Om Shele
THADOMAL SHAHANI TSEC ENGINEERING COLLEGE
TE C32
2103163

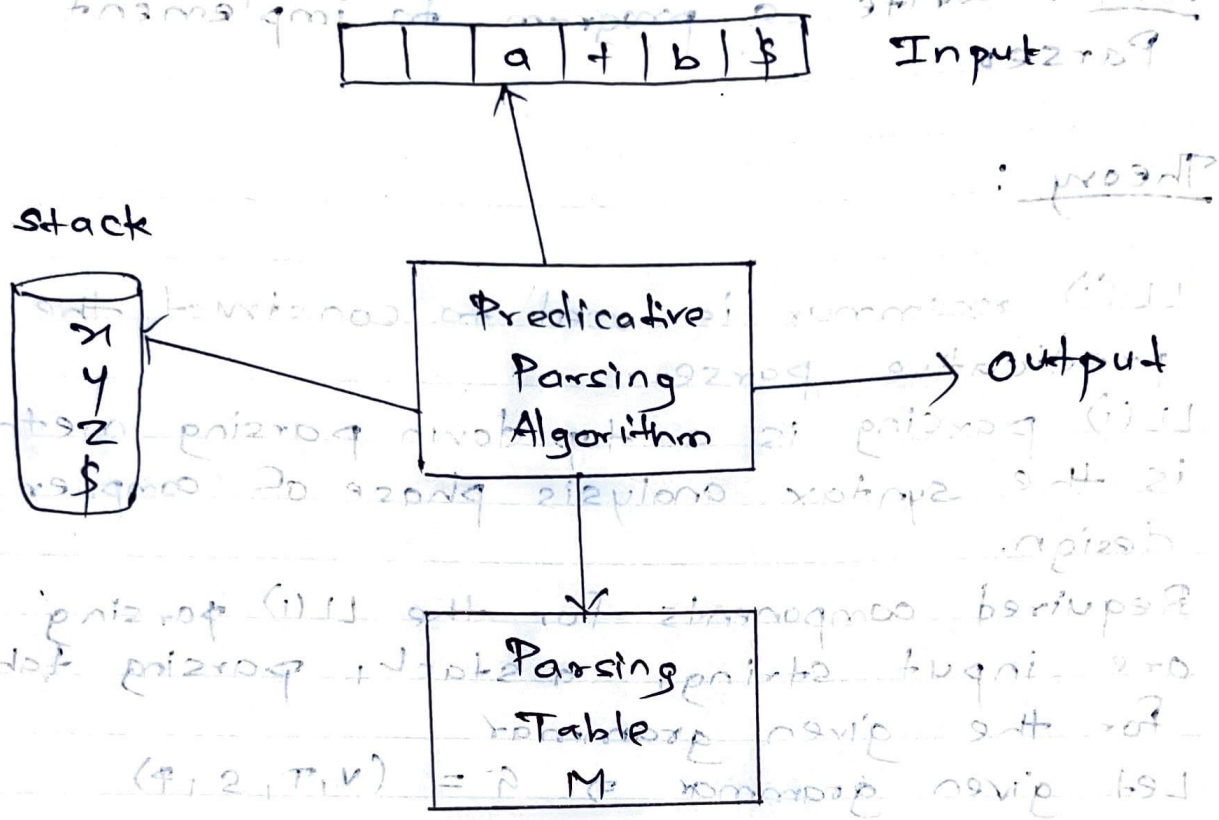
Experiment No: 4

Aim: Write a program to implement Parser.

Theory:

- LL(1) grammar is used to construct the predicative parser.
- LL(1) parsing is a top down parsing method is the syntax analysis phase of compiler design.
- Required components for the LL(1) parsing are input string, a stack, parsing table for the given grammar
- Let given grammar => $G = (V, T, S, P)$ where,
  - V = set of variables
  - T = terminal symbols set
  - S = start symbol
  - P = production set.
- Non-recursive predictive parser is also known as LL(1) parser.
- The LL(1) parser stands for :
  - "L" : left to right scan of input
  - "L" : Leftmost derivation
  - An LL parser is called an LL(K) parser if uses.
  - "K" : It uses k tokens of look ahead when parsing sentence.

Model of Non-Recursive Predicative Parser:



THADOMAL SHAHANI
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- **Algorithm:**

Input : Grammar G

Output : Parsing Table M

Step 1: For each terminal 'a' in FIRST(α) ADD A → α to M[A, a]

Step 2:

CASE 1

⇒ If ε is in FIRST(α) then for each terminal b in FOLLOW(A) ADD A → α to M[A, b]

CASE 2:

⇒ If ε is in FIRST(α) and $ in FOLLOW(A) then for each terminal b in FOLLOW(A) Add A → α to M[A, b]

Step 3: Make each undefined entry of M be an error.

