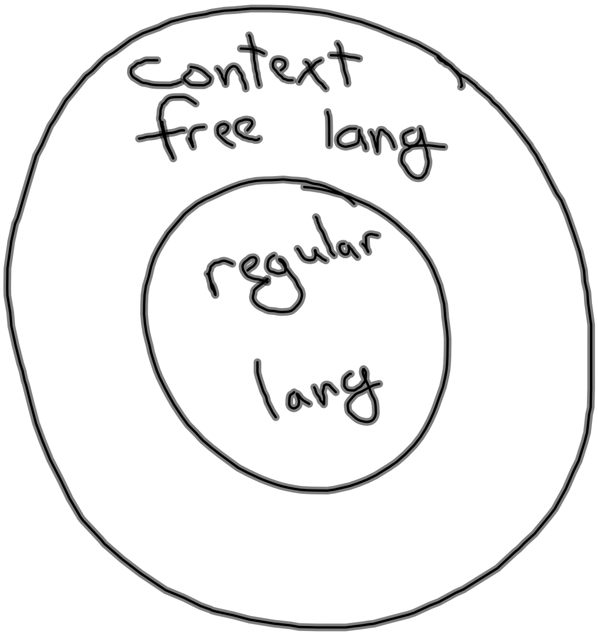
1.54 if $i = 1$ $ab^n c^n$

$i \neq 1$ $a^* b^* c^*$

$(\varepsilon \cup aaa^*) b^* c^*$



Context free grammars

- set of rules
- recursive

start var: $A \to 0A1$

$A \to B$

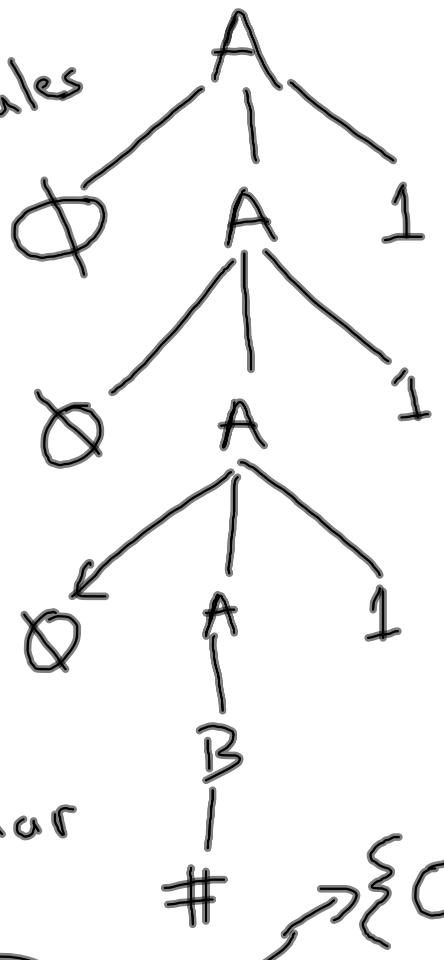
$B \to \#$

variables: A, B

terminals: $\underline{0, 1, \#}$

alphabet for strings

apply rules



$000\#111$

$0\#1$

$00\#11$

G: grammar

$L(G) \to \{0^n\#1^n \mid n \geq 0\}$

$A \to 0A1 \mid B$

$B \to \#$

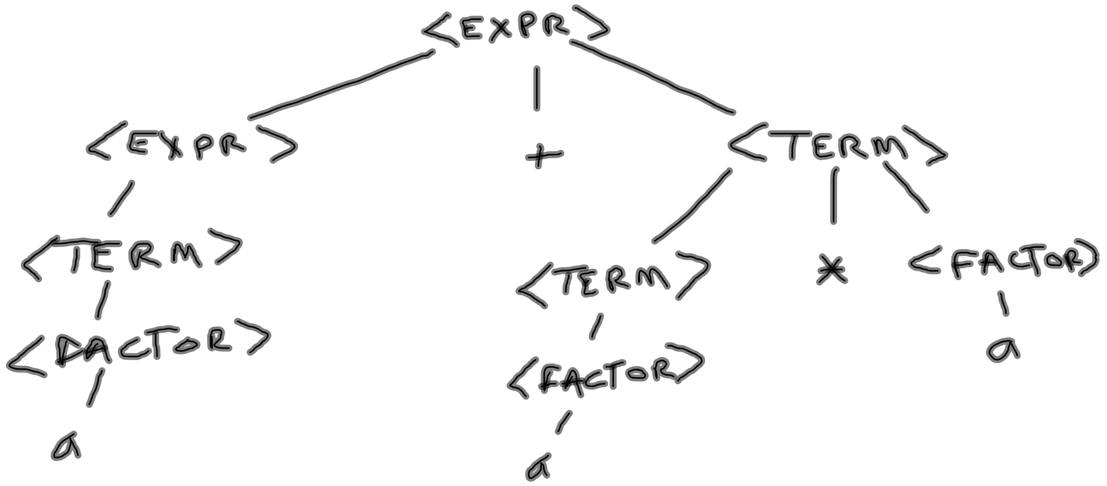
$$\langle EXPR \rangle \rightarrow \langle EXPR \rangle + \langle TERM \rangle \mid \langle TERM \rangle$$

$$\langle TERM \rangle \rightarrow \langle TERM \rangle \times \langle FACTOR \rangle \mid \langle FACTOR \rangle$$

$$\langle FACTOR \rangle \rightarrow (\langle EXPR \rangle) \mid a$$

Derive $a + a \times a$

$$\begin{aligned}
\langle EXPR \rangle &\Rightarrow \langle EXPR \rangle + \langle TERM \rangle \\
&\Rightarrow \langle TERM \rangle + \langle TERM \rangle \\
