SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

Kattankulathur, Chengalpattu District - 603203

18CSC304J/ COMPLIER DESIGN

MINI PROJECT REPORT

SLR PARSER

Gudied by:

Dr. Vinod

Submitted By:

Aryan Gupta (RA2011003010351)

Poorvi Mittal (RA2011003010361)

Shivank (RA2011003010386)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Under Section 3 of UGC Act, 1956)

BONAFIDE CERTIFICATE

Certified that Mini project report titled **"SLR PARSER"** is the bona fide work of **Aryan Gupta (RA2011003010351), Poorvi Mittal (RA2011003010361) and Shivank (RA2011003010386)** who carried out the minor project under my supervision. Certified further, that to the best of my knowledge, the work reported herein does not form any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

SIGNATURE

GUIDE NAME

GUIDE

Assistant Professor

Department of Computing Technologies

SIGNATURE

Dr. M. Pushpalatha

HEAD OF THE DEPARTMENT

Professor & Head

Department of Computing Technologies

TABLE OF CONTENTS

Aim:-

To create an SLR(1) parser for user defined grammar.

ABSTRACT:-

The goal of this project is to create an SLR parser in a programming language for user defined grammar. SLR stands for Simple LR grammar. It is an example of a bottom-up parser. The “L” in SLR represents the scanning that advances from left to right and the “R” stands for constructions of derivation in reverse order, and the “(1)” represents the number of input symbols of lookahead.

The project will start with designing the grammar for the programming language, which will define the syntax and structure of the language. Once the grammar is defined, it will be used to generate a lexical analyzer using the Lex tool. This lexical analyzer will scan the input source code and identify the tokens based on the grammar. The output of the lexical analyzer will be a stream of tokens that will be used as input to the SLR parser.

The SLR parser will then parse the input stream of tokens, constructing a parse tree to represent the structure of the program. The parser will be designed to detect and recover from errors in the input, providing informative error messages to the user. The parser will also be optimized to ensure fast parsing times, using techniques such as state compression and table optimization.

Finally, the parser will be tested on a suite of sample programs to ensure correct parsing behavior and error recovery. The project will explore various optimization techniques to improve the efficiency of the parser. The final product of this project will be a fully functional SLR parser for the target programming language, which can be used as a foundation for building compilers or interpreters for that language.

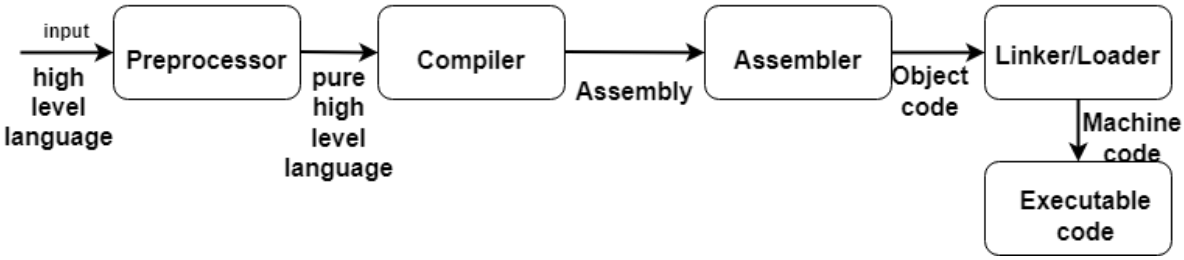
INTRODUCTION:-

Compiler design is a complex and fascinating area of computer science that involves creating software systems that translate high-level programming languages into machine-executable code. One of the most important components of a compiler is the parser, which is responsible for converting the input program into a data structure that can be further processed by the compiler. In this project, we will be focusing on the design and implementation of an SLR parser for a programming language.

SLR parsing is a technique that is commonly used in compiler design to efficiently handle large and complex grammars. The SLR algorithm allows for the creation of parsers that can handle ambiguous grammars and provide informative error messages to the user. The SLR parser is constructed using a deterministic finite automaton, which is built based on a state machine representation of the grammar.

The SLR parsing process involves scanning the input program for tokens using a lexical analyzer, which generates a stream of tokens that are then parsed by the SLR parser. The parser builds a parse tree that represents the structure of the program, which is then used by the compiler to generate executable code.

