

Assignment 2: Solutions

CSE 335A: Compiler Design

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1 question 1

Given Grammar:

$$\begin{aligned}Function &\rightarrow Type\ id\ (Arguments) \\Type &\rightarrow id\ |\ Type\ * \\Arguments &\rightarrow ArgList\ |\ \epsilon \\ArgList &\rightarrow Type\ id\ ,\ ArgList\ |\ Type\ id\end{aligned}$$

1.1 Part a

$$First^+(Type \rightarrow id|Type *) = First^+(Type \rightarrow id) \cap First^+(Type \rightarrow Type *) \quad (1)$$

$$\{id\} \cap \{id\} \neq \phi \quad (2)$$

Above you can see that intersection of $First^+$ of this grammar is not null. Meaning this grammar is not backtrack free. Which is required for LL(1) grammar.

Proving that this grammar is not LL(1).

1.2 Part b

Modified grammar:

$$\begin{aligned} \textit{Function} &\rightarrow \textit{Type id (Arguments)} \\ \textit{Type} &\rightarrow \textit{id A} \\ A &\rightarrow * A \mid \epsilon \\ \textit{Arguments} &\rightarrow \textit{ArgList} \mid \epsilon \\ \textit{ArgList} &\rightarrow \textit{Type id B} \\ B &\rightarrow , \textit{ArgList} \mid \epsilon \end{aligned}$$

1.3 Part c

First	Terminal
Function	id
Type	id
A	* ϵ
Arguments	id ϵ
ArgList	id
B	, ϵ

Figure 1: *First of MODIFIED GRAMMAR*

Follow	Terminal
Function	\$
Type	id
A	id
Arguments)
ArgList)
B)

Figure 2: *Follow of MODIFIED GRAMMAR*

1.4 Part d

Non-Terminal	id	*	()	\$,
Function	Function \rightarrow Type id Arguments					
Type	Type \rightarrow id A					
A	A $\rightarrow \epsilon$	A $\rightarrow *A$				
Arguments	Arguments \rightarrow ArgList			Arguments $\rightarrow \epsilon$		
ArgList	ArgList \rightarrow Type id B					
B				B $\rightarrow \epsilon$		B $\rightarrow ,$ ArgList

Figure 3: *LL(1) PARSING TABLE*

2 Question 2

Given grammar:

$$\begin{aligned}
 S &\rightarrow LM \mid Lp \mid qLr \mid sr \mid qsp \\
 L &\rightarrow aMb \mid s \mid t \\
 M &\rightarrow t
 \end{aligned}$$

First	Terminal
S	q s a t
L	a s t
M	t

Figure 4: *First of given q2 GRAMMAR*

Follow	Terminal
S	\$
L	t p r
M	b \$

Figure 5: *Follow of MODIFIED GRAMMAR*

Augmented Grammar:

$$\begin{array}{ll} 0 & S' \rightarrow S \\ 1 & S \rightarrow LM \\ 2 & S \rightarrow Lp \\ 3 & S \rightarrow qLr \\ 4 & S \rightarrow sr \\ 5 & S \rightarrow qsp \\ 6 & L \rightarrow aMb \\ 7 & L \rightarrow s \\ 8 & L \rightarrow t \\ 9 & M \rightarrow t \end{array}$$

Figure 6: *Augmented Grammar*

2.1 SLR(1)

LR(0) canonical collection:

$$\begin{aligned} I_0 &= \text{Closure}(S' \rightarrow \cdot S) \\ I_0 &= \{ \begin{array}{ll} S' & \rightarrow \cdot S \\ S & \rightarrow \cdot LM \\ S & \rightarrow \cdot LP \\ S & \rightarrow \cdot qLr \\ S & \rightarrow \cdot sr \\ S & \rightarrow \cdot qsp \\ L & \rightarrow \cdot aMb \\ L & \rightarrow \cdot s \\ L & \rightarrow \cdot t \end{array} \end{aligned}$$

