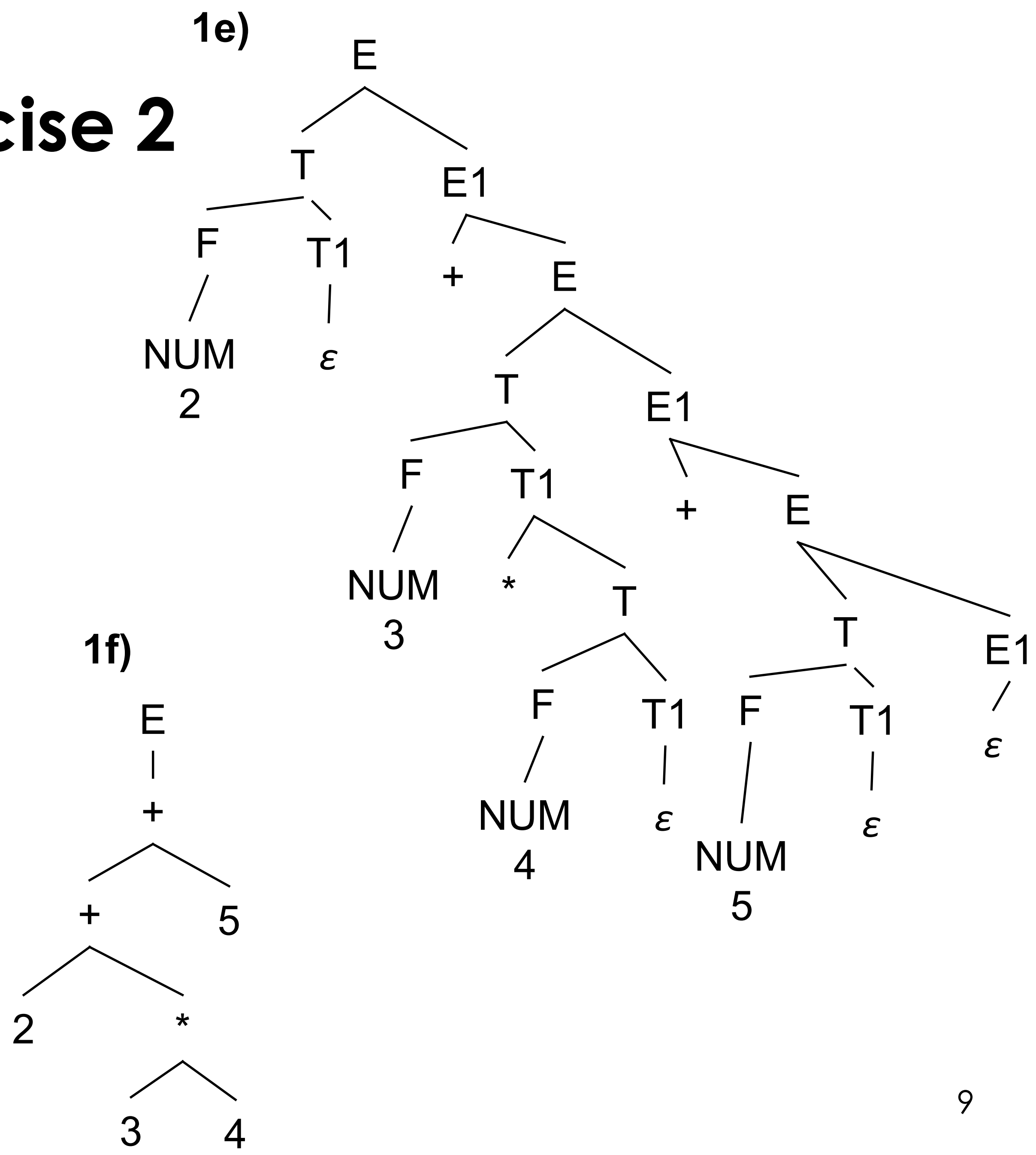
E1 → + E | ε

T → F T1

*T1 → * T | ε*

F → (E) | NUM

- **1e)** Show the concrete syntax tree (CST) for 2+3*4+5
- **1f)** Show a possible abstract syntax tree (AST) for 2+3*4+5


1e)
E
T
E1
F
T1
+
E
NUM
2
ε
T
E1
F
T1
+
E
NUM
3
*
T
T
E1
F
T1
F
T1
ε
NUM
4
ε
NUM
5
ε
1f)
E
+
+
5
2
*
3
4