- **Conclusion:** In this we have implemented LL(1) parser algorithm successfully.

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For e.g.,

$E \to TE'$, $E' \to +TE' \mid \varepsilon$, $T \to FT'$,

$T' \to *FT' \mid \varepsilon$, $F \to (E) \mid id$

$\Rightarrow$

	id	+	*	(	)	$
E	$E \to TE'$			$E \to TE'$		
E'		$E' \to +TE'$			$E' \to \varepsilon$	$E' \to \varepsilon$
T	$T \to FT'$			$T \to FT'$		
T'		$T' \to \varepsilon$	$T' \to *FT'$		$T' \to \varepsilon$	$T' \to \varepsilon$
F	$F \to id$			$F \to (E)$		

Code:

```
from collections import OrderedDict

def isterminal(char):
  if (char.isupper() or char == "`"):
    return False
  else:
    return True

def insert(grammar, lhs, rhs):
  if (lhs in grammar and rhs not in grammar[lhs] and grammar[lhs] !=
"null"):
    grammar[lhs].append(rhs)
  elif (lhs not in grammar or grammar[lhs] == "null"):
    grammar[lhs] = [rhs]
  return grammar

def first(lhs, grammar, grammar_first):
  rhs = grammar[lhs]
  for i in rhs:
    k = 0
    flag = 0
    current = []
    confirm = 0
    flog = 0
    if (lhs in grammar and "`" in grammar_first[lhs]):
      flog = 1
    while (1):
      check = []
      if (k >= len(i)):
        if (len(current) == 0 or flag == 1 or confirm == k or flog ==
1):
          grammar_first = insert(grammar_first, lhs, "`")
        break
      if (i[k].isupper()):
        if (grammar_first[i[k]] == "null"):
          grammar_first = first(i[k], grammar, grammar_first)
        for j in grammar_first[i[k]]:
          grammar_first = insert(grammar_first, lhs, j)
          check.append(j)
      else:
        grammar_first = insert(grammar_first, lhs, i[k])
```

```
        check.append(i[k])
      if (i[k] == "`"):
        flag = 1
      current.extend(check)
      if ("`" not in check):
        if (flog == 1):
          grammar_first = insert(grammar_first, lhs, "`")
        break
      else:
        confirm += 1
        k += 1
        grammar_first[lhs].remove("`")
  return (grammar_first)

def rec_follow(k, next_i, grammar_follow, i, grammar, start,
grammar_first,
               lhs):
  if (len(k) == next_i):
    if (grammar_follow[i] == "null"):
      grammar_follow = follow(i, grammar, grammar_follow, start)
    for q in grammar_follow[i]:
      grammar_follow = insert(grammar_follow, lhs, q)
  else:
    if (k[next_i].isupper()):
      for q in grammar_first[k[next_i]]:
        if (q == "`"):
          grammar_follow = rec_follow(k, next_i + 1, grammar_follow, i,
                                      grammar, start, grammar_first,
lhs)
        else:
          grammar_follow = insert(grammar_follow, lhs, q)
    else:
      grammar_follow = insert(grammar_follow, lhs, k[next_i])

  return (grammar_follow)

def follow(lhs, grammar, grammar_follow, start):
  for i in grammar:
    j = grammar[i]
    for k in j:
      if (lhs in k):
        next_i = k.index(lhs) + 1
```

```
        grammar_follow = rec_follow(k, next_i, grammar_follow, i,
grammar,
                                    start, grammar_first, lhs)
  if (lhs == start):
    grammar_follow = insert(grammar_follow, lhs, "$")
  return (grammar_follow)

def show_dict(dictionary):
  for key in dictionary.keys():
    print(key + "  :  ", end="")
    for item in dictionary[key]:
      if (item == "`"):
        print("Epsilon, ", end="")
      else:
        print(item + ", ", end="")
    print("\b\b")

def get_rule(non_terminal, terminal, grammar, grammar_first):
  for rhs in grammar[non_terminal]:
    #print(rhs)
    for rule in rhs:
      if (rule == terminal):
        string = non_terminal + "~" + rhs
        return string

      elif (rule.isupper() and terminal in grammar_first[rule]):
        string = non_terminal + "~" + rhs
        return string


def generate_parse_table(terminals, non_terminals, grammar,
grammar_first,
                         grammar_follow):
  parse_table = [[""] * len(terminals) for i in
range(len(non_terminals))]

  for non_terminal in non_terminals:
    for terminal in terminals:
      if terminal in grammar_first[non_terminal]:
        rule = get_rule(non_terminal, terminal, grammar, grammar_first)
      elif ("`" in grammar_first[non_terminal]
            and terminal in grammar_follow[non_terminal]):
        rule = non_terminal + "~`"
```

```
      elif (terminal in grammar_follow[non_terminal]):
        rule = "Sync"

      else:
        rule = ""

      parse_table[non_terminals.index(non_terminal)][terminals.index(
          terminal)] = rule

  return (parse_table)


def display_parse_table(parse_table, terminal, non_terminal):
  print("\t\t\t\t", end="")
  for terminal in terminals:
    print(terminal + "\t\t", end="")
  print("\n\n")

  for non_terminal in non_terminals:
    print("\t\t" + non_terminal + "\t\t", end="")
    for terminal in terminals:

print(parse_table[non_terminals.index(non_terminal)][terminals.index(
          terminal)] + "\t\t",
            end="")
    print("\n")

def parse(expr, parse_table, terminals, non_terminals):
  stack = ["$"]
  stack.insert(0, non_terminals[0])

  print("\t\t\tMatched\t\t\tStack\t\t\tInput\t\t\tAction\n")
  print("\t\t\t-\t\t\t", end="")
  for i in stack:
    print(i, end="")
  print("\t\t\t", end="")
  print(expr + "\t\t\t", end="")
  print("-")

  matched = "-"
  while (True):
    action = "-"
```