&\Rightarrow \langle FACTOR \rangle + \langle TERM \rangle \\
&\Rightarrow a + \langle TERM \rangle \\
&\Rightarrow a + \langle TERM \rangle \times \langle FACTOR \rangle \\
&\Rightarrow a + \langle FACTOR \rangle \times \langle FACTOR \rangle \\
&\Rightarrow a + a \times \langle FACTOR \rangle \\
&\Rightarrow a + a \times a
\end{aligned}$$



Formal Def. of CFG

$$(V, \Sigma, R, S)$$

1. V: finite set of variables
2. Σ: finite set of terminals, disjoint from V.
3. R: finite set of rules

   each rule is a single variable and a string of variables and terminals.
4. $S \in V$ start symbol

---

rule $A \to w$

uAv yields uwv

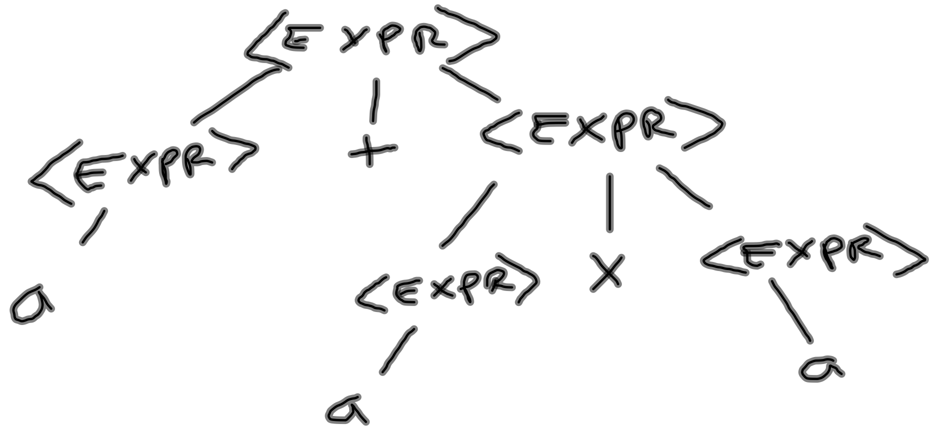
$uAv \Rightarrow uwv$

u derives v $\quad (u \overset{*}{\Rightarrow} v)$

$$u \Rightarrow u_1 \Rightarrow u_2 \Rightarrow u_3 \Rightarrow \cdots \Rightarrow v$$

$$\langle EXPR \rangle \to \langle EXPR \rangle + \langle EXPR \rangle \mid \langle EXPR \rangle \times \langle EXPR \rangle \mid (\langle EXPR \rangle) \mid a$$

$a + a \times a$



ambiguous lang.