

BU CS320 Assignment 6: Context Free Grammars

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1. Given the following grammar where $\langle expr \rangle$ is the starting symbol:

$\langle id \rangle$	$::= a \mid b \mid c \mid \dots \mid z$
$\langle dig \rangle$	$::= 0 \mid 1 \mid 2 \mid \dots \mid 9$
$\langle expr \rangle$	$::= () \mid \langle dig \rangle \mid \langle id \rangle$
	$\mid \text{let } \langle id \rangle = \langle expr \rangle \text{ in } \langle expr \rangle$
	$\mid \langle expr \rangle ; \langle expr \rangle$
	$\mid \text{begin } \langle expr \rangle \text{ end}$

Demonstrate the grammar above is ambiguous.

consider $\text{let } a = b \text{ in } c ; d$

① $\langle expr \rangle$

$\Rightarrow \text{let } \langle id \rangle = \langle expr \rangle \text{ in } \langle expr \rangle$

$\Rightarrow \text{let } a = \langle id \rangle \text{ in } \langle expr \rangle$

$\Rightarrow \text{let } a = b \text{ in } \langle expr \rangle$

$\Rightarrow \text{let } a = b \text{ in } \langle expr \rangle ; \langle expr \rangle$

$\Rightarrow \text{let } a = b \text{ in } \langle id \rangle ; \langle expr \rangle$

$\Rightarrow \text{let } a = b \text{ in } c ; \langle expr \rangle$

$\Rightarrow \text{let } a = b \text{ in } c ; \langle id \rangle$

$\Rightarrow \text{let } a = b \text{ in } c ; d$

② $\langle expr \rangle$

$\Rightarrow \langle expr \rangle ; \langle expr \rangle$

$\Rightarrow \text{let } \langle id \rangle = \langle expr \rangle \text{ in } \langle expr \rangle ; \langle expr \rangle$

$\Rightarrow \text{let } a = \langle expr \rangle \text{ in } \langle expr \rangle ; \langle expr \rangle$

$\Rightarrow \text{let } a = \langle id \rangle \text{ in } \langle expr \rangle ; \langle expr \rangle$

$\Rightarrow \text{let } a = b \text{ in } \langle expr \rangle ; \langle expr \rangle$

$\Rightarrow \text{let } a = b \text{ in } \langle id \rangle ; \langle expr \rangle$

$\Rightarrow \text{let } a = b \text{ in } c ; \langle expr \rangle$

$\Rightarrow \text{let } a = b \text{ in } c ; \langle id \rangle$

$\Rightarrow \text{let } a = b \text{ in } c ; d$

It's ambiguous because we can get the string "let $a = b$ in $c ; d$ "

by expanding $\langle expr \rangle$ in 2 different structure.

2. Modify the grammar (reproduced below) to be unambiguous. Hint: There is not just one way.

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 $\langle id \rangle ::= a \mid b \mid c \mid \dots \mid z$   
 $\langle dig \rangle ::= 0 \mid 1 \mid 2 \mid \dots \mid 9$   
 $\langle expr \rangle ::= () \mid \langle dig \rangle \mid \langle id \rangle$   
           $\mid \text{let } \langle id \rangle = \langle expr \rangle \text{ in } \langle expr \rangle$   
           $\mid \langle expr \rangle ; \langle expr \rangle$   
           $\mid \text{begin } \langle expr \rangle \text{ end}$ 
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$\langle expr \rangle ::= \langle simple_expr \rangle \mid \langle compound_expr \rangle$

$\langle simple_expr \rangle ::= () \mid \langle dig \rangle \mid \langle id \rangle$

$\langle compound_expr \rangle ::= \langle let_expr \rangle \mid \langle block_expr \rangle \mid \langle sequence_expr \rangle$

$\langle let_expr \rangle ::= \text{let } \langle id \rangle = \langle expr \rangle \text{ in } \langle expr \rangle$

$\langle block_expr \rangle ::= \text{begin } \langle expr \rangle \text{ end}$

$\langle sequence_expr \rangle ::= \langle expr \rangle ; \langle sequence_tail \rangle$

$\langle sequence_tail \rangle ::= \langle expr \rangle \mid \langle expr \rangle ; \langle sequence_tail \rangle$

3. Demonstrate your modified grammar fixes the previously shown ambiguity.

let $a = b$ in c ; d

$\langle \text{expr} \rangle$

$\Rightarrow \langle \text{compound_expr} \rangle$

$\Rightarrow \langle \text{let_expr} \rangle$

$\Rightarrow \text{let } \langle \text{id} \rangle = \langle \text{expr} \rangle \text{ in } \langle \text{expr} \rangle$

$\Rightarrow \text{let } a = \langle \text{expr} \rangle \text{ in } \langle \text{expr} \rangle$

$\Rightarrow \text{let } a = \langle \text{simple_expr} \rangle \text{ in } \langle \text{expr} \rangle$

$\Rightarrow \text{let } a = \langle \text{id} \rangle \text{ in } \langle \text{expr} \rangle$

$\Rightarrow \text{let } a = b \text{ in } \langle \text{expr} \rangle$

$\Rightarrow \text{let } a = b \text{ in } \langle \text{compound_expr} \rangle$

$\Rightarrow \text{let } a = b \text{ in } \langle \text{sequence_expr} \rangle$

$\Rightarrow \text{let } a = b \text{ in } \langle \text{expr} \rangle ; \langle \text{sequence_tail} \rangle$

$\Rightarrow \text{let } a = b \text{ in } \langle \text{simple_expr} \rangle ; \langle \text{sequence_tail} \rangle$

$\Rightarrow \text{let } a = b \text{ in } \langle \text{id} \rangle ; \langle \text{sequence_tail} \rangle$

$\Rightarrow \text{let } a = b \text{ in } c ; \langle \text{sequence_tail} \rangle$

$\Rightarrow \text{let } a = b \text{ in } c ; \langle \text{expr} \rangle$

$\Rightarrow \text{let } a = b \text{ in } c ; \langle \text{simple_expr} \rangle$

$\Rightarrow \text{let } a = b \text{ in } c ; \langle \text{id} \rangle$

$\Rightarrow \text{let } a = b \text{ in } c ; d$