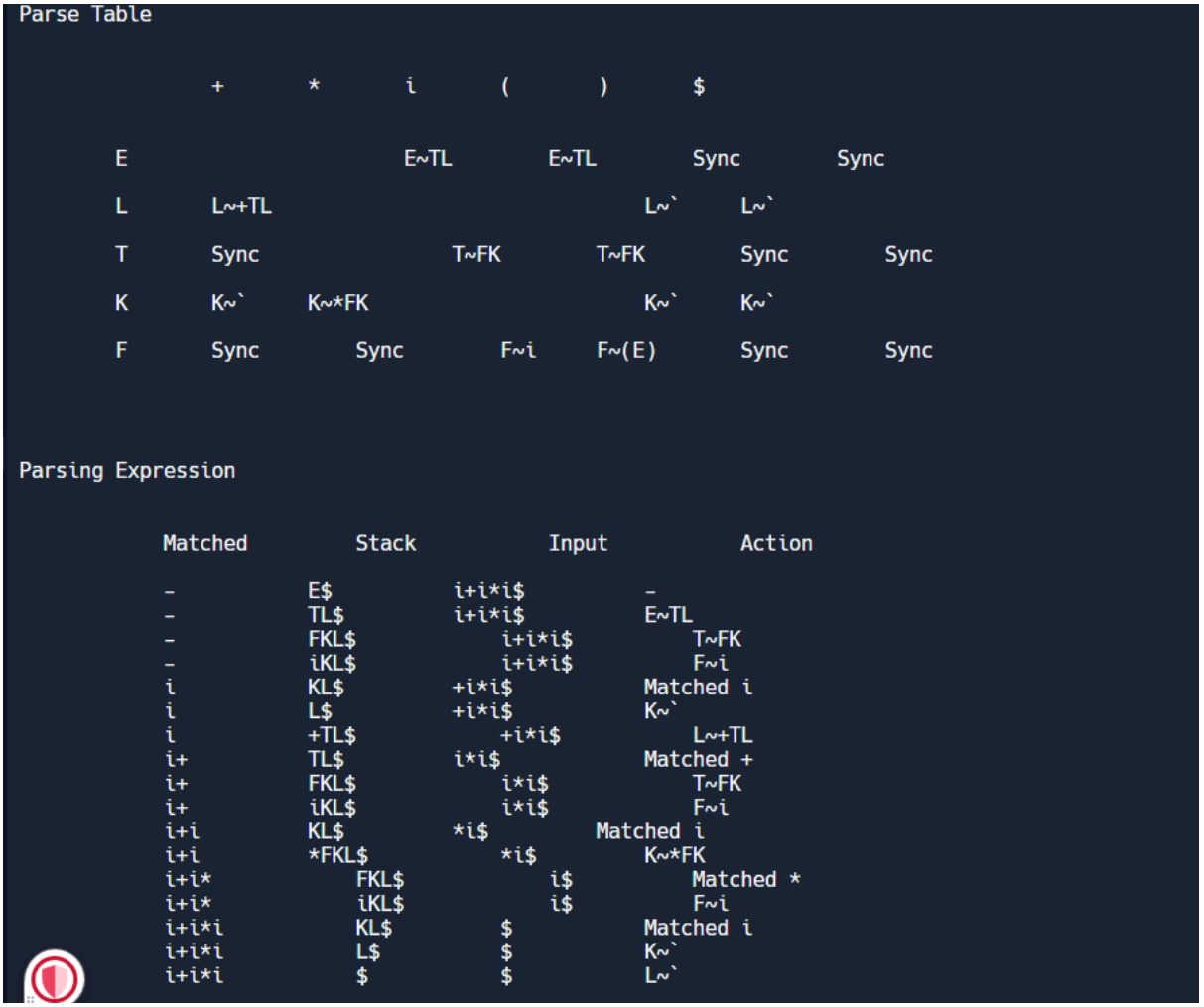
```
    if (stack[0] == expr[0] and stack[0] == "$"):
      break

    elif (stack[0] == expr[0]):
      if (matched == "-"):
        matched = expr[0]
      else:
        matched = matched + expr[0]
      action = "Matched " + expr[0]
      expr = expr[1:]
      stack.pop(0)

    else:
      action =
parse_table[non_terminals.index(stack[0])][terminals.index(
          expr[0])]
      stack.pop(0)
      i = 0
      for item in action[2:]:
        if (item != "`"):
          stack.insert(i, item)
        i += 1

    print("\t\t\t" + matched + "\t\t\t", end="")
    for i in stack:
      print(i, end="")
    print("\t\t\t", end="")
    print(expr + "\t\t\t", end="")
    print(action)

grammar = OrderedDict()
grammar_first = OrderedDict()
grammar_follow = OrderedDict()

f = open('grammar.txt')
for i in f:
  i = i.replace("\n", "")
  lhs = ""
  rhs = ""
  flag = 1
  for j in i:
    if (j == "~"):
```

```
      flag = (flag + 1) % 2
      continue
    if (flag == 1):
      lhs += j
    else:
      rhs += j
  grammar = insert(grammar, lhs, rhs)
  grammar_first[lhs] = "null"
  grammar_follow[lhs] = "null"

print("Grammar\n")
show_dict(grammar)

for lhs in grammar:
  if (grammar_first[lhs] == "null"):
    grammar_first = first(lhs, grammar, grammar_first)

print("\n")
print("First\n")
show_dict(grammar_first)

start = list(grammar.keys())[0]
for lhs in grammar:
  if (grammar_follow[lhs] == "null"):
    grammar_follow = follow(lhs, grammar, grammar_follow, start)

print("\n")
print("Follow\n")
show_dict(grammar_follow)

non_terminals = list(grammar.keys())
terminals = []

for i in grammar:
  for rule in grammar[i]:
    for char in rule:

      if (isterminal(char) and char not in terminals):
        terminals.append(char)

terminals.append("$")

print("Parse Table\n\n")
```

```
parse_table = generate_parse_table(terminals, non_terminals, grammar,
                                   grammar_first, grammar_follow)
display_parse_table(parse_table, terminals, non_terminals)

expr = "i+i*i$"

print("\n\n")
print("Parsing Expression\n\n")
parse(expr, parse_table, terminals, non_terminals)
```