To better understand the SLR parsing process, we can look at a high-level diagram of the components involved in the process:



As shown in the diagram, the process starts with the input program being scanned by the lexical analyzer, which generates a stream of tokens. The tokens are then parsed by the SLR parser, which constructs a parse tree that represents the structure of the program. The parse tree is then used by the compiler to generate machine-executable code.

MOTIVATION:-

The decision to choose SLR parser design as our project topic was motivated by several factors. Firstly, parser design is a fundamental component of compiler construction and a critical aspect of software engineering. Parser design is a challenging task that requires expertise in formal languages and automata theory. We were motivated to develop a better understanding of these concepts through practical implementation.

Secondly, SLR parsing is a widely used technique that can handle complex grammars, making it an essential component of most modern compilers. SLR parsing is faster and more efficient than other parsing techniques, making it an ideal choice for building compilers for large programming languages. Therefore, developing expertise in SLR parsing is highly valuable for any software engineer or computer science student interested in compiler design.

Lastly, the implementation of an SLR parser for a programming language would provide us with an opportunity to apply theoretical concepts learned in the classroom to a practical project. It would help us gain hands-on experience with compiler design, improve our problem-solving and critical thinking skills, and enhance our ability to work collaboratively on complex projects.

Overall, the decision to choose SLR parser design as our project topic was driven by our interest in compiler construction, our desire to learn more about SLR parsing techniques, and our eagerness to apply theoretical concepts to practical projects.

ALGORITHM FOR SLR PARSING:-

Algorithm for construction of SLR parsing table:

Input : An augmented grammar G'

Output : The SLR parsing table functions action and goto for G'

Method :

1. Construct C = {I0, I1, …. In}, the collection of sets of LR(0) items for G'.

2. State i is constructed from Ii.. The parsing functions for state i are determined as follows:

(a) If [A→α·aβ] is in Ii and goto(Ii,a) = Ij, then set action[i,a] to "shift j". Here a must be

terminal.

(b) If [A→α·] is in Ii , then set action[i,a] to "reduce A→α" for all a in FOLLOW(A).

(c) If [S'→S.] is in Ii, then set action[i,$] to "accept".

If any conflicting actions are generated by the above rules, we say grammar is not SLR(1). 3. The goto transitions for state i are constructed for all non-term

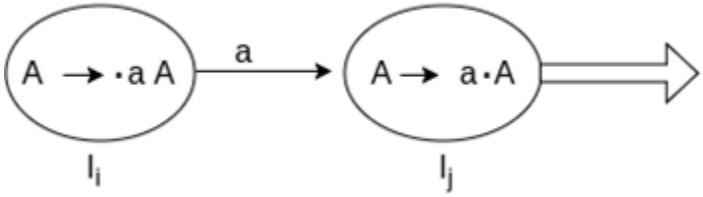
If goto(Ii,A) = Ij, then goto[i,A] = j.

4. All entries not defined by rules (2) and (3) are made "error"

5. The initial state of the parser is the one constructed from the [S'→.S].

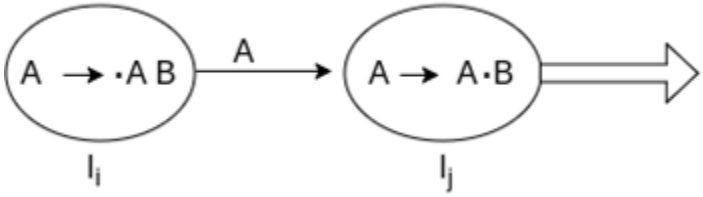
The steps which use to construct SLR (1) Table is given below:

If a state (I_i) is going to some other state (I_j) on a terminal then it corresponds to a shift move in the action part.



States	Action		Go to
	a	$	A
I_i I_j	Sj		

If a state (I_i) is going to some other state (I_j) on a variable then it correspond to go to move in the Go to part.

