CS323 Assignment4

SID: 12011625

Exercise1 (Simple LR)

1. G :
   (1) $S' \rightarrow S$
   (2) $S \rightarrow aB$
   (3) $B \rightarrow S * B$
   (4) $B \rightarrow \epsilon$

   $FIRST(S) = \{a\}, FOLLOW(S) = \{*, \$\}$
   $FIRST(B) = \{a, \epsilon\}, FOLLOW(B) = \{*, \$\}$

   The detailed steps for the calculations of $LR(0)$ item sets is as follows:
   $I_0 = CLOSURE(\{S' \rightarrow \cdot S\}) = \{S' \rightarrow \cdot S, S \rightarrow \cdot aB\}$

   For I_0:
   $GOTO(I_0, S) = CLOSURE(\{S' \rightarrow S\cdot\}) = \{S' \rightarrow S\cdot\} = I_1$
   $GOTO(I_0, a) = CLOSURE(\{S \rightarrow a \cdot B\}) = \{S \rightarrow a \cdot B, B \rightarrow \cdot S * B, B \rightarrow \cdot, S \rightarrow \cdot aB\} = I_2$

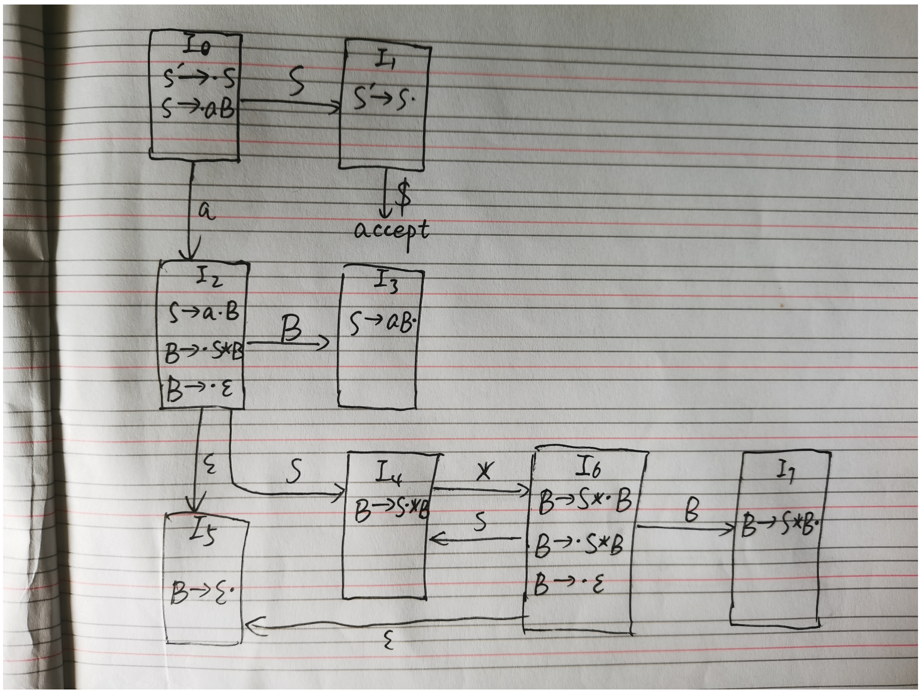
   For I_1:
   $GOTO(I_1, \$) = accept$

   For I_2:
   $GOTO(I_2, a) = CLOSURE(\{S \rightarrow a \cdot B\}) = \{S \rightarrow a \cdot B\} = I_2$
   $GOTO(I_2, B) = CLOSURE(\{S \rightarrow aB\cdot\}) = \{S \rightarrow aB\cdot\} = I_3$
   $GOTO(I_2, S) = CLOSURE(\{B \rightarrow S \cdot *B\}) = \{B \rightarrow S \cdot *B\} = I_4$

   For I_4:
   $GOTO(I_4, *) = CLOSURE(\{B \rightarrow S * \cdot B\}) = \{B \rightarrow S * \cdot B, B \rightarrow \cdot S * B, S \rightarrow \cdot aB, B \rightarrow \cdot\} = I_5$

   For I_5:
   $GOTO(I_5, a) = CLOSURE(\{S \rightarrow a \cdot B\}) = \{S \rightarrow a \cdot B\} = I_2$
   $GOTO(I_5, S) = CLOSURE(S \rightarrow a \cdot B) = \{S \rightarrow a \cdot B, B \rightarrow \cdot S * B, B \rightarrow \cdot, S \rightarrow \cdot aB\} = I_2$
   $GOTO(I_5, B) = CLOSURE(\{B \rightarrow S * B\cdot\}) = \{B \rightarrow S * B\cdot\} = I_6$

   The graph of all $LR(0)$ item sets is as follows:



The $SLR(1)$ parsing table for G is as follows:

STATE	ACTION			GOTO	
	a	$*$	$\$$	S	B
0	s2			1	
1			acc		
2	s2	r4	r4	4	3
3		r2	r2		
4		s5			
5	s2	r4	r4	4	6
6		r3	r3		

2. Since there is no conflict during the parsing table construction and there are no multiple actions for a table entry, G is $SLR(1)$.

