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Sebesta Chapter 3

3. Rewrite the BNF example 3.4 to give + precedence over * and force + to be right associative.

$\langle \text{assign} \rangle \rightarrow \langle \text{id} \rangle = \langle \text{expr} \rangle$

$\langle \text{id} \rangle \rightarrow A \mid B \mid C$

$\langle \text{expr} \rangle \rightarrow \langle \text{expr} \rangle * \langle \text{term} \rangle \mid \langle \text{term} \rangle$

$\langle \text{term} \rangle \rightarrow \langle \text{factor} \rangle + \langle \text{term} \rangle \mid \langle \text{factor} \rangle$

$\langle \text{factor} \rangle \rightarrow (\langle \text{expr} \rangle) \mid \langle \text{id} \rangle$

4. Rewrite the BNF of example 3.4 to add the ++ and -- unary operators of Java.

$\langle \text{assign} \rangle \rightarrow \langle \text{id} \rangle = \langle \text{expr} \rangle$

$\langle \text{id} \rangle = A \mid B \mid C.$

$\langle \text{expr} \rangle \rightarrow \langle \text{expr} \rangle + \langle \text{term} \rangle \mid \langle \text{term} \rangle$

$\langle \text{term} \rangle \rightarrow \langle \text{term} \rangle * \langle \text{factor} \rangle \mid \langle \text{factor} \rangle$

$\langle \text{factor} \rangle \rightarrow (\langle \text{expr} \rangle) \mid \langle \text{term} \rangle ++ \mid \langle \text{term} \rangle -- \mid ++\langle \text{term} \rangle \mid --\langle \text{term} \rangle \mid \langle \text{id} \rangle$

6. Using the grammar in Example 3.2, show a parse tree and a leftmost derivation for each of the following statements:

a. $A = A * (B + (C * A))$

$\langle \text{assign} \rangle \Rightarrow \langle \text{id} \rangle = \langle \text{expr} \rangle$

$\Rightarrow A = \langle \text{expr} \rangle$

$\Rightarrow A = \langle \text{id} \rangle * \langle \text{expr} \rangle$

$\Rightarrow A = A * \langle \text{expr} \rangle$

$\Rightarrow A = A * (\langle \text{expr} \rangle)$

$\Rightarrow A = A * (\langle \text{id} \rangle + \langle \text{expr} \rangle)$

$\Rightarrow A = A * (B + \langle \text{expr} \rangle)$

$\Rightarrow A = A * (B + (\langle \text{expr} \rangle))$

$\Rightarrow A = A * (B + (\langle \text{id} \rangle * \langle \text{expr} \rangle))$

$\Rightarrow A = A * (B + (C * \langle \text{expr} \rangle))$

$\Rightarrow A = A * (B + (C * \langle \text{id} \rangle))$

$\Rightarrow A = A * (B + (C * A))$

*b. $B = C * (A * C + B)$*

$\langle \text{assign} \rangle \Rightarrow \langle \text{id} \rangle = \langle \text{expr} \rangle$

$\Rightarrow B = \langle \text{expr} \rangle$

$\Rightarrow B = \langle \text{id} \rangle * \langle \text{expr} \rangle$

$\Rightarrow B = C * \langle \text{expr} \rangle$

$\Rightarrow B = C * (\langle \text{expr} \rangle)$

$\Rightarrow B = C * (\langle \text{id} \rangle * \langle \text{expr} \rangle)$

$\Rightarrow B = C * (A * \langle \text{expr} \rangle)$

$\Rightarrow B = C * (A * \langle \text{id} \rangle + \langle \text{expr} \rangle)$

$\Rightarrow B = C * (A * C + \langle \text{expr} \rangle)$

$\Rightarrow B = C * (A * C + \langle \text{id} \rangle)$

$\Rightarrow B = C * (A * C + B)$

*c. $A = A * (B + (C))$*

$\langle \text{assign} \rangle \Rightarrow \langle \text{id} \rangle = \langle \text{expr} \rangle$