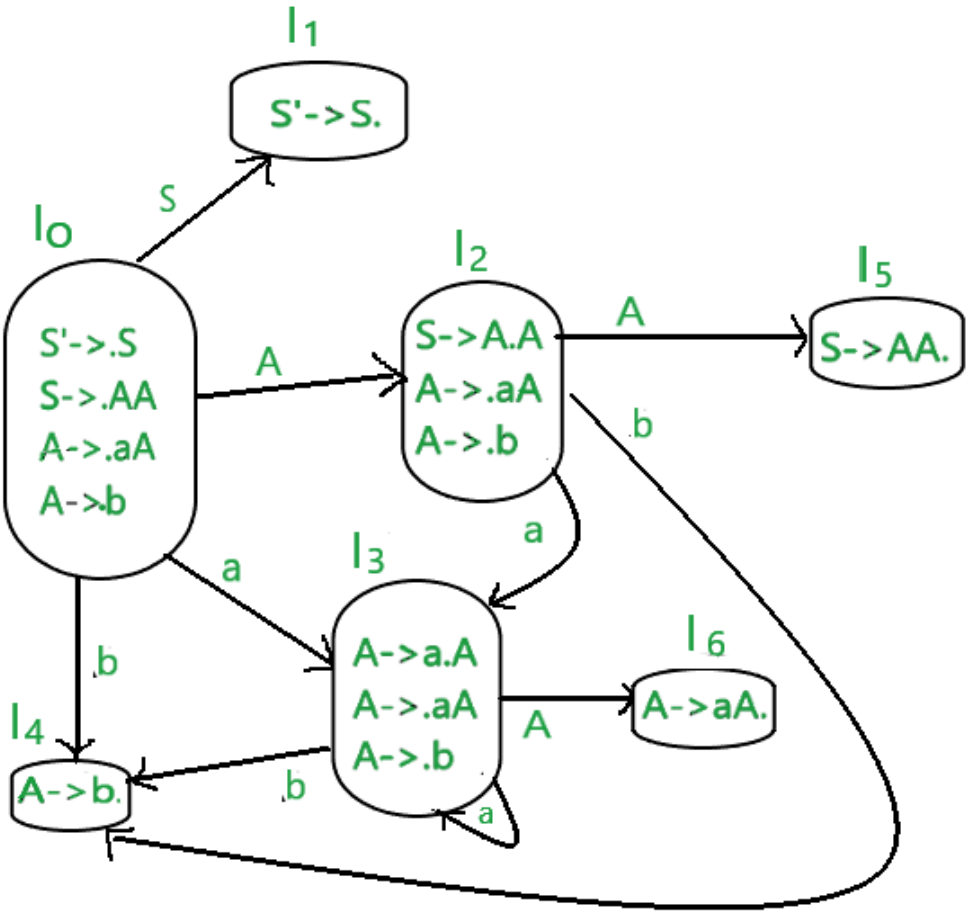


States	Action		Go to
	a	$	A
I_i I_j			j

If a state (I_i) contains the final item like A → ab• which has no transitions to the next state then the production is known as reduce production. For all terminals X in FOLLOW (A), write the reduce entry along with their production numbers.

.

CONSTRUCTION:-



DESCRIPTION OF MODULES:-

Shift and Reduce Operations

The next important concept is SHIFT and REDUCE operations. During parsing, we can enter two types of states. First, we may have a state where '·' is at the end of production. This state is called "Handle". Here comes the role of REDUCE operation. Second, while parsing we may have a state where '·' is pointing at some grammar symbol and there is still scope for advancement. In this scenario, a Shift operation is performed.

