$E \to E + E \mid E * E \mid id$

id + id * id

$E \underset{lm}{\Rightarrow} E + E \underset{lm}{\Rightarrow} id + E \underset{lm}{\Rightarrow} id + E * E \underset{lm}{\Rightarrow} id + id * E \underset{lm}{\Rightarrow} id + id * id$

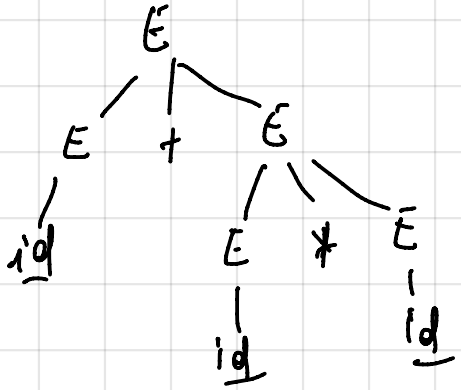
leftmost non-terminal

sentential form $\alpha \in (V \cup T)^+$

that is obtained as a step during a derivation

e.g. id id +

The corresponding parse tree is:

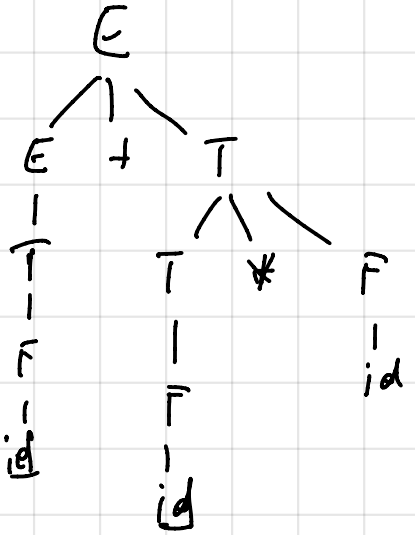


$E \to E + T \mid T$

$T \to T * F \mid F$

$F \to (E) \mid id$

$id + id * id$



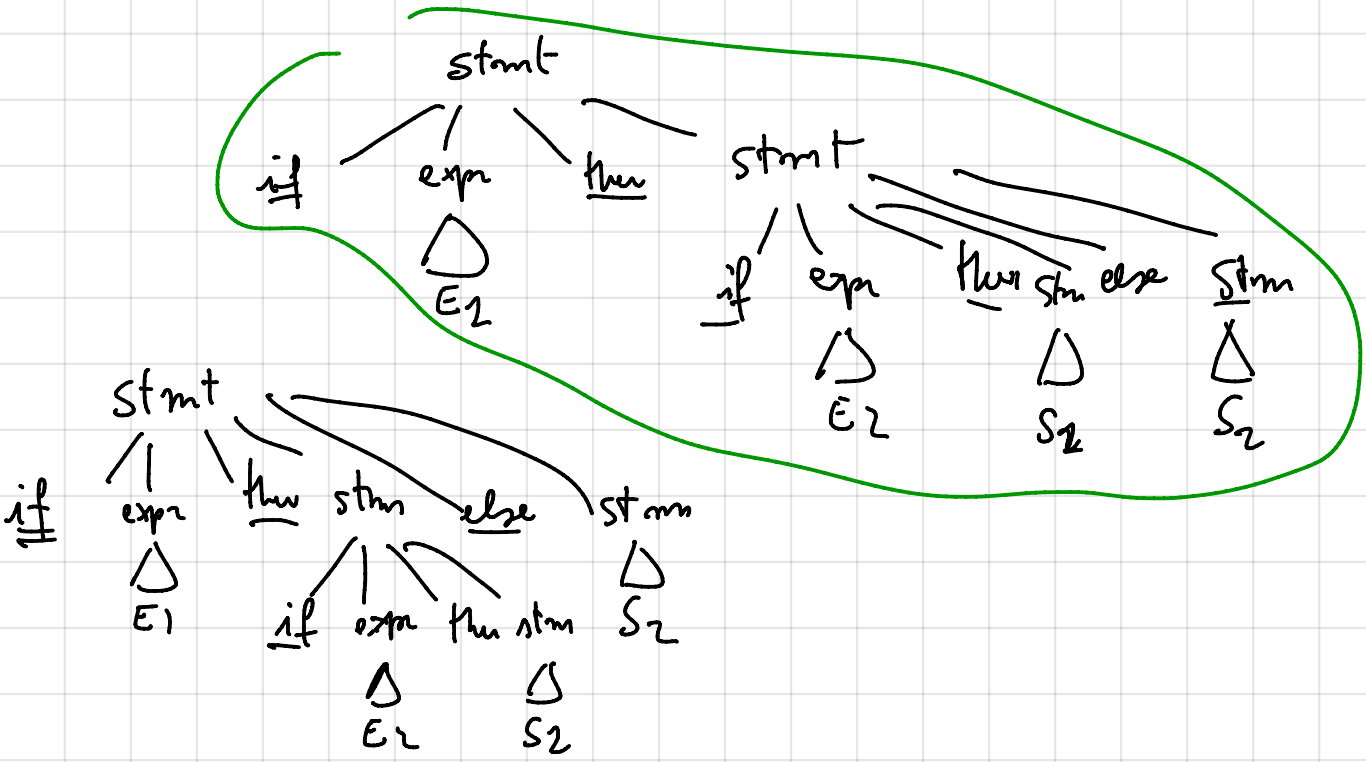
$E \underset{lm}{\Rightarrow} E+T \underset{lm}{\Rightarrow} T+T \underset{lm}{\Rightarrow} F+T \underset{lm}{\Rightarrow} id+T \underset{lm}{\Rightarrow} id+T*F \underset{lm}{\Rightarrow} id+F*F \underset{lm}{\Rightarrow} id+id*F \underset{lm}{\Rightarrow} id+id*id$

