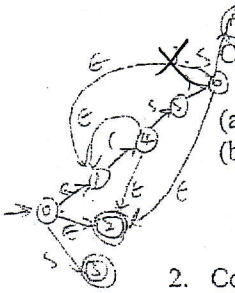


1. Consider the following language
$$L = \{a^n b a^n \mid n \geq 0\}$$
(a) [10] Is L regular? Prove or disprove it.
(b) [10] Construct a NFA or pushdown automata that recognizes L

2. Consider NFA N in Figure 1
(a) [10] Use the subset construction algorithm to find all possible sets of states
(b) [5] Build a DFA D that accepts the same language as the NFA N

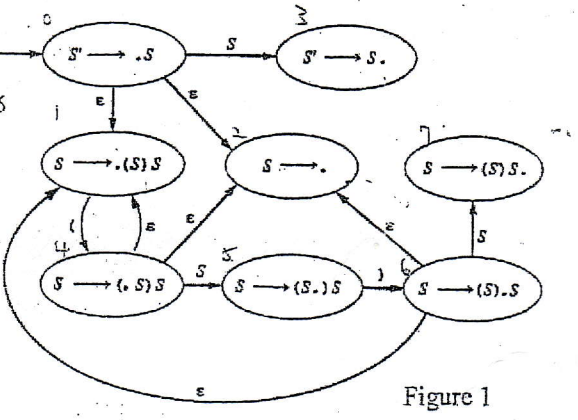


Figure 1

3. Consider the following grammar G
$$S \rightarrow ABd$$
$$A \rightarrow aA \mid \epsilon$$
$$B \rightarrow b \mid cA$$
(a) [5] What is the language generated by G
(b) [10] Write down the FIRST and FOLLOW sets for all nonterminals of G
(c) [10] Show the predictive parsing table of G
(d) [5] Show the process of parsing a string in L(G) by the predictive parser

4. Consider the following grammar G
$$S \rightarrow (S)S \mid \epsilon$$
(a) [10] Find all the possible sets of LR(0) items
(b) [10] Compute the SLR(1) parsing table for G
(c) [10] Show the process of parsing the string "( ) $" by the parser

5. Consider the following grammar G
$$S \rightarrow iEtS \mid iEtSeS \mid a$$
$$E \rightarrow b$$
where S and E are nonterminals and i, t, e, a, and b are terminals
(a) [10] Is G LL(1)? If yes, why? If not, why?
(b) [10] Is G SLR(1)? If yes, why? If not, why?

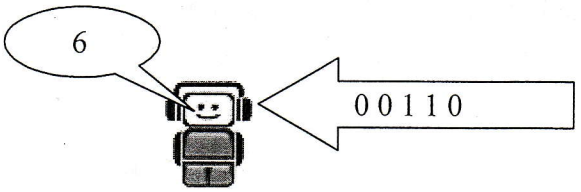
1. [10] Eliminate left recursion from the grammar
   S → Aa | b
   A → Sc | Ad | e

2. Consider the following grammar G:
   $E' \rightarrow E$
   $E \rightarrow (L) \mid a$
   $L \rightarrow E\,L \mid E$
   (a) [10] Construct the collection of the sets of LR(0) items
   (b) [10] When constructing the action table of SLR parser of G, what are the rules to determine the parsing actions? That is, what is the rule for a shift action at state *i*? What is the rule for a reduce action at state *i*?
   (c) [10] Construct the SLR parsing table of *G*. Please specify clearly how every shift or reduce action is determined

3. Consider the following grammar G
   $S \rightarrow ABd$
   $A \rightarrow aA \mid \epsilon$
   $B \rightarrow b \mid cA$
   (a) [5] What is the language generated by G
   (b) [10] Write down the FIRST and FOLLOW sets for all nonterminals of G
   (c) [10] Show the predictive parsing table of G

4. Consider the following grammar G
   S → iEtS | iEtSeS | a
   E → b
   where S and E are nonterminals and i, t, e, a, and b are terminals
   (a) [10] Is G LL(1)? If yes, why? If not, why?
   (b) [10] Is G SLR(1)? If yes, why? If not, why?

5. Consider the grammar G
   $S' \rightarrow S$
   $S \rightarrow L = R \mid R$
   $L \rightarrow * R \mid \mathbf{id}$
   $R \rightarrow L$
   (a) [10] Build the goto graph of the sets of LR(1) items
   (b) [10] Construct the LALR(1) parsing table of *G*



6. iRobot only knows binary digits: **0** and **1**. After he hears a sequence of binary digits, he will convert the binary number into a decimal value. For example, it computes the decimal value of the binary number 0 0 1 1 0 is 6.

Our goal is to use LEX and YACC to write a compiler that will perform the following tasks:

(1) scan and parse the binary digits,
(2) generate a Java bytecode program that computes the decimal value, and
(3) print iRobot's answer.

(a) [15] Write a LEX program and a YACC program that will work together to scan and parse iRobot's input.
(b) [10] Extend your YACC program so that it will generate a sequence of Java bycode instructions that convert a binary number into its decimal value.
(c) [10] Use your compiler to translate the sequence binary digits 0 0 1 1 0 into a Java bytecode program.

For your reference,

PRINT Statements *print expression;*

The PRINT statements in *sC* are modeled by invoking the *print* method in *java.io* package using the following format

```
getstatic java.io.PrintStream java.lang.System.out
...  /* compute expression */
invokevirtual void java.io.PrintStream.print(java.lang.String)
```

if the type of *expression* is a string. Types *int* or *boolean* will replace *java.lang.String* if the type of *expression* is integer or boolean.