Computer Science Comprehensive Exam—Spring 2006
Compiler Construction

Instructions: Do *not* put your name on the exam, please answer all the questions directly on the exam itself. Answer **all** the questions. Explain answers as fully as possible, give examples or define terms, if appropriate.

1. What is dataflow analysis and how is it used in a compiler?

2. Do all reasonable programming languages have a LALR(1) grammar? Explain.

3. Refer to the DFA in the "appendix." Suppose it were used by a lexer to find tokens in an input file.

   (a) How many characters past the end of a token might the lexer have to examine before matching the token?

   (b) Suppose your answer is k to part (a), show an input file containing at least two tokens such the the first token returned by the lexer will examine k characters past the end of the first token before returning the first token. Indicate clearly the endpoint of each token in the input file.

4. What is the relationship between the set, S, of ambiguous grammars and the set of LL(1) grammars? Circle the best response.

   (a) S is a subset of LL(1)
   (b) LL(1) is a subset of S
   (c) Their intersection is non-empty
   (d) Their intersection is empty
   (e) They are the same

5. What is the relationship between the set of LR(2) grammars and the set of LR(4) grammars? Circle the best response.

   (a) LR(2) is a subset of LR(4)
   (b) LR(2) is a subset of LR(4)
   (c) Their intersection is non-empty
   (d) Their intersection is empty
   (e) They are the same

6. What is the relationship between the set of LR(1) grammars and the set of LL(2) grammars? Circle the best response.

   (a) LR(1) is a subset of LL(2)
   (b) LR(1) is a subset of LL(2)
   (c) Their intersection is non-empty
   (d) Their intersection is empty
   (e) They are the same

7. What is the relationship between the set, S, of ambiguous grammars and the set, T, of unambiguous grammar? Circle the best response.

   (a) S is a subset of T
   (b) T is a subset of S
   (c) Their intersection is non-empty
   (d) Their intersection is empty
   (e) They are the same

8. Rewrite this grammar so that it is LL(1).

$$
\begin{array}{ll}
0 & S' \to E\,\$ \\
1 & S \to E{+}T \\
2 & S \to T \\
3 & T \to \mathbf{t}
\end{array}
$$

Do the following for the *rewritten* grammar:

(a) Compute nullable, FIRST, and FOLLOW for all nonterminals of the grammar.

(b) For each production $A \to \alpha$ compute the FIRST of α.

(c) Compute and show the LL(1) parsing table.

9. Consider the algorithm to compute CLOSE[I] for the set of LR(1) items I for some grammar. Suppose the grammar contains the production $X \rightarrow \gamma$ where X is some non-terminal and γ is some string of terminals and non-terminals. Answer the following questions assuming A is some non-terminal, α and β are strings of terminals and non-terminals, and y and z are terminal symbols.

   (a) If $A \rightarrow \alpha \bullet X$, z is in I, which item or items (if any) would be added to CLOSE[I]?

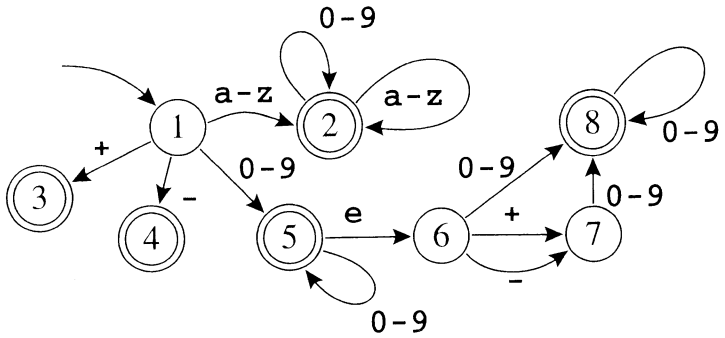
   (b) If $A \rightarrow \alpha \bullet Xy$, z is in I, which item or items (if any) would be added to CLOSE[I]?

   (c) If $A \rightarrow \alpha \bullet X\beta$, z is in I, which item or items (if any) would be added to CLOSE[I]?

10. Consider the grammar:

$$
\begin{array}{rlll}
0 & S' & \rightarrow & S\,\$ \\
1 & S & \rightarrow & V = E \\
2 & S & \rightarrow & E \\
3 & E & \rightarrow & V \\
4 & V & \rightarrow & \textbf{id} \\
5 & V & \rightarrow & \textbf{*}\,E
\end{array}
$$

Refer to the LR(1) automaton for the grammar given in the "appendix." Give the LR(1) parsing table for the grammar.