$E \underset{rm}{\Rightarrow} E+T \underset{rm}{\Rightarrow} E+T*F \underset{rm}{\Rightarrow} E+T*id \underset{rm}{\Rightarrow} E+F*id \underset{rm}{\Rightarrow} E+id*id \underset{rm}{\Rightarrow} T+id*id \underset{rm}{\Rightarrow} F+id*id \underset{rm}{\Rightarrow} id+id*id$

stmt → if expr then stmt |
if expr then stmt else stmt |
other

expr → ....

if E_2 then if E_2 then S_1 else S_2



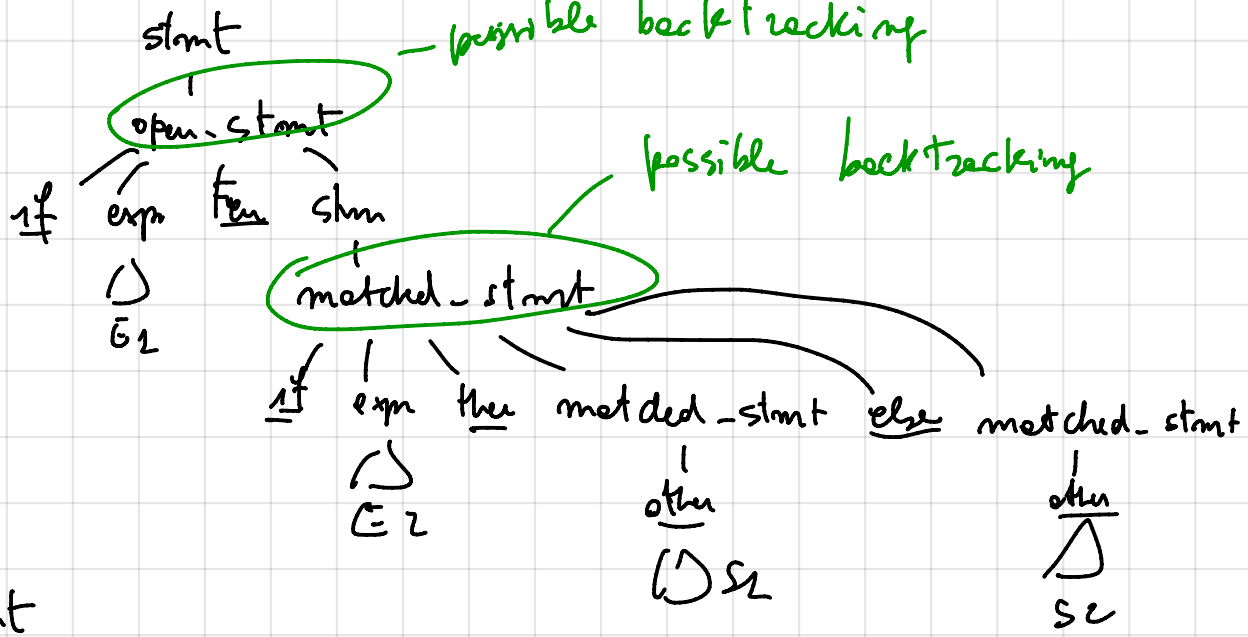
stmt → matched-stmt | open-stmt

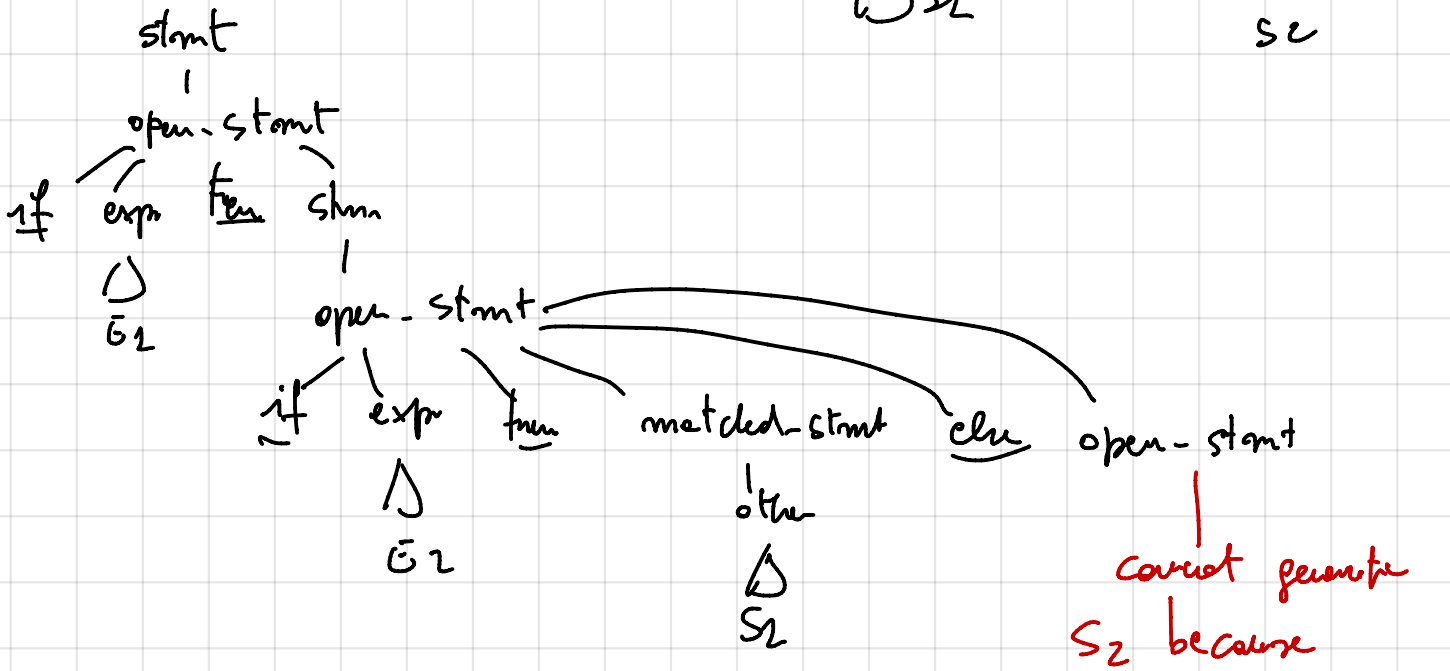
matched-stmt → other | if expr then matched-stmt else matched-stmt