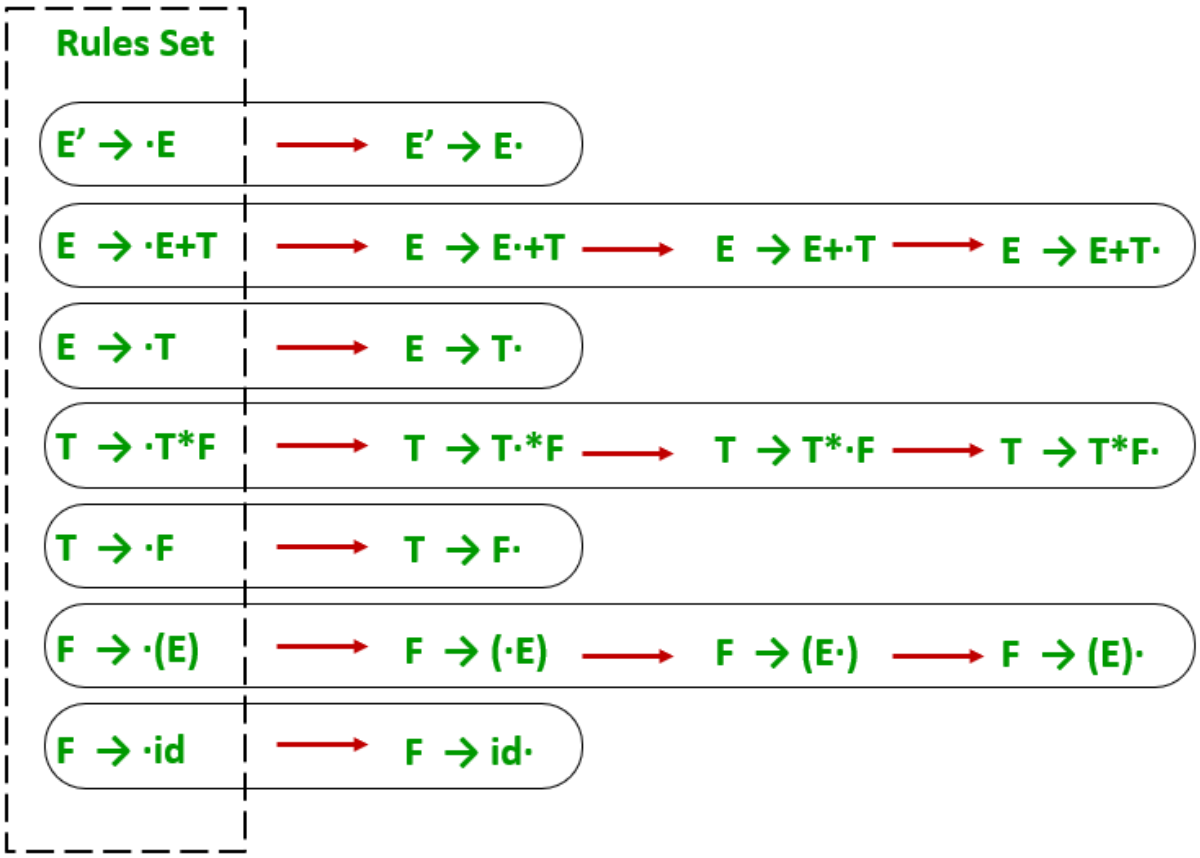


Figure illustrates all possible "Items" generated, during Shift-Reduce operations for given Production rule

By: Tanmay Bisen

Use of Dot [·]

In LR parsing we use Dot '·' as a character in the rule so that we know the progress in parsing at any given point. Note that '·' is like an informer and, it should not be considered as a grammar symbol. In SLR (1), we have only one input symbol as lookahead, which is ultimately helping us determine the current state during parsing activity.

Parsing Decisions

For making the parsing decisions we need to construct the deterministic finite automaton. It helps us determine the current state to which we have arrived while we are parsing. When we design it for SLR parser it is referred to as LR automaton. The states of this automaton are the set of "Items" related to the production rules set.

Generating LR Collection

The first step is to create an augmented grammar. The augmentation process starts by bringing the start symbol on the right-hand side of a production rule. We cannot alter the existing rule so we add a new rule in the productions. Bringing the start symbol on RHS ensures that the parsing reaches the acceptance state. The REDUCE operation on this newly added rule determines the string acceptance.

For example,

IF we have 'K' as a start symbol

THEN L → K is added in productions

(where 'L' represents any non-preexisting symbol in the collection)

CLOSURE and GOTO Operations

In the process of construction of deterministic finite automaton, there are two requirements. The first is creating "States" and the second is developing "Transitions" in the automaton.

1) CLOSURE

Closure operation helps us to form the "States". Before taking the closure operation all the rules must be separated. Then number all the rules. This will be helpful later for making the Shift and Reduce entries in the parsing table. Let I0 be the collection of rules obtained after grammar augmentation. This means we also have a newly added rule in collection I0.