$\Rightarrow A = \langle \text{expr} \rangle$

$\Rightarrow A = \langle \text{id} \rangle * \langle \text{expr} \rangle$

$\Rightarrow A = A * \langle \text{expr} \rangle$

$\Rightarrow A = A * (\langle \text{expr} \rangle)$

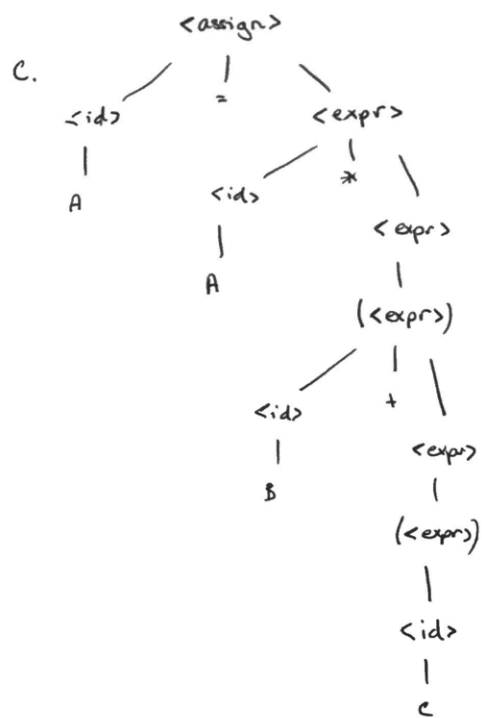
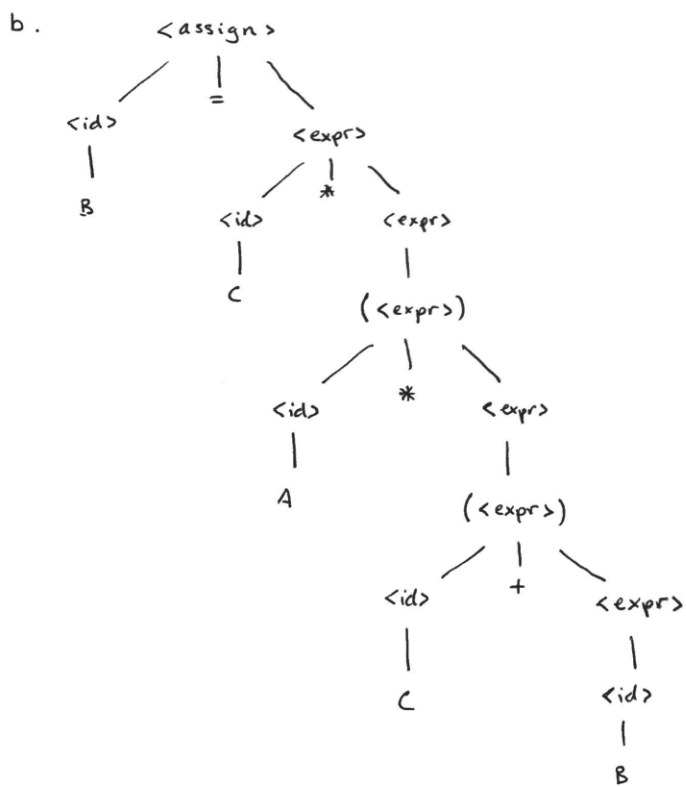
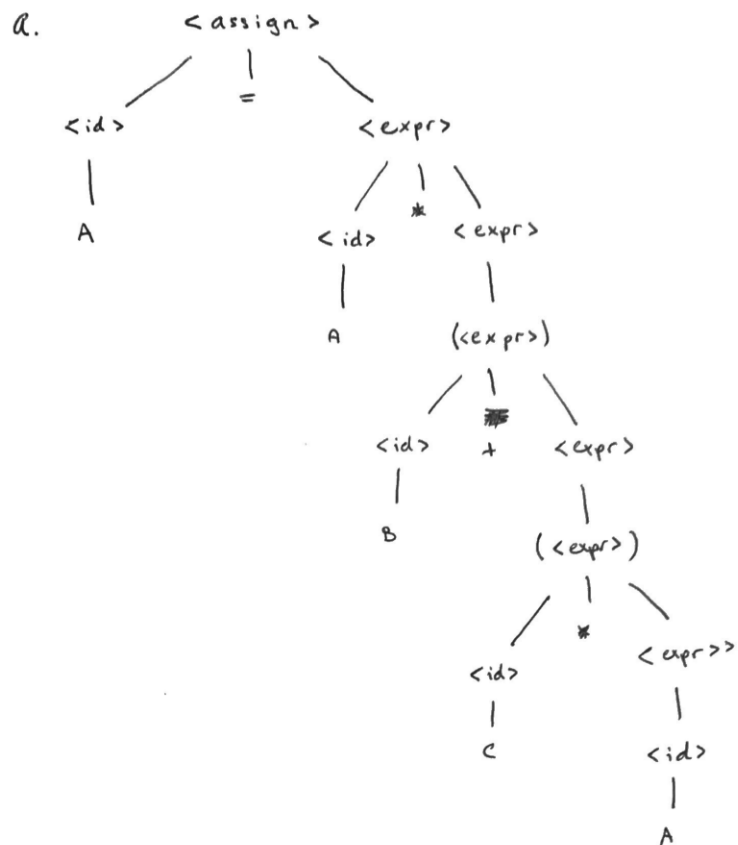
$\Rightarrow A = A * (\langle \text{id} \rangle + \langle \text{expr} \rangle)$