0-9
a-z
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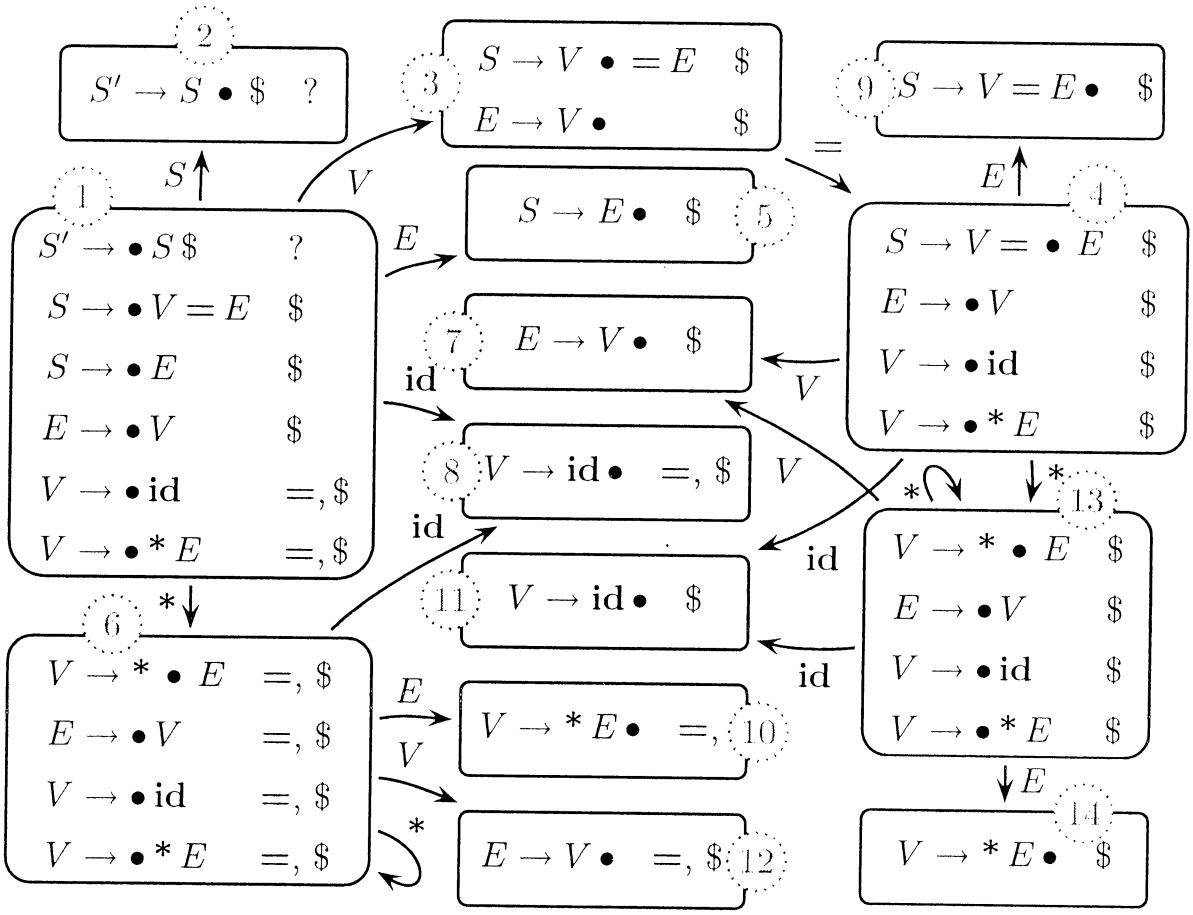
2
$S' \to S \bullet \$$?
3
$S \to V \bullet = E$ $
$E \to V \bullet$ $
9
$S \to V = E \bullet$ $
S
V
=
E
1
$S' \to \bullet S \$$?
$S \to \bullet V = E$ $
$S \to \bullet E$ $
$E \to \bullet V$ $
$V \to \bullet \mathrm{id}$ =, $
$V \to \bullet * E$ =, $
E
$S \to E \bullet$ $
5
4
$S \to V = \bullet E$ $
$E \to \bullet V$ $
$V \to \bullet \mathrm{id}$ $
$V \to \bullet * E$ $
7
$E \to V \bullet$ $
id
V
8
$V \to \mathrm{id} \bullet$ =, $
V
*
*
13
$V \to * \bullet E$ $
$E \to \bullet V$ $
$V \to \bullet \mathrm{id}$ $
$V \to \bullet * E$ $
id
id
11
$V \to \mathrm{id} \bullet$ $
id
6
*
$V \to * \bullet E$ =, $
$E \to \bullet V$ =, $
$V \to \bullet \mathrm{id}$ =, $
$V \to \bullet * E$ =, $
E
V
*
$V \to * E \bullet$ =, 10
$E \to V \bullet$ =, $ 12
E
14
$V \to * E \bullet$ $