open-stmt → if expr then stmt |

if expr then matched-stmt else open-stmt

if E_2 then if E_2 then S_1 else S_2





correct because S_2 is, by hypothesis, not a Conditional stmt

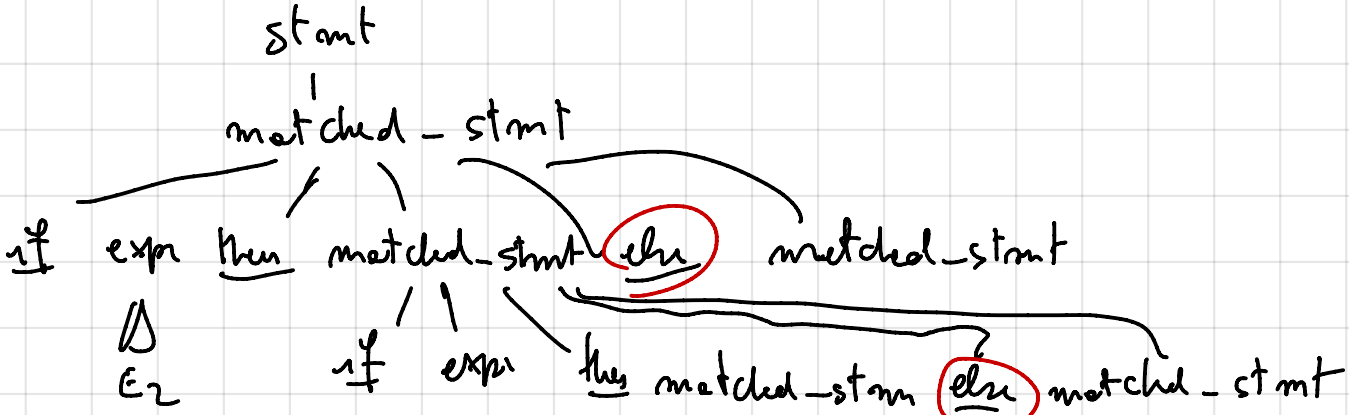
stmt → matched-stmt | open-stmt

matched-stmt → other | if expr then matched-stmt else matched-stmt

open-stmt → if expr then stmt |

if expr then matched-stmt else open-stmt

if E_2 then if E_2 then S_1 else S_2



$L = \{ a^n b^m c^k \mid n = m \ \underline{OR} \ m = k \ ; \ n, m, k \geq 0 \}$

$S \to S_1 C \mid A S_2$

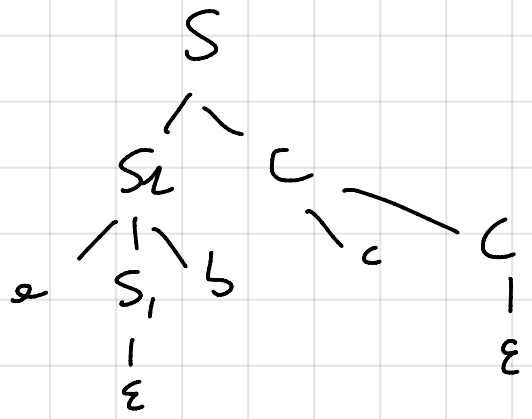
$S_1 \to a S_1 b \mid \varepsilon$

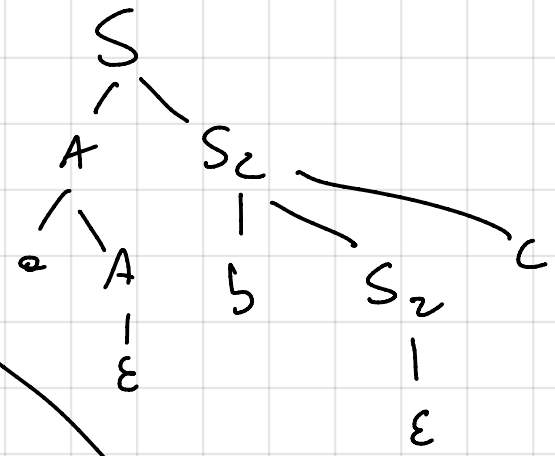
$S_2 \to b S_2 c \mid \varepsilon$

$A \to a A \mid \varepsilon$

$C \to c C \mid \varepsilon$

abc





$L_1 = \{ a^n b^n c^m \mid n \neq m \}$

non-context-free language

$L_2 = \{ a^n b^n c^n \mid n \geq 0 \}$

$L_3 = \{ a^n b^m c^n d^m \mid n, m \geq 0 \}$

- it does not exist any context-free grammer

$S \to SS+ \mid SS* \mid a$

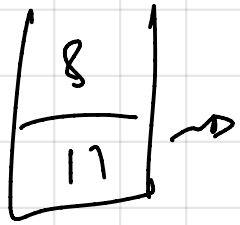
aa+a*

2) lm derivation for aa+a*

$S \Rightarrow_{lm} SS* \Rightarrow_{lm} SS+S* \Rightarrow_{lm} aS+S* \Rightarrow_{lm} aa+S* \Rightarrow_{lm} aa+a*$

5 6 + 8 * $ ≈

6 + 5 = 11

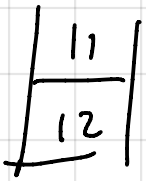


8 * 11 = 88

(5 + 6) * 8

8 * (6 + 5)