$\Rightarrow A = A * (B + \langle \text{expr} \rangle)$

$\Rightarrow A = A * (B + (\langle \text{expr} \rangle))$

$\Rightarrow A = A * (B + (\langle \text{id} \rangle))$

$\Rightarrow A = A * (B + (C))$



7.

$$a. A = (A + B) * C$$

$\langle \text{assign} \rangle \Rightarrow \langle \text{id} \rangle = \langle \text{expr} \rangle$

$\Rightarrow A = \langle \text{expr} \rangle$

$\Rightarrow A = \langle \text{term} \rangle$

$\Rightarrow A = \langle \text{term} \rangle * \langle \text{factor} \rangle$

$\Rightarrow A = \langle \text{factor} \rangle * \langle \text{factor} \rangle$

$\Rightarrow A = (\langle \text{expr} \rangle) * \langle \text{factor} \rangle$

$\Rightarrow A = (\langle \text{expr} \rangle + \langle \text{term} \rangle) * \langle \text{factor} \rangle$

$\Rightarrow A = (\langle \text{term} \rangle + \langle \text{term} \rangle) * \langle \text{factor} \rangle$

$\Rightarrow A = (\langle \text{factor} \rangle + \langle \text{term} \rangle) * \langle \text{factor} \rangle$

$\Rightarrow A = (\langle \text{id} \rangle + \langle \text{term} \rangle) * \langle \text{factor} \rangle$

$\Rightarrow A = (A + \langle \text{term} \rangle) * \langle \text{factor} \rangle$

$\Rightarrow A = (A + \langle \text{factor} \rangle) * \langle \text{factor} \rangle$

$\Rightarrow A = (A + \langle \text{id} \rangle) * \langle \text{factor} \rangle$

$\Rightarrow A = (A + B) * \langle \text{factor} \rangle$

$\Rightarrow A = (A + B) * \langle \text{id} \rangle$

$\Rightarrow A = (A + B) * C$

$$b. A = B + C + A$$

$\langle \text{assign} \rangle \Rightarrow \langle \text{id} \rangle = \langle \text{expr} \rangle$

$\Rightarrow A = \langle \text{expr} \rangle$

$\Rightarrow A = \langle \text{expr} \rangle + \langle \text{term} \rangle$

$\Rightarrow A = \langle \text{term} \rangle + \langle \text{term} \rangle$

$\Rightarrow A = \langle \text{factor} \rangle + \langle \text{term} \rangle$

$\Rightarrow A = \langle \text{id} \rangle + \langle \text{term} \rangle$

$\Rightarrow A = B + \langle \text{term} \rangle$

$\Rightarrow A = B + \langle \text{factor} \rangle$

$\Rightarrow A = B + \langle \text{expr} \rangle$

$\Rightarrow A = B + \langle \text{expr} \rangle + \langle \text{term} \rangle$

$\Rightarrow A = B + \langle \text{term} \rangle + \langle \text{term} \rangle$

$\Rightarrow A = B + \langle \text{factor} \rangle + \langle \text{term} \rangle$