$$I_1 = \text{Goto}(I_0, S)$$

$$I_1 = \{ S' \rightarrow S. \}$$

$$I_2 = \text{Goto}(I_0, L)$$

$$I_2 = \{ S \rightarrow L.M$$

$$S \rightarrow L.p$$

$$M \rightarrow .t \}$$

$$I_3 = \text{Goto}(I_0, q)$$

$$I_3 = \{ S \rightarrow q.Lr$$

$$S \rightarrow q.sp$$

$$L \rightarrow .aMb$$

$$L \rightarrow .s$$

$$L \rightarrow .t \}$$

$$I_4 = \text{Goto}(I_0, S)$$

$$I_4 = \{ S \rightarrow s.r$$

$$L \rightarrow s. \}$$

$$I_5 = \text{Goto}(I_0, a)$$

$$I_5 = \{ L \rightarrow a.Mb$$

$$M \rightarrow .t \}$$

$$I_6 = \text{Goto}(I_0, t)$$

$$I_6 = \{ L \rightarrow t. \}$$

$$I_7 = \text{Goto}(I_2, M)$$

$$I_7 = \{ S \rightarrow LM. \}$$

$$I_8 = \text{Goto}(I_2, p)$$

$$I_8 = \{ S \rightarrow Lp. \}$$

$$I_9 = \text{Goto}(I_2, t)$$

$$I_9 = \{ M \rightarrow t. \}$$

$$I_{10} = \text{Goto}(I_3, L)$$

$$I_{10} = \{S \rightarrow qL.r\}$$

$$I_{11} = \text{Goto}(I_3, s)$$

$$I_{11} = \{S \rightarrow qs.p$$

$$L \rightarrow s.\}$$

$$I_{12} = \text{Goto}(I_3, t)$$

