Syntax and semantics - The Basic Principles of SOS

1 Learning Objectives

1. Abstract syntax - BIMS.
2. Transition Systems.
3. Big-Step Semantics for AEXP; derivation trees.
4. Small-Step Semantics for AEXP; derivation trees.
5. Determinacy.

2 Readings

Hüttel's book:
Part II – First Examples, Chapter 3. The basic Principles

3 Homework - Exercises

Exercise 1. This exercise is about big-step semantics of commands. Evaluate the following expressions and describe the derivation trees

$$\texttt{(}\underline{3}\texttt{+}\underline{12}\texttt{)*(}\underline{4}\texttt{*(}\underline{5}\texttt{*}\underline{8}\texttt{))}$$

$$\texttt{(}\underline{3}\texttt{+(}\underline{12}\texttt{*}\underline{4}\texttt{))*(}\underline{5}\texttt{*}\underline{8}\texttt{))}$$

$$\texttt{(}\underline{3}\texttt{+(}\underline{12}\texttt{))*((}\underline{4}\texttt{)*(}\underline{5}\texttt{*}\underline{8}\texttt{))}$$

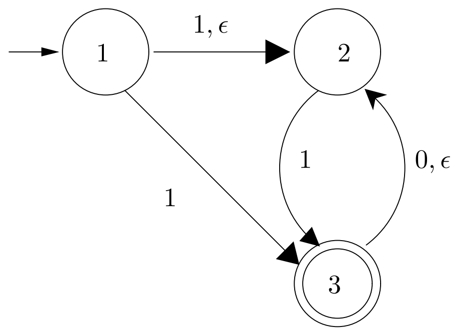
Exercise 2. Suggest a new small-step semantics of **Aexp**, which is *deterministic*. *Hint:* Use syntax-driven rules to ensure the evaluation is always from left to right.

Exercise 3. Give a big-step semantics for BEXP for the case

$$b ::= \ a_1 = a_2 \mid a_1 < a_2 \mid \neg b_1 \mid b_1 \wedge b_2 \mid (b_1)$$

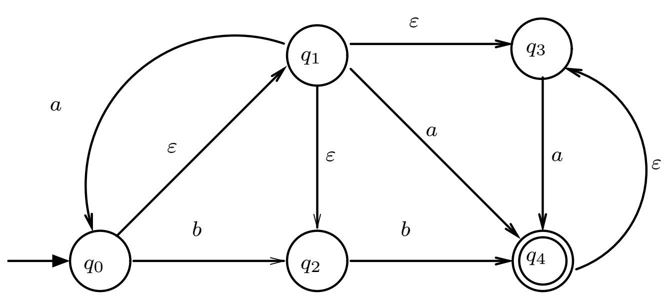
assuming that we have defined a big-step semantics $\longrightarrow_A$ for AEXP.

Exercise 4. Consider the following non-deterministic automaton.



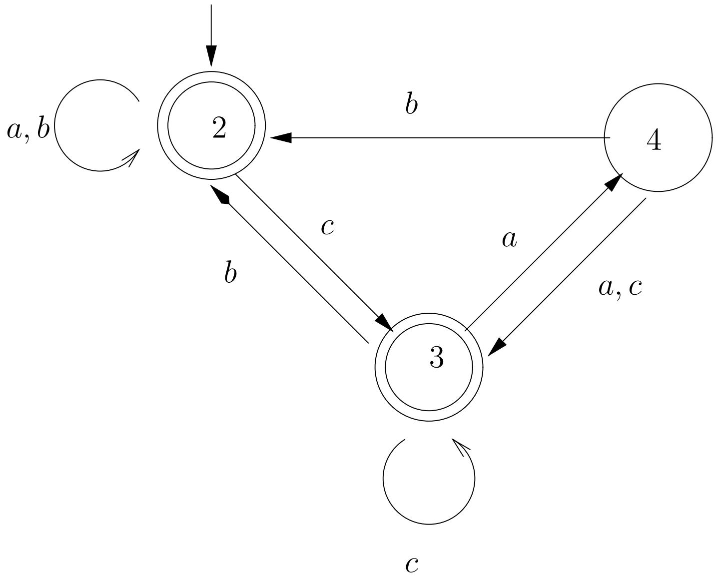
Convert this NFA to a DFA.

Exercise 5. Consider the above non-deterministic automaton:



Convert this NFA to a DFA.

Exercise 6. Consider the following DFA:



Define a regular expression equivalent to the DFA. *You must only use the textbook's method, i.e., no ad hoc solutions and "smart" shortcuts.*

Exercise 7. Consider the regular expression

$$(\texttt{bc} \cup \texttt{aaa})^* .$$

Construct, by using the book's algorithm, an NFA which is equivalent to this regular expression. *No ad hoc solution or "smart shortcuts".*

Exercise 8. Consider the language L_1 defined by

$$L_1 = \{a^k b^{2k} \mid k \geq 0\}$$

Prove that L_1 is context-free

Exercise 9. Consider the following language

$$L_1 = \{w \in \{a, b\}^* \mid w \text{ is a palindrome}\}$$

A palindrome is a string that is the same both read backwards and forwards. Examples of palindromes are *abba* and *bbb* whereas *ab* is not a palindrome.

Prove that L_1 is context-free.