3. Yes. The $SLR(1)$ parser can accept the input string $aaaa***$. The process is as follows:

STACK	SYMBOLS	INPUT	ACTION
0	$	aaaa***$	shift to 2
0 2	$a	aaa***$	shift to 2
0 2 2	$aa	aa***$	shift to 2
0 2 2 2	$aaa	a***$	shift to 2
0 2 2 2 2	$aaaa	***$	reduce by $B \to \epsilon$
0 2 2 2 3	$aaaaB	***$	reduce by $S \to aB$
0 2 2 2 4	$aaaS	***$	shift to 5
0 2 2 2 4 5	$aaaS*	**$	reduce by $B \to \epsilon$

STACK	SYMBOLS	INPUT	ACTION
0 2 2 2 4 5 6	$aaaS*B	**$	reduce by $B \to S * B$
0 2 2 2 3	$aaaB	**$	reduce by $S \to aB$
0 2 2 4	$aaS	**$	shift to 5
0 2 2 4 5	$aaS*	*$	reduce by $B \to \epsilon$
0 2 2 4 5 6	$aaS*B	*$	reduce by $B \to S * B$
0 2 2 3	$aaB	*$	reduce by $S \to aB$
0 2 4	$aS	*$	shift to 5
0 2 4 5	$aS*	$	reduce by $B \to \epsilon$
0 2 4 5 6	$aS*B	$	reduce by $B \to S * B$
0 2 3	$aB	$	reduce by $S \to aB$
0 1	$S	$	accept

Exercise2 (Canonical LR)

1. G :

   (1) $S' \to S$

   (2) $S \to aB$

   (3) $B \to S * B$

   (4) $B \to \epsilon$

   $$FIRST(S) = \{a\}, FOLLOW(S) = \{*, \$\}$$
   $$FIRST(B) = \{a, \epsilon\}, FOLLOW(B) = \{*, \$\}$$

   The detailed steps for the calculations of $LR(0)$ item sets is as follows:
   $I_0 = CLOSURE(\{[S' \to \cdot S, \$]\}) = \{[S' \to \cdot S, \$], [S \to \cdot aB, \$]\}$

   For I_0:
   $GOTO(I_0, S) = CLOSURE(\{[S' \to S\cdot, \$]\}) = \{[S' \to S\cdot, \$]\} = I_1$
   Since $FIRST(*B\$) = *$,
   $GOTO(I_0, a) = CLOSURE(\{[S \to a \cdot B, \$]\}) = \{[S \to a \cdot B, \$], [B \to \cdot S * B, \$], [B \to \cdot, \$], [S \to \cdot aB, *]\} = I_2$

   For I_1:
   $GOTO(I_1, \$) = accept$

   For I_2:
   $GOTO(I_2, B) = CLOSURE(\{[S \to aB\cdot, \$]\}) = \{[S \to aB\cdot, \$]\} = I_3$
   $GOTO(I_2, S) = CLOSURE(\{[B \to S \cdot *B, \$]\}) = \{[B \to S \cdot *B, \$]\} = I_4$
   Since $FIRST(*B*) = *$,
   $GOTO(I_2, a) = CLOSURE(\{[S \to a \cdot B, *]\}) = \{[S \to a \cdot B, *], [B \to \cdot S * B, *], [B \to \cdot, *], [S \to \cdot aB, *]\} = I_5$

   For I_4:

Since $FIRST(*B\$) = *$,

$GOTO(I_4, *) = CLOSURE(\{[B \to S \cdot *B, \$]\}) = \{[B \to S * \cdot B, \$], [B \to \cdot S * B, \$], [B \to \cdot, \$], [S \to \cdot aB, *]\} = I_6$

For I_5:

$GOTO(I_5, a) = CLOSURE(\{[S \to a \cdot B, *]\}) = \{[S \to a \cdot B, *], [B \to \cdot S * B, *], [B \to \cdot, *], [S \to \cdot aB, *]\} = I_5$

$GOTO(I_5, B) = CLOSURE(\{[S \to aB\cdot, *]\}) = \{[S \to aB\cdot, *]\} = I_8$

$GOTO(I_5, S) = CLOSURE(\{[B \to S \cdot *B, *]\}) = \{[B \to S \cdot *B, *]\} = I_9$

