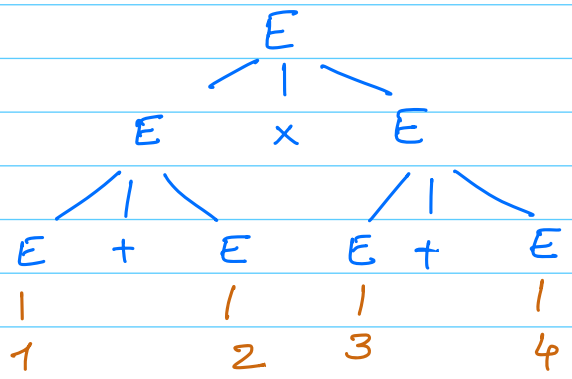
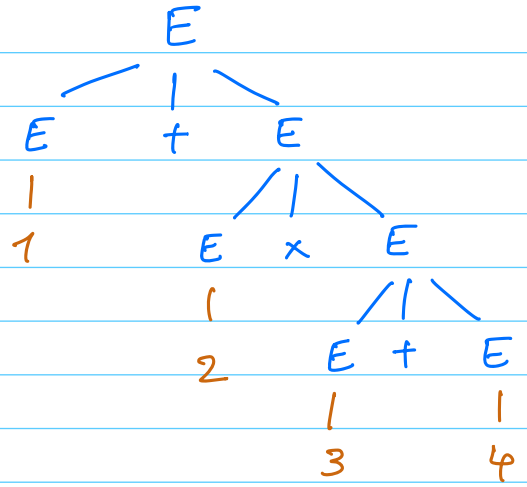
leftmost derivations: Each time expand the left-most non-terminal using a production rule.

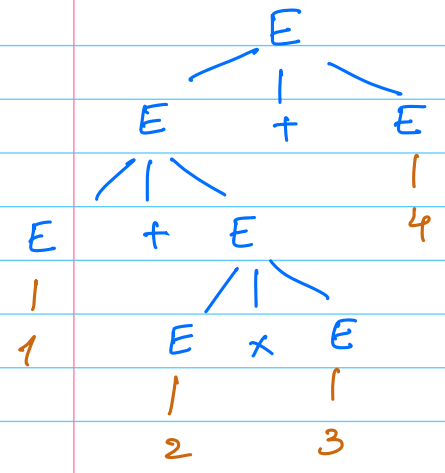
$E \to E+E \mid E \times E \mid 0 \mid 1 \mid 2 \mid \ldots \mid 9$ [1+2x3+4]



parsed as (1+2) x (3+4)



parsed as 1+ 2x (3+4)



parsed as 1+ (2x3) +4

A CFG is ambiguous if it has more than one leftmost derivation

$E \rightarrow E + T \mid T$

$T \rightarrow T \times F \mid F$

$F \rightarrow 0 \mid 1 \mid 2 \mid \ldots \mid 9$

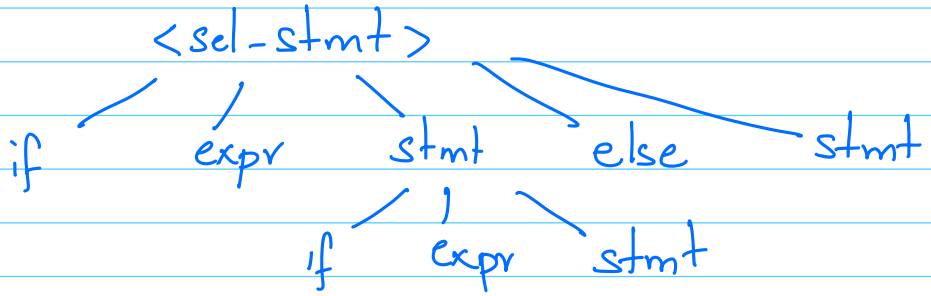
} Implements the precedence of the operators

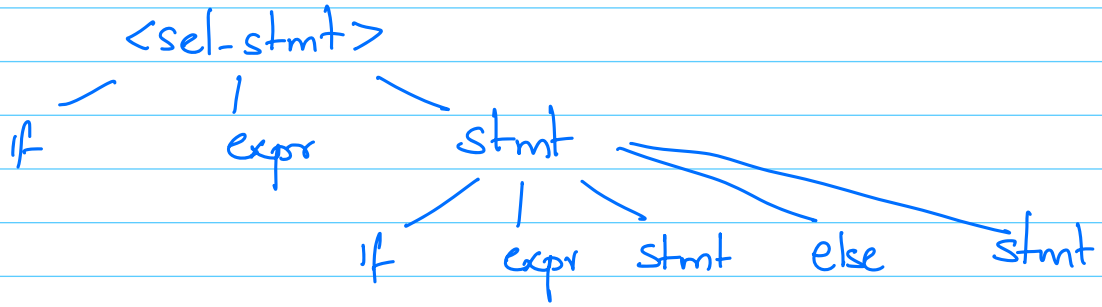
Dangling else

<sel-stmt> := if (<expr>) <stmt> |

if (<expr>) <stmt> else <stmt>

if _ if _ else _





<stmt> := <matched> | <unmatched>

<matched> := if <expr> <matched> else <matched>

<matched> := <non-sel-stmt>

<unmatched> := if <expr> <stmt> |
if <expr> <matched> else <unmatched>

Inherently ambiguous languages

$L = \{ a^i b^j c^k d^l \mid i=j \text{ and } k=l \text{ or } i=l \text{ and } j=k \}$

Closure properties

- Union $S \to S_1 \mid S_2$

$S_1 \to \ldots$ $S_2 \to \ldots$

- Concatenation $S \to S_1 \cdot S_2$

$S_1 \to \ldots$ $S_2 \to \ldots$

- Kleene closure $S \to SS_1 \mid \varepsilon$

$S_1 \to \ldots$

Not closed under intersection and complementation