Assumption – (consider [L, K] are non-terminals and [m, t, p] are set of zero or more terminals or non-terminals)

DO REPEAT (Till-No-New-Rule-Gets-Added) {

IF (any production of the form " L → m · K t " exists) and (we have production K → · p)

THEN {add production K → · p to the Closure set if not preexisting}

}

2) GOTO

GOTO operation helps us to form the "Transitions". In operation GOTO (I, X), 'I' can be elaborated as the state we are looking at and 'X' is the symbol pointed by Dot (·). So, GOTO takes in a state with items and a grammar symbol and produces the new or existing state as output.

The GOTO (I, X) represents the state transition from "I" on the input symbol "X".

For any production rule " L → m · K t " in "I"

GOTO (I, X) outputs the closure of a set of all the productions " L → m K · t "

Program approach

The input for the program is the list of rules having a set of items and lists determining terminal and non-terminal symbols. The control starts form grammarAugmentation() function, then we have to calculate I0 state, that is

calculated by calling findClosure(), now for new states generation generateStates() function is called and finally createParseTable() function is called.

A) grammarAugmentation

- In this function firstly we create a unique symbol and use it to create a new item to bring the start symbol on RHS. Then we format the items into a nested list and add a dot at the start of the item's RHS. Also, we keep only one derivation in one item. Thus we have generated a list named separatedRulesList.

B) findClosure

- This function runs differently for I0 state. For I0 state, we directly append to closureSet the newly created item from augmentation. In any other case, closureSet gets initialized with the received argument "input_state".
- Now continue iterations till we are receiving new items in closureSet. We follow the rules mentioned under "Item-set Closure" title above to look for the next items to be added in closureSet.

C) generateStates

- In this function we are starting with GOTO computation. "statesDict" is a dictionary that stores all the states and is used as a global variable. We iterate over the statesDict till new states are getting added to it. We call the compute_GOTO() function on each added state only once.

D) compute_GOTO

- Now control reaches compute_GOTO, this function doesn't have actual goto logic, but it creates metadata to call the GOTO() function iteratively. For the given input state, we call GOTO(state,Xi), where Xi represents a symbol

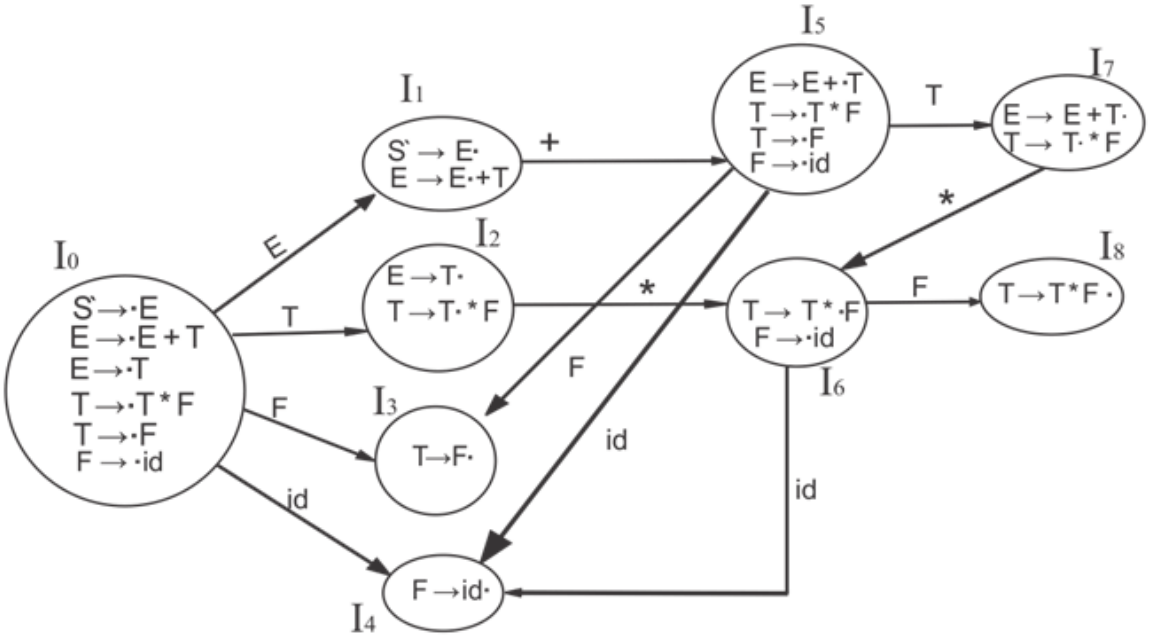
pointed by a dot. There can be multiple Xi, so isolating iteration procedure from actual GOTO() logic implementation reduces complexity.

