

Context-free languages

Tuesday, February 16, 2021 11:38 AM

$$L = \{a^n b^n \mid n \geq 0\}$$

A more powerful way to specify languages.

NOAM CHOMSKY

Regular grammars \leftrightarrow Reg. langs

\Rightarrow Context free grammars \leftrightarrow Context-free languages
(CFG)

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X Context sensitive

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Phrase structure

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Push down automata
bounded automata
Turing machine

ALL programming languages are
CONTEXT FREE.

A CONTEXT-FREE GRAMMAR
consists of (i) a set of symbols called
the terminal symbols or alphabet

Σ or T : finite.

(ii) The non-terminal or variable symbols

V : finite set

$$V \cap T = \emptyset$$

(iii) a special symbol, usually $S \in V$ called the start symbol.

(iv) a finite set of rules or productions of the form

$$A \rightarrow \alpha \in (V \cup T)^*$$

↑
one
variable

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EXAMPLE $T = \{a, b\}$

$$V = \{S\}$$

$$S \xrightarrow{1} \epsilon$$

$$S \xrightarrow{2} a S b$$

We produce strings by starting with S and using rules as we please until all symbols from V are gone.

$$S \rightarrow a S b \rightarrow a \overbrace{a S b} \rightarrow a a \overbrace{a S b} b b \rightarrow a a a \overbrace{a S b} b b b$$

← using ②

... a a a b b b

→ a a a . . .

aaa bbb is in the language defined by this grammar.

$$L(G) = \{a^n b^n \mid n \geq 0\}$$

ARITHMETIC EXPRESSIONS

$$\Sigma = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, +, \times, (,)\}$$

$$V = \{\underline{\langle EXP \rangle}, \langle NUM \rangle, \langle NZ \rangle, \langle N \rangle\}$$

$$\langle EXP \rangle \rightarrow \langle EXP \rangle + \langle EXP \rangle \mid \langle EXP \rangle \times \langle EXP \rangle \mid (\langle EXP \rangle)$$

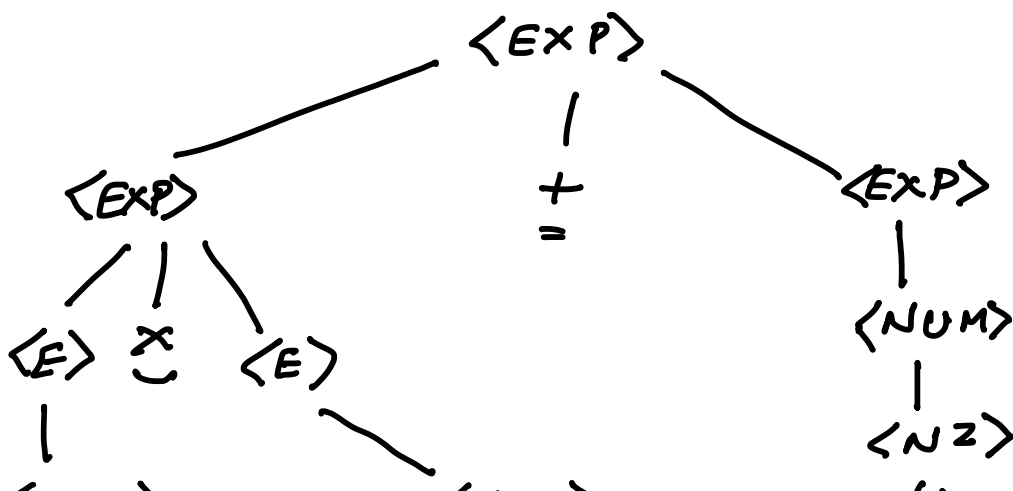
$$\langle EXP \rangle \rightarrow \langle NUM \rangle$$

