Mid-term Exam
COSE312 Compilers, Spring 2017

Instructor: Hakjoo Oh

Problem 1. Consider the regular expression $a \cdot (b \mid c)^*$.

1. Convert the regular expression to an NFA via Thompson's construction.
2. Convert the NFA to a DFA via subset construction.

Problem 2. (Top-down Parsing) Consider the following grammar for lists:

$$\begin{array}{lcl} E & \rightarrow & [L] \mid a \\ L & \rightarrow & E\ T \\ T & \rightarrow & ;\ L \mid \epsilon \end{array} \quad (1)$$

E denotes a single element, either an atom a or a bracketed list $[L]$. L is a list, which consists of an element and a tail. T is a tail, either empty or a semicolon followed by a list. E is the start variable.

1. Compute the *FIRST* and *FOLLOW* sets of the grammar:
   - *FIRST*(E): $\{[, a\}$
   - *FIRST*(L): $\{[, a\}$
   - *FIRST*(T): $\{;, \epsilon\}$
   - *FOLLOW*(E): $\{\$, ;,]\}$
   - *FOLLOW*(L): $\{]\}$
   - *FOLLOW*(T): $\{]\}$
2. Construct the LL parsing table for the grammar:

	a	[	]	;	$
E					
L					
T					

	a	[	]	;	$
E	$E \rightarrow a$	$E \rightarrow [L]$			
L	$L \rightarrow ET$	$L \rightarrow ET$			
T			$T \rightarrow \epsilon$	$T \rightarrow ; L$	

3. Show the parsing sequence for string $[a; [a; a]]$:

Stack	Input
$E\$$	$[a; [a; a]]\$$
$[L]\$$	$[a; [a; a]]\$$
$L]\$$	$a; [a; a]]\$$
$ET]\$$	$a; [a; a]]\$$
$aT]\$$	$a; [a; a]]\$$
$T]\$$	$; [a; a]]\$$
$; L]\$$	$; [a; a]]\$$
$L]\$$	$[a; a]]\$$
$ET]\$$	$[a; a]]\$$
$[L]T]\$$	$[a; a]]\$$
$L]T]\$$	$a; a]]\$$
$ET]T]\$$	$a; a]]\$$
$aT]T]\$$	$a; a]]\$$
$T]T]\$$	$; a]]\$$
$; L]T]\$$	$; a]]\$$
$L]T]\$$	$a]]\$$
$ET]T]\$$	$a]]\$$
$aT]T]\$$	$a]]\$$
$T]T]\$$	$]]\$$
$]T]\$$	$]]\$$
$T]\$$	$]\$$
$]\$$	$]\$$
$\$$	$\$$

4. Is the grammar in (1) LL(1)?

Problem 3. (Bottom-up Parsing) Consider the grammar:

$$\begin{array}{lrcl} (1) & S' & \to & S \\ (2) & S & \to & (S)S \\ (3) & S & \to & \epsilon \end{array}$$

1. Construct the LR(0) automaton for the grammar.

DFA states:

$$I_0 = \boxed{\begin{array}{lcl} S' & \to & .S \\ S & \to & .(S)S \\ S & \to & . \end{array}} \quad I_1 = \boxed{S' \to S.}$$

$$I_2 = \boxed{\begin{array}{lcl} S & \to & (.S)S \\ S & \to & .(S)S \\ S & \to & . \end{array}} \quad I_3 = \boxed{S \to (S.)S}$$

$$I_4 = \boxed{\begin{array}{lcl} S & \to & (S).S \\ S & \to & .(S)S \\ S & \to & . \end{array}} \quad I_5 = \boxed{S \to (S)S.}$$

DFA edges:

$$I_0 \xrightarrow{S} I_1$$
$$I_0 \xrightarrow{(} I_2$$
$$I_2 \xrightarrow{(} I_2$$
$$I_2 \xrightarrow{S} I_3$$
$$I_3 \xrightarrow{)} I_4$$
$$I_4 \xrightarrow{(} I_2$$
$$I_4 \xrightarrow{S} I_5$$

2. Construct the LR(0) parsing table.
3. Construct the SLR parsing table.

State	(	)	$	S
0	$s2$	$r3$	$r3$	$g1$
1			accept	
2	$s2$	$r3$	$r3$	$g3$
3		$s4$		
4	$s2$	$r3$	$r3$	$g5$
5		$r2$	$r2$	

4. Show the SLR parsing sequence for string $()()$.

Stack	Symbols	Input	Action
$0	$	$()()$	

Stack	Symbols	Input	Action
$0	$	$()()$	shift 2
$02	$(	$)()$	reduce 3
$023	$(S$	$)()$	shift 4
$0234	(S)	$()$	shift 2
$02342	$(S)($	$)$	reduce 3
$023423	$(S)(S$	$)$	shift 4
$0234234	$(S)(S)$	$	reduce 3
$02342345	$(S)(S)S$	$	reduce 2
$02345	$(S)S$	$	reduce 2
$01	S	$	accept

Problem 4. Consider the expression grammar:

$$E \to E + E \mid E * E \mid (E) \mid \mathbf{id}$$

1. The SLR parsing for string $\mathbf{id} + \mathbf{id} * \mathbf{id}$ encounters the following shift/reduce conflict:

Stack	Input	Action
$E + E$	$*\mathbf{id}$	shift or reduce

Assuming the conventional precedence, which action is correct? Explain the reason intuitively and clearly.

2. The SLR parsing for string $\mathbf{id} + \mathbf{id} + \mathbf{id}$ encounters the following shift/reduce conflict:

Stack	Input	Action
$E + E$	$+\mathbf{id}$	shift or reduce

Assuming the conventional associativity, which action is correct? Explain the reason intuitively and clearly.