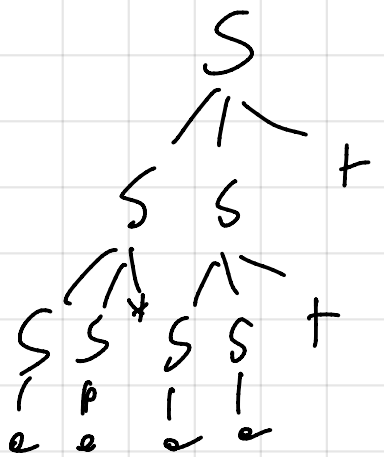
6 6 + 11 ~

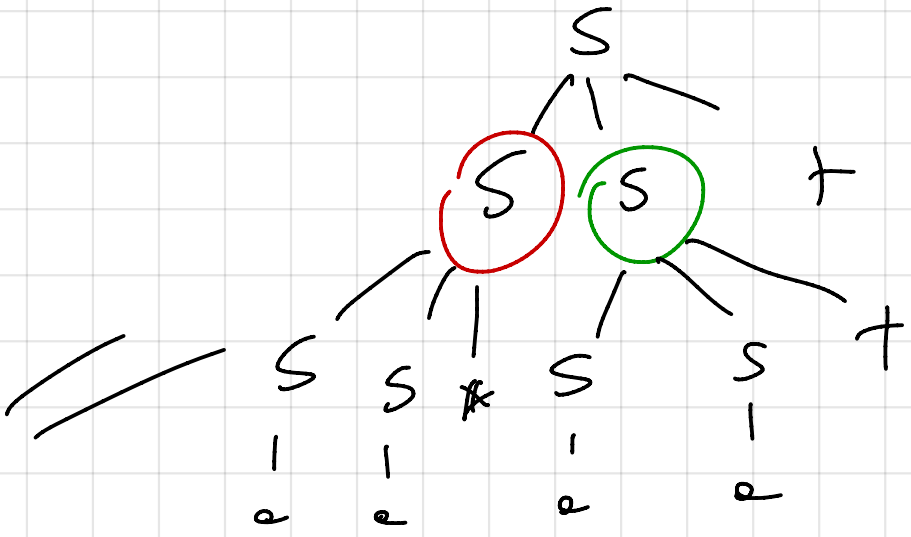


11 6 6 + /

$S \to SS+ \mid SS* \mid a$

aa * aa + +





$L = \{ w \in \{0,1\}^* \mid w \text{ is palindrom} \}$

0 1 1 1 0 　　1 0 1 1 0 1

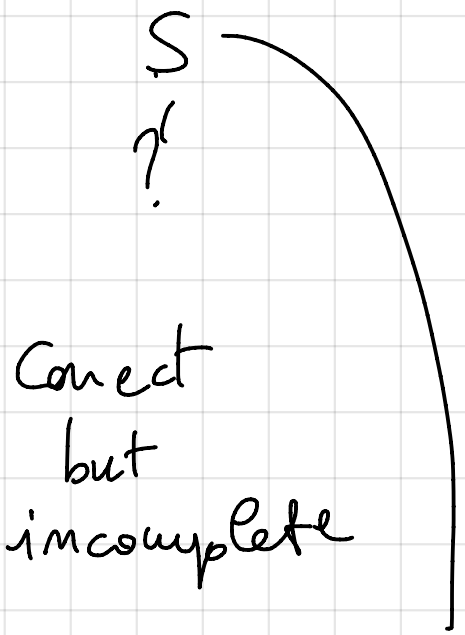
$S \to 0S0 \mid 1S1 \mid 1 \mid 0 \mid \varepsilon$

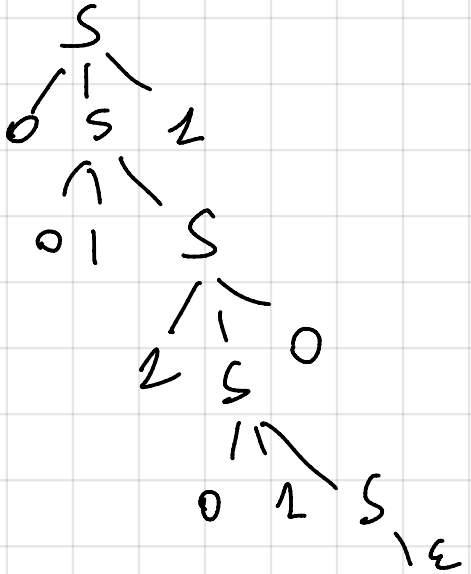