$\Rightarrow A = B + \langle \text{id} \rangle + \langle \text{term} \rangle$

$\Rightarrow A = B + C + \langle \text{term} \rangle$

$\Rightarrow A = B + C + \langle \text{factor} \rangle$

$\Rightarrow A = B + C + \langle \text{id} \rangle$

$\Rightarrow A = B + C + A$

c. $A = A * (B + C)$

$\langle \text{assign} \rangle \Rightarrow \langle \text{id} \rangle = \langle \text{expr} \rangle$

$\Rightarrow A = \langle \text{expr} \rangle$

$\Rightarrow A = \langle \text{term} \rangle$

$\Rightarrow A = \langle \text{term} \rangle * \langle \text{factor} \rangle$

$\Rightarrow A = \langle \text{factor} \rangle * \langle \text{factor} \rangle$

$\Rightarrow A = \langle \text{id} \rangle * \langle \text{factor} \rangle$

$\Rightarrow A = A * \langle \text{factor} \rangle$

$\Rightarrow A = A * (\langle \text{expr} \rangle)$

$\Rightarrow A = A * (\langle \text{expr} \rangle + \langle \text{term} \rangle)$

$\Rightarrow A = A * (\langle \text{term} \rangle + \langle \text{term} \rangle)$

$\Rightarrow A = A * (\langle \text{factor} \rangle + \langle \text{term} \rangle)$

$\Rightarrow A = A * (\langle \text{id} \rangle + \langle \text{term} \rangle)$

$\Rightarrow A = A * (B + \langle \text{term} \rangle)$

$\Rightarrow A = A * (B + \langle \text{factor} \rangle)$

$\Rightarrow A = A * (B + \langle \text{id} \rangle)$

$\Rightarrow A = A * (B + C)$

d. $A = B * (C * (A + B))$

$\langle \text{assign} \rangle \Rightarrow \langle \text{id} \rangle = \langle \text{expr} \rangle$

$\Rightarrow A = \langle \text{expr} \rangle$

$\Rightarrow A = \langle \text{term} \rangle$

$\Rightarrow A = \langle \text{term} \rangle * \langle \text{factor} \rangle$

=> A = <factor> * <factor>

=> A = <id> * <factor>

=> A = B * <factor>

=> A = B * (<expr>)

=> A = B * (<term>)

=> A = B * (<term> * <factor>)

=> A = B * (<factor> * <factor>)

=> A = B * (<id> * <factor>)

=> A = B * (C * <factor>)

=> A = B * (C * (<expr>))

=> A = B * (C * (<expr> + <term>))

=> A = B * (C * (<term> + <term>))

=> A = B * (C * (<factor> + <term>))

=> A = B * (C * (<id> + <term>))

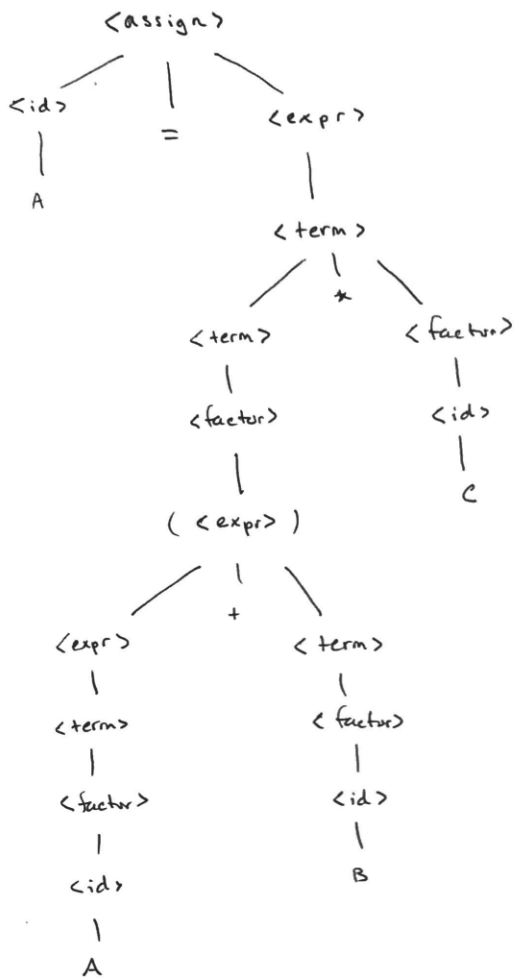
=> A = B * (C * (A + <term>))