For I_6:

$GOTO(I_6, B) = CLOSURE(\{[B \to S * B\cdot, \$]\}) = \{[B \to S * B\cdot, \$]\} = I_7$

For I_9:

Since $FIRST(*B*) = *$,

$GOTO(I_9, *) = CLOSURE(\{[B \to S * \cdot B, *]\}) = \{[B \to S * \cdot B, *], [B \to \cdot S * B, *], [B \to \cdot, *], [S \to \cdot aB, *]\} = I_{10}$

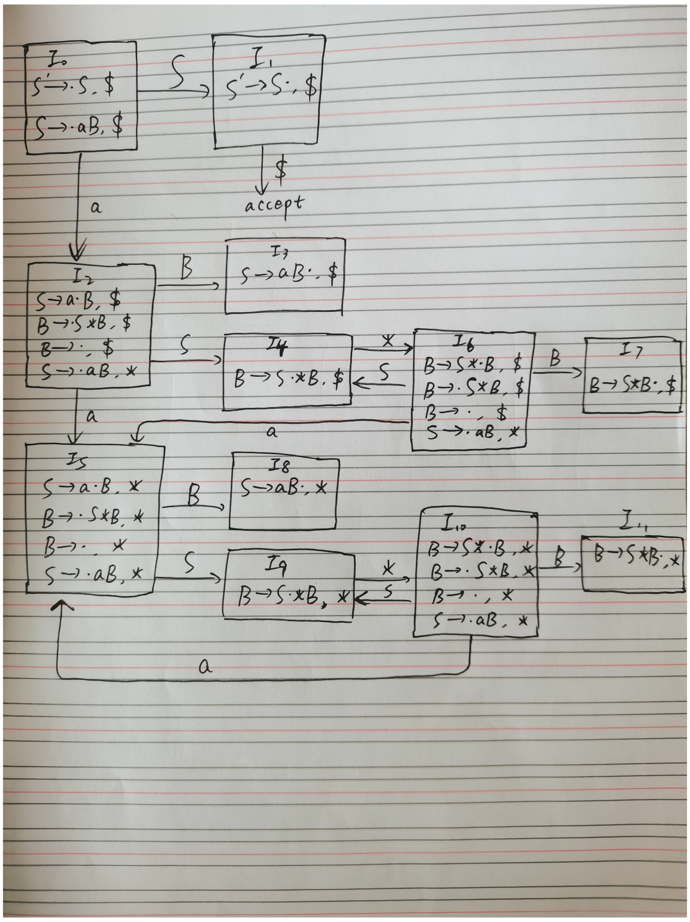
For I_{10}:

$GOTO(I_{10}, a) = CLOSURE(\{[S \to \cdot aB, *]\}) = \{[S \to a \cdot B, *], [B \to \cdot S * B, *], [B \to \cdot, *], [S \to \cdot aB, *]\} = I_5$

$GOTO(I_{10}, S) = CLOSURE(\{[B \to S \cdot *B, *]\}) = \{[B \to S \cdot *B, *]\} = I_9$

$GOTO(I_{10}, B) = CLOSURE(\{[B \to S * B\cdot, *]\}) = \{[B \to S * B\cdot, *]\} = I_{11}$

The graph of all $LR(0)$ item sets is as follows:



The $LR(1)$ parsing table for G is as follows:

STATE	ACTION			GOTO	

STATE	ACTION			GOTO	
	a	*	$	S	B
0	s2			1	
1			acc		
2	s5		r4	4	3
3			r2		
4		s6			
5	s5	r4		9	8
6	s5		r4	4	7
7			r3		
8		r2			
9		s10			
10	s5	r4		9	11
11		r3			

2. Since there is no conflict during the parsing table construction and there are no multiple actions for a table entry, G is $LR(1)$.

3. Yes. The $LR(1)$ parser can accept the input string $aaaa***$. The process is as follows:

STACK	SYMBOLS	INPUT	ACTION
0	$	aaaa***$	shift to 2
0 2	$a	aaa***$	shift to 5
0 2 5	$aa	aa***$	shift to 5
0 2 5 5	$aaa	a***$	shift to 5
0 2 5 5 5	$aaaa	***$	reduce by $B \to \epsilon$
0 2 5 5 5 8	$aaaaB	***$	reduce by $S \to aB$
0 2 5 5 9	$aaaS	***$	shift to 10
0 2 5 5 9 10	$aaaS*	**$	reduce by $B \to \epsilon$
0 2 5 5 9 10 11	$aaaS*B	**$	reduce by $B \to S * B$
0 2 5 5 8	$aaaB	**$	reduce by $S \to aB$
0 2 5 9	$aaS	**$	shift to 10
0 2 5 9 10	$aaS*	*$	reduce by $B \to \epsilon$
0 2 5 9 10 11	$aaS*B	*$	reduce by $B \to S * B$
0 2 5 8	$aaB	*$	reduce by $S \to aB$
0 2 9	$aS	*$	shift to 10
0 2 9 10	$aS*	$	reduce by $B \to \epsilon$
0 2 9 10 11	$aS*B	$	reduce by $B \to S * B$