$$I_{12} = \{L \rightarrow t.\}$$

$$I_{13} = \text{Goto}(I_4, r)$$

$$I_{13} = \{S \rightarrow sr.\}$$

$$I_{14} = \text{Goto}(I_5, M)$$

$$I_{14} = \{L \rightarrow aM.b\}$$

$$I_{15} = \text{Goto}(I_{10}, r)$$

$$I_{15} = \{S \rightarrow qLr.\}$$

$$I_{16} = \text{Goto}(I_{11}, p)$$

$$I_{16} = \{S \rightarrow qsp.\}$$

$$I_{17} = \text{Goto}(I_{14}, b)$$

$$I_{17} = \{L \rightarrow aMb.\}$$

$$I_5 = \text{Goto}(I_3, a)$$

$$I_9 = \text{Goto}(I_5, t)$$

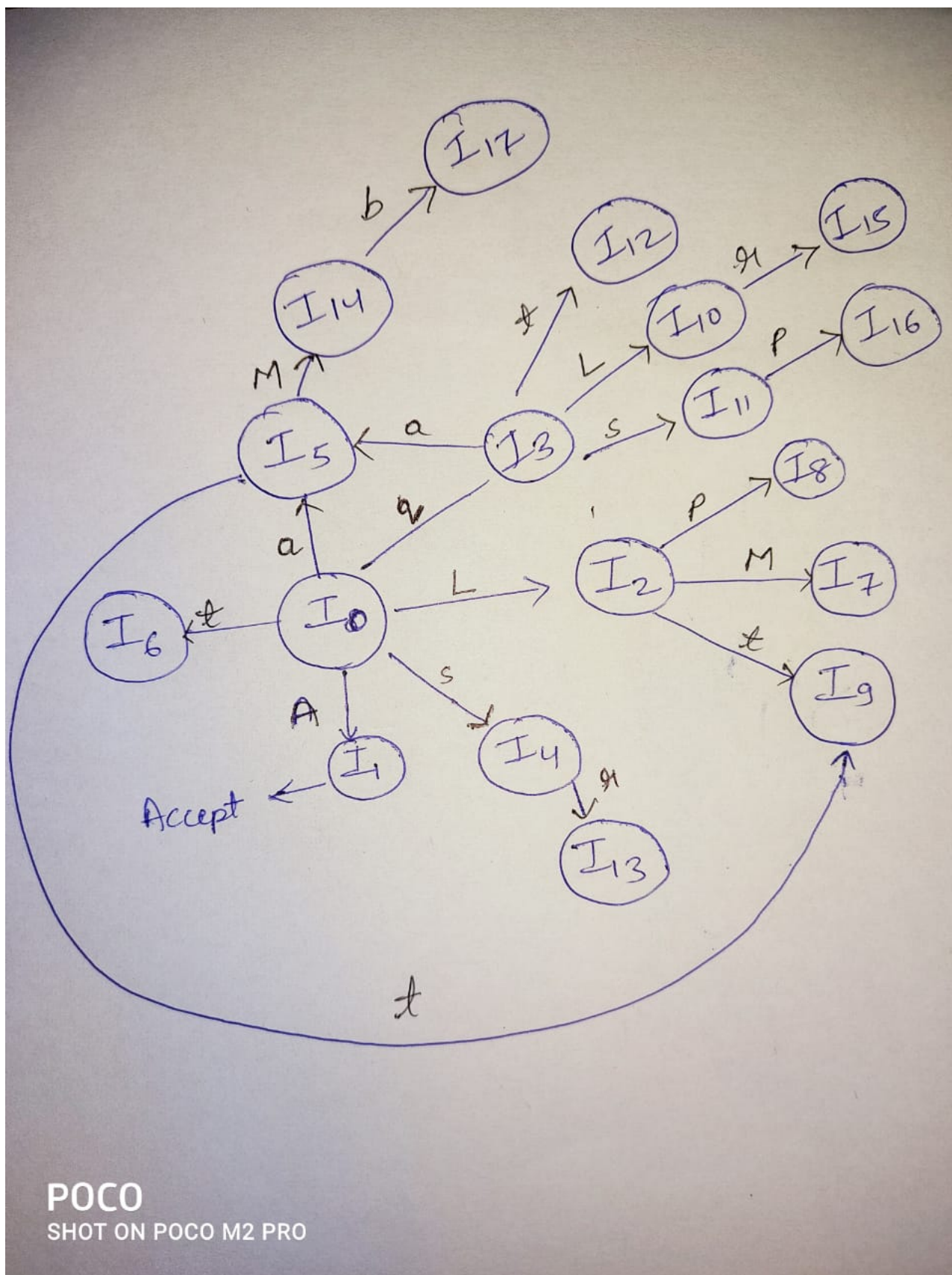


Figure 7: LR(0) automaton

State	p	q	r	s	t	a	b	\$	A	L	M
I_0		S3		S4	S6	S5			1	2	
I_1								Accept			
I_2	S8				S9						7
I_3				S11	S12	S5				10	
I_4			S13/r7		r7						
I_5					S16						14
I_6	r8		r8		r8						
I_7								r1			
I_8								r2			
I_9							r9	r9			
I_{10}			S15								
I_{11}	S16/r7		r7		r7						
I_{12}	r8		r8		r8						
I_{13}								r4			
I_{14}							S17				
I_{15}								r3			
I_{16}								r5			
I_{17}	r6		r6		r6						