=> A = B * (C * (A + <factor>))

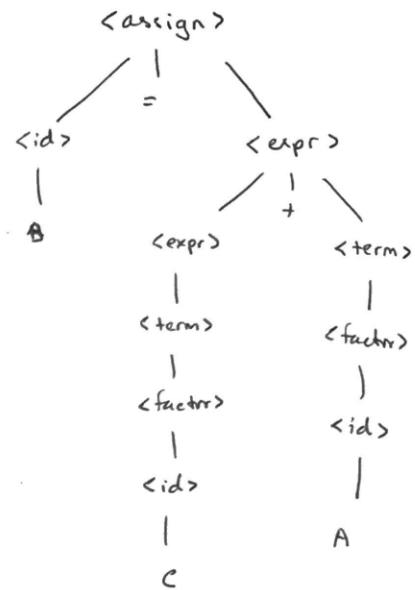
=> A = B * (C * (A + <id>))

=> A = B * (C * (A + B))

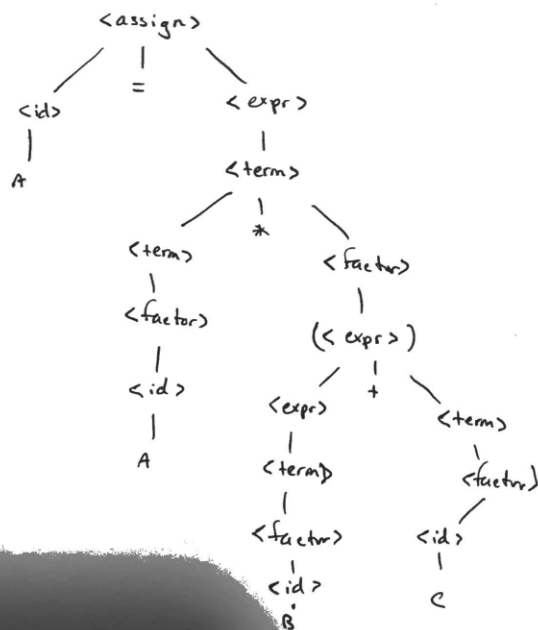
a.



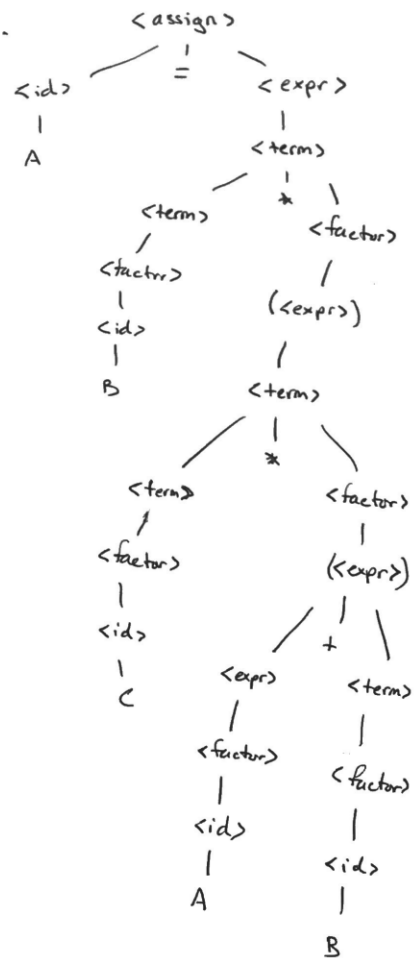
b.



c.



d.