E) GOTO

- This function is called by compute_GOTO() function, we receive "input_state" and "charNextToDot", we perform the shift operation and generate a new state.
- Now for any item in a new state, dot can point to some symbol for which we may have another item, so to include all the items for the new state, we call findClosure() function that I discussed above.
- To store this information of "GOTO(state, symbol) = newState", the stateMap dictionary is created having key of type tuple and value of type integer. This will help in parsing table generation and printing output.

F) createParseTable

- Firstly we create the table in its initial empty state. Columns will have ACTION (Terminals and $) and GOTO (Non-terminals). Rows will have numbered states (I0-In).
- Using stateMap fill in the SHIFT and GOTO entries. To add reduce entries in LR parser, find the "handles" (item with the dot at the end) in the generated states, and place Rn (n is the item number in separatedRulesList), in Table[stateNo] [Ai], where "stateNo" is the state in which item belongs.
- "Ai" is any symbol belonging to FOLLOW of LHS symbol of the current item that we are traversing. REDUCE entry for the new augmented rule shows "Acceptance". The parser may have RR (Reduce-Reduce) and SR (Shift-Reduce) conflicts.



States	Action				Go to		
	id	+	*	**$**	**E**	**T**	**F**
I_0	S_4				1	2	3
I_1		S_5		Accept			
I_2		R_2	S_6	R2			
I_3		R_4	R_4	R4			
I_4		R_5	R5	R5			
I_5	S4					7	3
I_6	S4						8
I_7		R1	S6	R1			
I_8		R3	R3	R3			

Requirements to run the script:

To run an SLR parser script, the following requirements must be met:

1. A compatible Python interpreter version must be installed on the system.
2. The script must be saved in a directory with proper read and write permissions.
3. The input grammar to be parsed must be provided in a specific format or file type, as specified by the script.
4. The script may require additional dependencies or modules to be installed, which should be installed prior to running the script.
5. The input program to be parsed must be provided in a specific format or file type, as specified by the script.
6. The system must have enough resources to handle the size of the input program to be parsed, as parsing large programs may require significant memory and processing power.
7. The output format or destination for the parsed output must be specified or configured in the script.