Figure 8: *SLR parsing table*

2.2 LALR

LALR canonical collection:

$$\begin{aligned}
 I_0 &= \text{Closure}(S' \rightarrow . S) \\
 I_0 &= \{ S' \rightarrow . S \$, \\
 &\quad S \rightarrow . LM \$, \\
 &\quad S \rightarrow . Lp \$, \\
 &\quad S \rightarrow . qLr \$, \\
 &\quad S \rightarrow . sr \$, \\
 &\quad S \rightarrow . qsp \$, \\
 &\quad L \rightarrow . aMb, t/p, \\
 &\quad L \rightarrow . s, t/p \\
 &\quad L \rightarrow . t, t/p \}
 \end{aligned}$$

$$I_1 = \text{Goto}(I_0, S)$$

$$I_1 = \{ S' \rightarrow S. , \$ \}$$

$$I_2 = \text{Goto}(I_0, L)$$

$$I_2 = \{ S \rightarrow L.M , \$$$

$$S \rightarrow L.p , \$$$

$$M \rightarrow .t , \$ \}$$

$$I_3 = \text{Goto}(I_0, q)$$

$$I_3 = \{ S \rightarrow q.Lr , \$$$

$$S \rightarrow q.sp , \$$$

$$L \rightarrow .aMb , r$$

$$L \rightarrow .s , r$$

$$L \rightarrow .t , r \}$$

$$I_4 = \text{Goto}(I_0, s)$$

$$I_4 = \{ S \rightarrow s.r , \$$$

$$L \rightarrow s. , t/p \}$$

$$I_5 = \text{Goto}(I_0, t)$$

$$I_5 = \{ L \rightarrow t. , t/r/p \}$$

$$I_6 = \text{Goto}(I_0, a)$$

$$I_6 = \{ L \rightarrow a.Mb , t/r/p$$

$$M \rightarrow .t , b \}$$

$$I_7 = \text{Goto}(I_2, M)$$

$$I_7 = \{ S \rightarrow LM. , \$ \}$$

$$I_8 = \text{Goto}(I_2, p)$$

$$I_8 = \{ S \rightarrow Lp. , \$ \}$$

$$I_9 = \text{Goto}(I_2, t)$$

$$I_9 = \{ M \rightarrow t. , \$ / b \}$$

$$I_{10} = \text{Goto}(I_3, L)$$

$$I_{10} = \{S \rightarrow qL.r, \$\}$$

$$I_{11} = \text{Goto}(I_3, s)$$