$L = \{ w \in \{0,1\}^* \mid w \text{ contains the same occurences of 0s and 1s} \}$

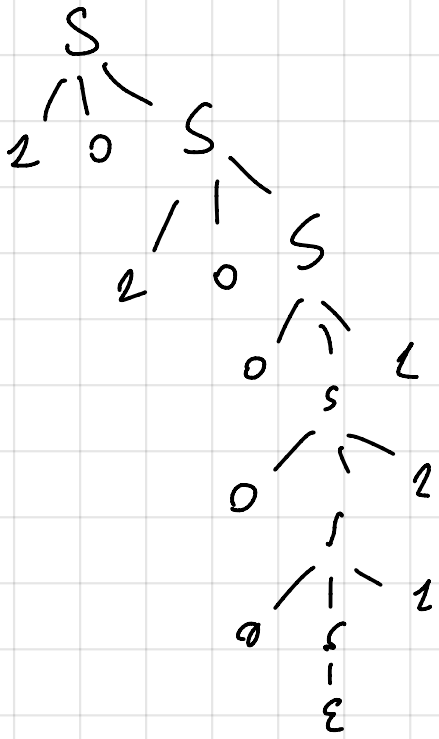
0 0 1 1 0 1 0 1 *

1 0 1 0 0 0 0 1 1

$S \to 0S1 \mid 1S0 \mid 0S1 \mid \varepsilon \mid 10S \mid S01 \mid S10$







0 0 1 1 1 1 0 0

$S \rightarrow 1S0S \mid 0S1S \mid \varepsilon$

$S_2 \rightarrow (S_2)S_2 \mid \varepsilon$