CONTEXT-FREE GRAMMARS:

A more powerful way to specify languages.

A CFG has consists of (1) A set of symbols called terminals (Σ) (2) A set of symbols called non-terminals or variables V (3) A set of rules for generating sequences: productions. (4) A special variable called the start symbol: S.

Example For $\Sigma = \{a, b\}$ $V = \{S\}$

$S \xrightarrow{1} \varepsilon$ $S \xrightarrow{2} aSb$

How does this produce a string in Σ^*?

$S \xrightarrow{2} aSb \xrightarrow{2} aaSbb \xrightarrow{1} aaabbb$.

When you produce a string without variables you stop. The sequence is called a derivation.

This grammar produces the language $\{a^n b^n / n \geq 0\}$ which is not regular.

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Used in linguistics to model sentence generation:

$\langle SENTENCE \rangle \rightarrow \langle N.P. \rangle \langle V.P. \rangle$

$\langle N.P. \rangle \rightarrow \langle C.N. \rangle \mid \langle CN. \rangle \langle PREP\text{-}PHRASE \rangle$

$\langle V.P. \rangle \rightarrow \langle C.V. \rangle \mid \langle C.V. \rangle \langle PREP\text{-}P. \rangle$

$\langle P.PHRASE \rangle \rightarrow \langle PREP \rangle \langle C.N \rangle$

ARITHMETIC EXPRESSIONS: $\Sigma = \{0, 1, 2, \cdots 9, +, \times, (,)\}$.

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

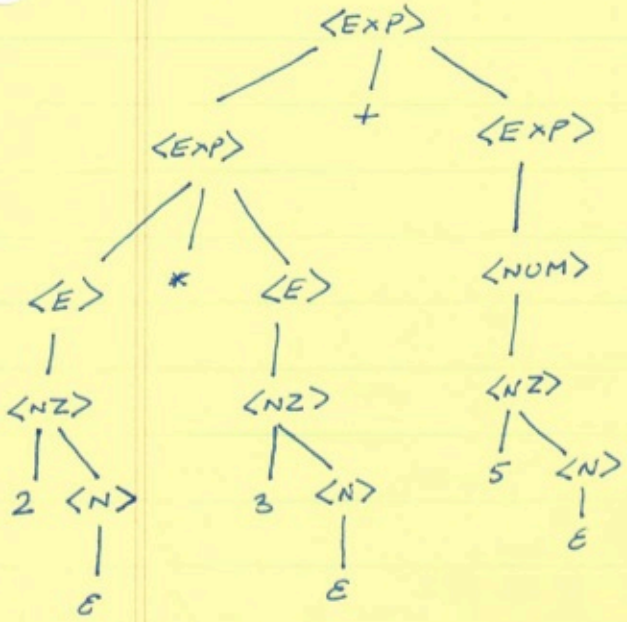
$\langle EXP \rangle \rightarrow \langle EXP \rangle + \langle EXP \rangle \mid \langle EXP \rangle * \langle EXP \rangle \mid (\langle EXP \rangle) \mid \langle NUM \rangle$

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

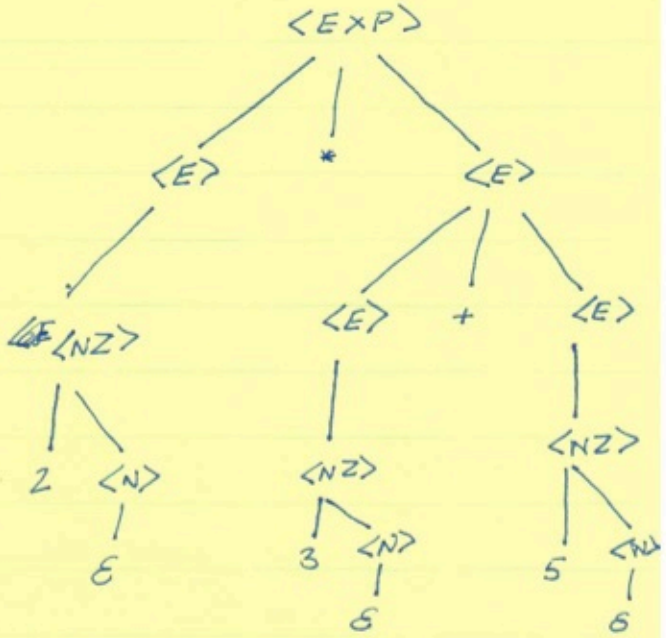
$\langle NZ \rangle \rightarrow 1\langle N \rangle \mid 2\langle N \rangle \mid \cdots \mid 9\langle N \rangle$

$\langle N \rangle \rightarrow 0\langle N \rangle \mid 1\langle N \rangle \mid \cdots \mid 9\langle N \rangle \mid \varepsilon$.

To display derivations it is far better to use a tree: parse tree of a string. CFG's capture tree structure



2 * 3 + 5



2 * 3 + 5

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Def A grammar is said to be ambiguous if there are two distinct parse trees for the same string.

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

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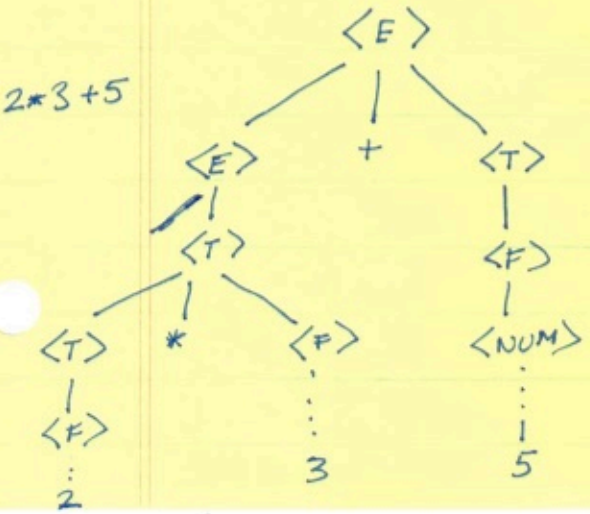
$V = \{\langle E\rangle, \langle T\rangle, \langle F\rangle\}$

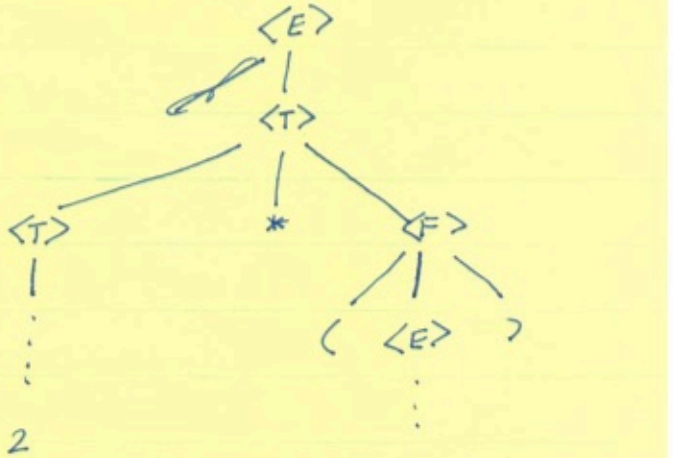
$\langle E\rangle \rightarrow \langle E\rangle + \langle T\rangle \mid \langle T\rangle$

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

$\langle F\rangle \rightarrow (\langle E\rangle) \mid \langle NUM\rangle$

2*3+5





2 * (3+5) PARENS ARE FORCED