- Python
- Code Editor

Code:

```
# SLR(1)
 #include<stdio.h>
#include<string.h>
#include<conio.h>

int i,j,k,m,n=0,o,p,ns=0,tn=0,rr=0,ch=0;
char
read[15][10],gl[15],gr[15][10],temp,templ[15],tempr[15][10],*ptr,temp2[5],dfa[15
][15];

struct states
{
   char lhs[15],rhs[15][10];
   int n;
}I[15];

int compstruct(struct states s1,struct states s2)
{
   int t;
   if(s1.n!=s2.n)
      return 0;
   if( strcmp(s1.lhs,s2.lhs)!=0 )
      return 0;
   for(t=0;t<s1.n;t++)
      if( strcmp(s1.rhs[t],s2.rhs[t])!=0 )
         return 0;
```

```
    return 1;
}

void moreprod()
{
    int r,s,t,l1=0,rr1=0;
    char *ptr1,read1[15][10];

    for(r=0;r<I[ns].n;r++)
    {
        ptr1=strchr(I[ns].rhs[l1],'.');
        t=ptr1-I[ns].rhs[l1];
        if( t+1==strlen(I[ns].rhs[l1]) )
        {
            l1++;
            continue;
        }
        temp=I[ns].rhs[l1][t+1];
        l1++;
        for(s=0;s<rr1;s++)
            if( temp==read1[s][0] )
                break;
        if(s==rr1)
        {
            read1[rr1][0]=temp;
            rr1++;
        }
```

```
        else
            continue;

        for(s=0;s<n;s++)
        {
            if(gl[s]==temp)
            {
                I[ns].rhs[I[ns].n][0]='.';
                I[ns].rhs[I[ns].n][1]=NULL;
                strcat(I[ns].rhs[I[ns].n],gr[s]);
                I[ns].lhs[I[ns].n]=gl[s];
                I[ns].lhs[I[ns].n+1]=NULL;
                I[ns].n++;
            }
        }
    }
}

void canonical(int l)
{
    int t1;
    char read1[15][10],rr1=0,*ptr1;
    for(i=0;i<I[l].n;i++)
    {
        temp2[0]='.';
        ptr1=strchr(I[l].rhs[i],'.');
        t1=ptr1-I[l].rhs[i];
```

```
if( t1+1==strlen(I[l].rhs[i]) )
   continue;

temp2[1]=I[l].rhs[i][t1+1];
temp2[2]=NULL;

for(j=0;j<rr1;j++)
   if( strcmp(temp2,read1[j])==0 )
      break;
if(j==rr1)
{
   strcpy(read1[rr1],temp2);
   read1[rr1][2]=NULL;
   rr1++;
}
else
   continue;

for(j=0;j<I[0].n;j++)
{
   ptr=strstr(I[l].rhs[j],temp2);
   if( ptr )
   {
      templ[tn]=I[l].lhs[j];
      templ[tn+1]=NULL;
      strcpy(tempr[tn],I[l].rhs[j]);
      tn++;
```

```
    }
}

for(j=0;j<tn;j++)
{
    ptr=strchr(tempr[j],'.');
    p=ptr-tempr[j];
    tempr[j][p]=tempr[j][p+1];
    tempr[j][p+1]='.';
    I[ns].lhs[I[ns].n]=templ[j];
    I[ns].lhs[I[ns].n+1]=NULL;
    strcpy(I[ns].rhs[I[ns].n],tempr[j]);
    I[ns].n++;
}

moreprod();
for(j=0;j<ns;j++)
{
    //if ( memcmp(&I[ns],&I[j],sizeof(struct states))==1 )
    if( compstruct(I[ns],I[j])==1 )
    {
        I[ns].lhs[0]=NULL;
        for(k=0;k<I[ns].n;k++)
            I[ns].rhs[k][0]=NULL;
        I[ns].n=0;
        dfa[l][j]=temp2[1];
        break;
```

```
            }
        }
        if(j<ns)
        {
            tn=0;
            for(j=0;j<15;j++)
            {
                templ[j]=NULL;
                tempr[j][0]=NULL;
            }
            continue;
        }

        dfa[l][j]=temp2[1];
        printf("\n\nI%d :",ns);
        for(j=0;j<I[ns].n;j++)
            printf("\n\t%c -> %s",I[ns].lhs[j],I[ns].rhs[j]);
        ns++;
        tn=0;
        for(j=0;j<15;j++)
        {
            templ[j]=NULL;
            tempr[j][0]=NULL;
        }
    }
}
```

```
int main()
{
   FILE *f;
   int l;

   for(i=0;i<15;i++)
   {
      I[i].n=0;
      I[i].lhs[0]=NULL;
      I[i].rhs[0][0]=NULL;
      dfa[i][0]=NULL;
   }

   f=fopen("data.txt","r");
   while(!feof(f))
   {
      fscanf(f,"%c",&gl[n]);
      fscanf(f,"%s\n",gr[n]);
      n++;
   }

   printf("THE GRAMMAR IS AS FOLLOWS\n");
   for(i=0;i<n;i++)
      printf("\t\t\t\t%c -> %s\n",gl[i],gr[i]);

   I[0].lhs[0]='Z';
   strcpy(I[0].rhs[0],".S");
```

```
I[0].n++;
l=0;
for(i=0;i<n;i++)
{
   temp=I[0].rhs[l][1];
   l++;
   for(j=0;j<rr;j++)
      if( temp==read[j][0] )
         break;
   if(j==rr)
   {
      read[rr][0]=temp;
      rr++;
   }
   else
      continue;
   for(j=0;j<n;j++)
   {
      if(gl[j]==temp)
      {
         I[0].rhs[I[0].n][0]='.';
         strcat(I[0].rhs[I[0].n],gr[j]);
         I[0].lhs[I[0].n]=gl[j];
         I[0].n++;
      }
   }
}
```

```
    ns++;

    printf("\nI%d :\n",ns-1);
    for(i=0;i<I[0].n;i++)
        printf("\t%c -> %s\n",I[0].lhs[i],I[0].rhs[i]);

    for(l=0;l<ns;l++)
        canonical(l);

    printf("\t\t\tDFA TABLE IS AS FOLLOWS\n\n\n");
    for(i=0;i<ns;i++)
    {
        printf("I%d : ",i);
        for(j=0;j<ns;j++)
            if(dfa[i][j]!='\0')
                printf("'%c'->I%d | ",dfa[i][j],j);
        printf("\n\n\n");
    }

    printf("\n\n\n\t\tPRESS ANY KEY TO EXIT");
    getch();
}
```