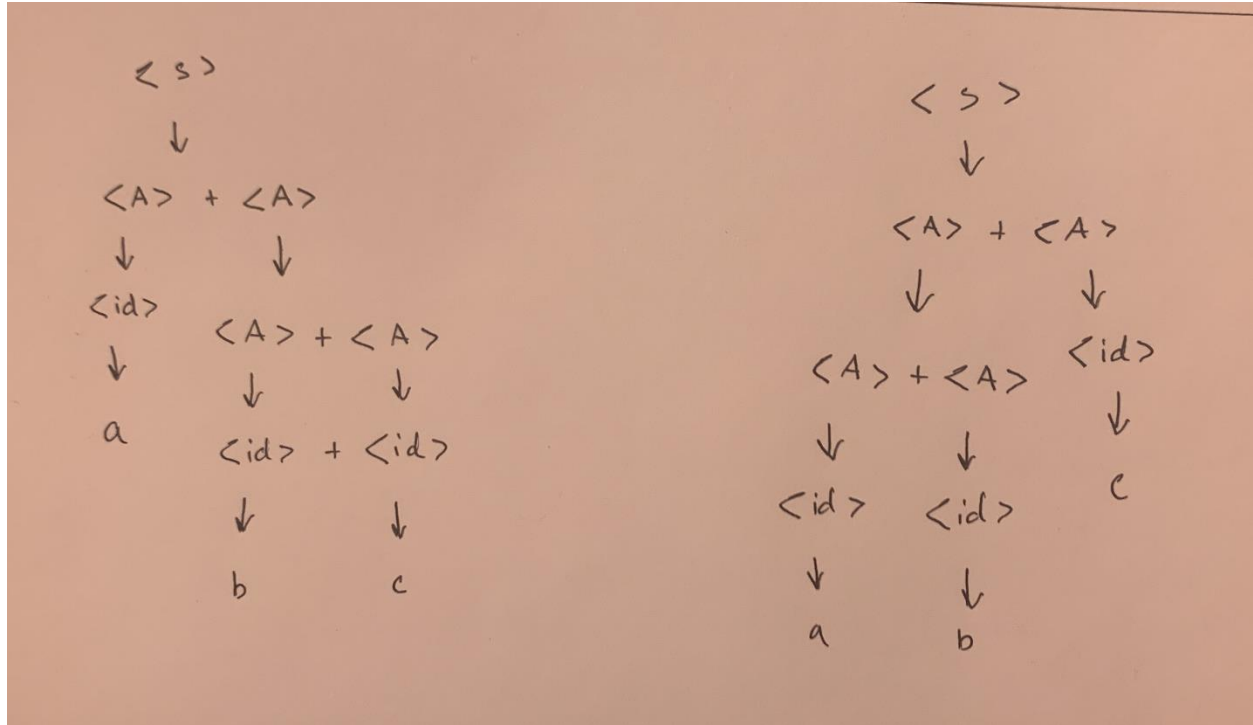
8. Prove that the following grammar is ambiguous:

$\langle S \rangle \rightarrow \langle A \rangle$

$\langle A \rangle \rightarrow \langle A \rangle + \langle A \rangle \mid \langle id \rangle$

$\langle id \rangle \rightarrow a \mid b \mid c$

This grammar is ambiguous because the same sentence can be produced by two or more different parse trees. For example, the sentence "a + b + c" can be produced by:



11. Consider the following grammar:

$\langle S \rangle \rightarrow \langle A \rangle a \langle B \rangle b$

$\langle A \rangle \rightarrow \langle A \rangle b \mid b$

$\langle B \rangle \rightarrow a \langle B \rangle \mid a$

Which of the following sentences are in the language generated by this grammar?

a. baab (Yes)

b. bbbab (No)

c. bbaaaaa (No)

d. bbaab (Yes)

12. Consider the following grammar:

$\langle S \rangle \rightarrow a \langle S \rangle c \langle B \rangle \mid \langle A \rangle \mid b$

$\langle A \rangle \rightarrow c \langle A \rangle \mid c$

$\langle B \rangle \rightarrow d \mid \langle A \rangle$

Which of the following sentences are in the language generated by this grammar?

a. abcd (Yes)

b. acccbd (No)

c. acccbcc (No)

d. acd (No)

e. accc (Yes)

13. Write a grammar for the language consisting of strings that have n copies of the letter a followed by the same number of copies of the letter b , where $n > 0$. For example, the strings ab , $aaaabbbb$, and $aaaaaaaaabbbbbbb$ are in the language, but a , abb , ba and $aaabb$ are not.

$\langle S \rangle \rightarrow a \langle S \rangle b \mid ab$

14. Draw parse trees for the sentences $aabb$ and $aaaabbbb$, as derived from the grammar of problem 13.