$$I_{11} = \{S \rightarrow qs.p, \$$$

$$L \rightarrow s., r\}$$

$$I_{12} = \text{Goto}(I_4, r)$$

$$I_{12} = \{S \rightarrow sr., \$\}$$

$$I_{13} = \text{Goto}(I_6, M)$$

$$I_{13} = \{L \rightarrow aM.b, t/r/p\}$$

$$I_{14} = \text{Goto}(I_{10}, r)$$

$$I_{14} = \{S \rightarrow qLr., \$\}$$

$$I_{15} = \text{Goto}(I_{11}, p)$$

$$I_{15} = \{S \rightarrow qsp., \$\}$$

$$I_{16} = \text{Goto}(I_{13}, b)$$

$$I_{16} = \{L \rightarrow aMb., t/r/p\}$$

$$I_6 = \text{Goto}(I_3, a)$$

$$I_5 = \text{Goto}(I_3, t)$$

$$I_9 = \text{Goto}(I_6, t)$$

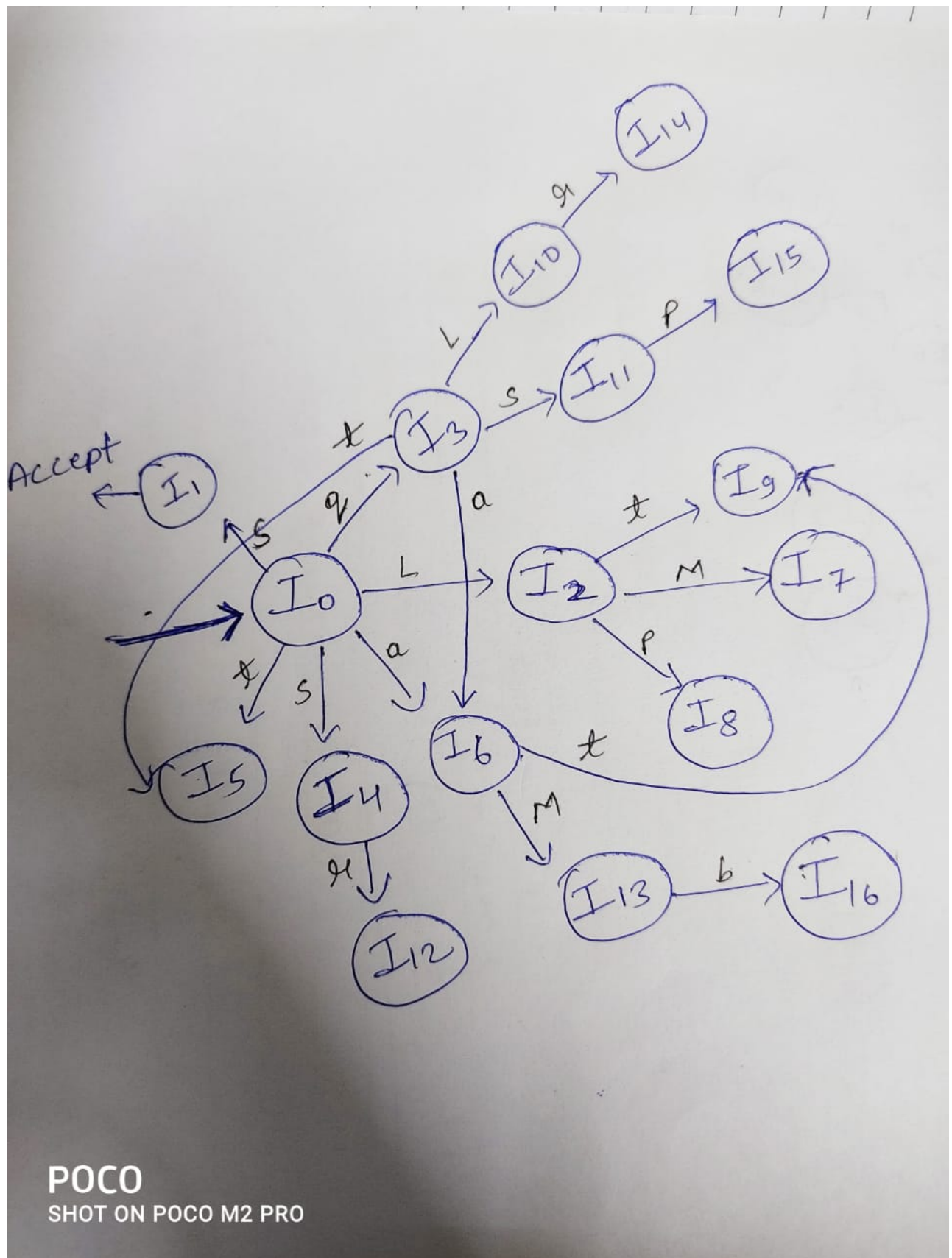


Figure 9: LR(1) automaton

State	p	q	r	s	t	a	b	\$	A	L	M
I_0		S3		S4	S5	S6			1	2	
I_1								Accept			
I_2	S8				S9						7
I_3				S11	S5	S6				10	
I_4			S12		r7						
I_5	r8		r8		r8						
I_6					S9						
I_7								r1			
I_8								r2			
I_9							r9	r9			
I_{10}			S14								
I_{11}	S15		r7								
I_{12}								r4			
I_{13}							S16				
I_{14}								r3			
I_{15}								r5			
I_{16}	r6		r6		r6						

Figure 10: *LALR(1) parsing table*

3 Question 3

There will be a make file for compilation.
simple make command to compile. It is assumed that flex and bison are preinstalled. make all clean command to clear all temporary files.

```
$ make
```

```
$ make clean
```

after compilation, a program will be created known as compiler. Use it as executable and then file name on which it had to execute let it be example.txt

```
$ ./compiler example.txt
```