STACK	SYMBOLS	INPUT	ACTION
0 2 3	$aB	$	reduce by $S \to aB$
0 1	$S	$	accept

Exercise3 (Lookahead LR)

1. G :

   (1) $S' \to S$

   (2) $S \to aB$

   (3) $B \to S * B$

   (4) $B \to \epsilon$

   $FIRST(S) = \{a\}, FOLLOW(S) = \{*, \$\}$
   $FIRST(B) = \{a, \epsilon\}, FOLLOW(B) = \{*, \$\}$

   From **Exercise2**, we get all the item sets:
   $I_0 = CLOSURE(\{[S' \to \cdot S, \$]\})$
   $I_1 = CLOSURE(\{[S' \to S\cdot, \$]\})$
   $I_2 = CLOSURE(\{[S \to a \cdot B, \$]\})$
   $I_3 = CLOSURE(\{[S \to aB\cdot, \$]\})$
   $I_4 = CLOSURE(\{[B \to S \cdot *B, \$]\})$
   $I_5 = CLOSURE(\{[S \to a \cdot B, *]\})$
   $I_6 = CLOSURE(\{[B \to S \cdot *B, \$]\})$
   $I_7 = CLOSURE(\{[B \to S * B\cdot, \$]\})$
   $I_8 = CLOSURE(\{[S \to aB\cdot, *]\})$
   $I_9 = CLOSURE(\{[B \to S \cdot *B, *]\})$
   $I_{10} = CLOSURE(\{[B \to S * \cdot B, *]\})$
   $I_{11} = CLOSURE(\{[B \to S * B\cdot, *]\})$

   We can see that the core of some item sets are the same, we can merge them into one state.
   I_2 and $I_5 \to I_{25}$
   I_3 and $I_8 \to I_{38}$
   I_4 and $I_9 \to I_{49}$
   I_6 and $I_{10} \to I_{6\&10}$
   I_7 and $I_{11} \to I_{7\&11}$

   The $LALR(1)$ parsing table for G is as follows:

STATE	ACTION			GOTO	
	a	*	$	S	B
0	s25			1	
1			acc		
25	s25	r4	r4	49	38
38		r2	r2		

STATE	ACTION			GOTO	
49		s6&10			
6&10	s25	r4	r4	49	7&11
7&11		r3	r3		

2. Since there is no conflict during the parsing table construction and there are no multiple actions for a table entry, G is $LALR(1)$.

3. Yes. The $LALR(1)$ parser can accept the input string $aaaa***$. The process is as follows:

STACK	SYMBOLS	INPUT	ACTION
0	$	aaaa***$	shift to 25
0 25	$a	aaa***$	shift to 25
0 25 25	$aa	aa***$	shift to 25
0 25 25 25	$aaa	a***$	shift to 25
0 25 25 25 25	$aaaa	***$	reduce by $B \rightarrow \epsilon$
0 25 25 25 25 38	$aaaaB	***$	reduce by $S \rightarrow aB$
0 25 25 25 49	$aaaS	***$	shift to 6&10
0 25 25 25 49 6&10	$aaaS*	**$	reduce by $B \rightarrow \epsilon$
0 25 25 25 49 6&10 7&11	$aaaS*B	**$	reduce by $B \rightarrow S * B$
0 25 25 25 38	$aaaB	**$	reduce by $S \rightarrow aB$
0 25 25 49	$aaS	**$	shift to 6&10
0 25 25 49 6&10	$aaS*	*$	reduce by $B \rightarrow \epsilon$
0 25 25 49 6&10 7&11	$aaS*B	*$	reduce by $B \rightarrow S * B$
0 25 25 38	$aaB	*$	reduce by $S \rightarrow aB$
0 25 49	$aS	*$	shift to 6&10
0 25 49 6&10	$aS*	$	reduce by $B \rightarrow \epsilon$
0 25 49 6&10 7&11	$aS*B	$	reduce by $B \rightarrow S * B$
0 25 38	$aB	$	reduce by $S \rightarrow aB$
0 1	$S	$	accept