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INFO-F-403 – Introduction to language theory and compiling
First session examination

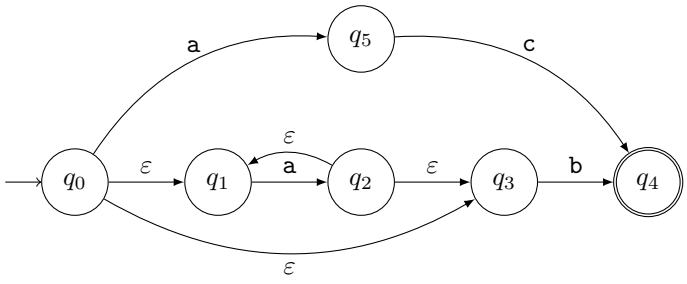
January, 6th, 2015

Instructions

— This is a closed book test. You are not allowed to use any kind of reference.
— You can anwser in French or in English.
— Write your first and last names on each sheet that you hand in.
— Write clearly: you can use a pencil or a ballpen or even a quill as long as your answers are readable!
— Always provide full and rigourous justifications along with your answers.
— This test is worth 12 points out of 20. The weight of each questions is given as a reference.
— In your answers (diagrams representing automata, grammars,. . .), you can always use the conventions adopted in the course, without recalling them explicitely. If you deviate from these conventions, be sure to make it clear.

Question 1 — 3 points

1. Give a formal definition of the ε-closure (denoted eclose or εclosure) of a state q of an ε-NFA $\langle Q, \Sigma, \delta, q_0, F\rangle$.
2. Compute the ε-closure of all states in the following ε-NFA (on alphabet $\{\mathtt{a}, \mathtt{b}, \mathtt{c}\}$):



3. Based on the computation of the ε-closure you have given above, convert this ε-NFA into an equivalent DFA.

Question 2 — 2 points

1. Explain what is the *semantic analysis* phase of a compiler, and how it interracts with the other phases of the compiler.
2. Explain two checks that are performed on the input code during semantic analysis, using examples to support your explanations.
3. Explain briefly one formal tool that can be used during semantic analysis.

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Question 3 — 2 points

1. Give an example of a context-free language which is not regular.
2. Prove that this language is context-free by giving either a context-free grammar or a pushdown automaton recognising it.
3. Explain intuitively why this language is not regular.
4. Give an example of a context-sensitive language which is not context-free and explain intuitively why it is not context-free.

Question 4 — 2 points

1. Give the formal definition of a *strongly LL(1) grammar*, and explain it intuitively.
2. Is the following grammar strongly LL(1)? Justify your answer, (preferably using the definition you have given above).

(1)	S	$\rightarrow$	Ab
(2)	A	$\rightarrow$	B
(3)		$\rightarrow$	c
(4)		$\rightarrow$	ε
(5)	B	$\rightarrow$	b

3. If the grammar is not LL(1) give an equivalent LL(1) grammar, or explain why it is not possible.

Question 5 — 3 points

1. Give the LR(1) canonical finite state machine (CFSM) of the following grammar (where the set of variables is $\{S', S, A, B, C\}$ and the set of terminals is $\{a, b, c, d\}$):

(1)	S'	$\rightarrow$	$S\$$
(2)	S	$\rightarrow$	aAb
(3)		$\rightarrow$	aA
(4)		$\rightarrow$	c
(5)	A	$\rightarrow$	dA
(6)		$\rightarrow$	a
(7)	B	$\rightarrow$	bC
(8)	C	$\rightarrow$	ε

2. Give the action table of the LR(1) parser.
3. Is this grammar SLR(1)? Justify your answer.