Output:

```
Original grammar input:

E -> E + T | T
T -> T * F | F
F -> ( E ) | id

Grammar after Augmentation:

E' -> . E
E -> . E + T
E -> . T
T -> . T * F
T -> . F
F -> . ( E )
F -> . id
```

```
Calculated closure: I0

E' -> . E
E -> . E + T
E -> . T
T -> . T * F
T -> . F
F -> . ( E )
F -> . id

States Generated:

State = I0
E' -> . E
E -> . E + T
E -> . T
T -> . T * F
T -> . F
F -> . ( E )
F -> . id
```

```
States Generated:

State = I0
E' -> . E
E -> . E + T
E -> . T
T -> . T * F
T -> . F
F -> . ( E )
F -> . id

State = I1
E' -> E .
E -> E . + T

State = I2
E -> T .
T -> T . * F

State = I3
T -> F .
```

```
State = I4
F -> ( . E )
E -> . E + T
E -> . T
T -> . T * F
T -> . F
F -> . ( E )
F -> . id

State = I5
F -> id .

State = I6
E -> E + . T
T -> . T * F
T -> . F
F -> . ( E )
F -> . id
```

```
State = I7
T -> T * . F
F -> . ( E )
F -> . id

State = I8
F -> ( E . )
E -> E . + T

State = I9
E -> E + T .
T -> T . * F

State = I10
T -> T * F .

State = I11
F -> ( E ) .
```

```
Result of GOTO computation:

GOTO ( I0 , E ) = I1
GOTO ( I0 , T ) = I2
GOTO ( I0 , F ) = I3
GOTO ( I0 , ( ) = I4
GOTO ( I0 , id ) = I5
GOTO ( I1 , + ) = I6
GOTO ( I2 , * ) = I7
GOTO ( I4 , E ) = I8
GOTO ( I4 , T ) = I2
GOTO ( I4 , F ) = I3
GOTO ( I4 , ( ) = I4
GOTO ( I4 , id ) = I5
GOTO ( I6 , T ) = I9
GOTO ( I6 , F ) = I3
GOTO ( I6 , ( ) = I4
GOTO ( I6 , id ) = I5
GOTO ( I7 , F ) = I10
GOTO ( I7 , ( ) = I4
GOTO ( I7 , id ) = I5
GOTO ( I8 , ) ) = I11
```

SLR(1) parsing table:

	id	+	*	(	)	$	E	T	F
I0	S5			S4			1	2	3
I1		S6				Accept			
I2		R2	S7		R2	R2			
I3		R4	R4		R4	R4			
I4	S5			S4			8	2	3
I5		R6	R6		R6	R6			
I6	S5			S4				9	3
I7	S5			S4					10
I8		S6			S11				
I9		R1	S7		R1	R1			
I10		R3	R3		R3	R3			
I11		R5	R5		R5	R5			

Result:

Hence, an SLR parser for user defined grammar was successfully implemented and tested.

CONCLUSION:-

In conclusion, the construction of an SLR parser is a complex task that requires a solid understanding of parsing techniques and compiler design principles. Through this project, we have implemented an SLR parser using the Python programming language and have demonstrated its ability to parse input programs and generate correct output.

We began by designing the grammar for the language to be parsed and implemented a tokenizer module to convert the input program into a stream of tokens. We then constructed States for the grammar, Results of the goto computation and constructed the SLR parsing table using the computed lookahead sets. Finally, we implemented a parser module to parse the input program using the constructed parsing table and output the result.

Overall, this project has provided us with a deeper understanding of parsing techniques and has enabled us to apply our knowledge to the implementation of an SLR parser. With further optimization and refinement, this SLR parser can be used as a tool for parsing and analyzing input programs in various applications, including compilers and interpreters.

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