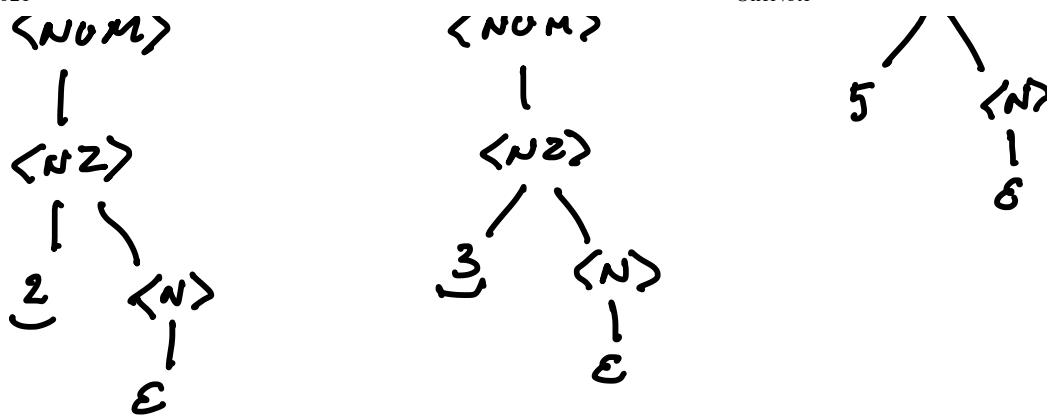
$$\langle NUM \rangle \rightarrow 0 \mid \langle NZ \rangle$$

$$\langle NZ \rangle \rightarrow 1 \langle N \rangle \mid 2 \langle N \rangle \mid \dots \mid 9 \langle N \rangle$$

$$\langle N \rangle \rightarrow 0 \langle N \rangle \mid 1 \langle N \rangle \mid \dots \mid 9 \langle N \rangle \mid \epsilon$$

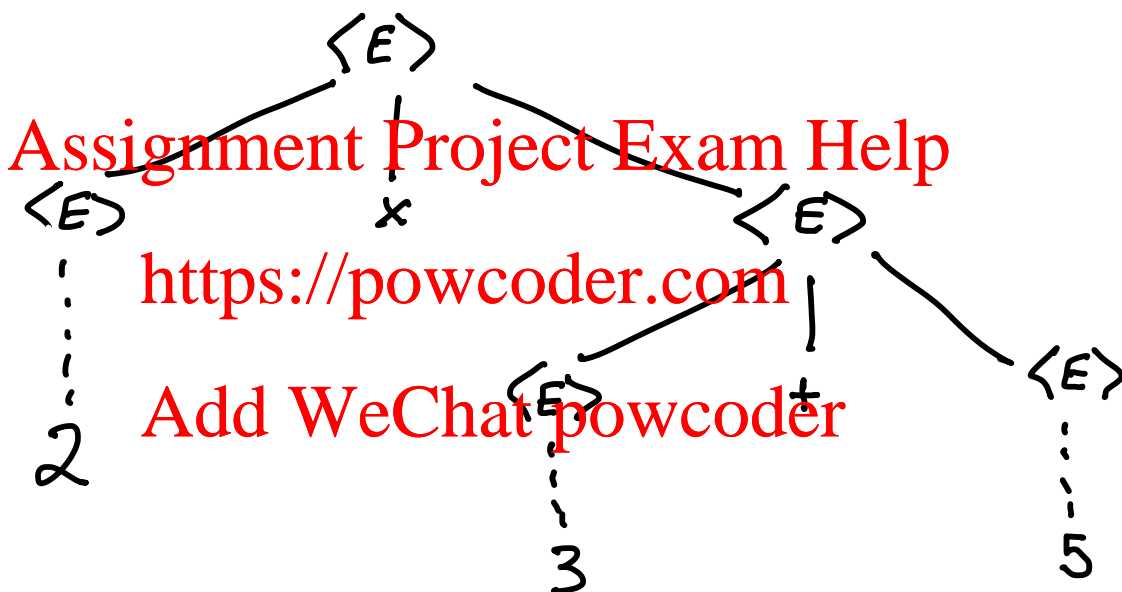
To display derivations we use a tree rather than a string





string generated is $2 \times 3 + 5$

The 2, 3 are grouped more tightly



$2 \times 3 + 5$ same string but the tree is different and the grouping is wrong.

PROBLEM: The same string is (parsed) generated in 2 ways with different grouping.

SUCH A grammar is said to be
AMBIGUOUS.

This is a badly designed grammar.

This is a property of the grammar not
 of the language.

$$V = \{ \underline{\langle E \rangle}, \langle T \rangle, \langle F \rangle, \langle N \rangle, \dots \}$$

$$\langle E \rangle \rightarrow \langle E \rangle + \langle T \rangle \mid \langle T \rangle$$

$$\langle T \rangle \rightarrow \langle T \rangle \times \langle F \rangle \mid \langle F \rangle$$

$$\langle F \rangle \rightarrow (\langle E \rangle$$

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