Output:

```
Grammar

E  :  TL,
L  :  +TL, Epsilon,
T  :  FK,
K  :  *FK, Epsilon,
F  :  i, (E),


First

E  :  i, (,
L  :  +, Epsilon,
T  :  i, (,
K  :  *, Epsilon,
F  :  i, (,


Follow

E  :  ), $,
L  :  ), $,
T  :  +, ), $,
K  :  +, ), $,
F  :  *, +, ), $,
```



Parse Table

	+	*	i	(	)	$
E			E~TL	E~TL	Sync	Sync
L	L~+TL				L~`	L~`
T	Sync		T~FK	T~FK	Sync	Sync
K	K~`	K~*FK			K~`	K~`
F	Sync	Sync	F~i	F~(E)	Sync	Sync

Parsing Expression

Matched	Stack	Input	Action
-	E$	i+i*i$	-
-	TL$	i+i*i$	E~TL
-	FKL$	i+i*i$	T~FK
-	iKL$	i+i*i$	F~i
i	KL$	+i*i$	Matched i
i	L$	+i*i$	K~`
i	+TL$	+i*i$	L~+TL
i+	TL$	i*i$	Matched +
i+	FKL$	i*i$	T~FK
i+	iKL$	i*i$	F~i
i+i	KL$	*i$	Matched i
i+i	*FKL$	*i$	K~*FK
i+i*	FKL$	i$	Matched *
i+i*	iKL$	i$	F~i
i+i*i	KL$	$	Matched i
i+i*i	L$	$	K~`
i+i*i	$	$	L~`