

## LAB ASSIGNMENT II

Design a SLR parser for the grammar given below:

$E \rightarrow E+T/T$

$T \rightarrow T*F/F$

$F \rightarrow (E)/id$

This will involve three steps:

Generate the Set of Items (5 Marks) (3 Lab of 2 Hrs.)

Generate the Action and GOTO table (5 marks) (3 Labs of 2 Hrs. each)

OR

Design a SLR parser for the any grammar (Generic)

General SLR Parsing Table code with input example as:

$E \rightarrow E+T/T$

$T \rightarrow T*F/F$

$F \rightarrow (E)/i$

```
#include <iostream>
```

```
#include <vector>
```

```
#include <map>
```

```
#include <set>
```

```
#include <string>
```

```
#include <sstream>
```

```
#include <algorithm>
```

```
#include <bits/stdc++.h>
```

```
using namespace std;
```

```
class SLRParser {
```

```
public:
```

```
    struct Production {
```

```
        char left;
```

```
        string right;
```

```
    };
```

```
    map<char, vector<string>>> productions;
```

```
    vector<Production> productionRules; // Vector to store productions with rule numbers
```

```
    map<char, set<char>>> first, follow;
```

```
    vector<vector<pair<char, string>>> itemsets;
```

```
    map<pair<int, char>, int> gotoTable;
```

```
    map<pair<int, char>, string> actionTable;
```

```
    vector<char> terminals, nonTerminals;
```

```
    char startSymbol;
```

```
    void computeFirst(char symbol, set<char>& firstSet);
```

```
    void computeFollow(char symbol, set<char>& followSet, set<char>& processed);
```

```
    vector<pair<char, string>> closure(const vector<pair<char, string>>& kernel);
```

```
    void buildItemSets();
```

```

void buildParsingTable();

SLRParser(const vector<Production>& prods, char start);

void buildParser();

void displayResults() const;

};

SLRParser::SLRParser(const vector<Production>& prods, char start) : startSymbol(start) {

int ruleNumber = 1; // Rule numbers start at 1

for (const auto& prod : prods) {

productions[prod.left].push_back(prod.right);

productionRules.push_back(prod); // Store the production with its number

if (find(nonTerminals.begin(), nonTerminals.end(), prod.left) == nonTerminals.end()) {

nonTerminals.push_back(prod.left);

}

for (char c : prod.right) {

if (isupper(c)) {

if (find(nonTerminals.begin(), nonTerminals.end(), c) == nonTerminals.end()) {

nonTerminals.push_back(c);

}

} else if (find(terminals.begin(), terminals.end(), c) == terminals.end()) {

terminals.push_back(c);

}

}

}

terminals.push_back('$'); // Add end-of-input marker

}

void SLRParser::computeFirst(char symbol, set<char>& firstSet) {

if (first.find(symbol) != first.end()) {

firstSet.insert(first[symbol].begin(), first[symbol].end());

return;

}

if (find(terminals.begin(), terminals.end(), symbol) != terminals.end()) {

firstSet.insert(symbol);

return;

}

for (const auto& rhs : productions[symbol]) {

if (rhs[0] == symbol) continue;

bool allDeriveEpsilon = true;

for (char c : rhs) {

set<char> tempFirst;

```

```

computeFirst(c, tempFirst);

firstSet.insert(tempFirst.begin(), tempFirst.end());

if (tempFirst.find('e') == tempFirst.end()) {

allDeriveEpsilon = false;

break;

}

}

if (allDeriveEpsilon) {

firstSet.insert('e');

}

}

first[symbol] = firstSet;

}

void SLRParser::computeFollow(char symbol, set<char>& followSet, set<char>& processed) {

if (processed.find(symbol) != processed.end()) return;

processed.insert(symbol);

if (symbol == startSymbol) {

followSet.insert('$');

}

for (const auto& [left, rights] : productions) {

for (const auto& right : rights) {

auto pos = right.find(symbol);

if (pos != string::npos) {

if (pos == right.length() - 1) {

if (left != symbol) {

set<char> tempFollow;

computeFollow(left, tempFollow, processed);

followSet.insert(tempFollow.begin(), tempFollow.end());

}

} else {

set<char> tempFirst;

computeFirst(right[pos + 1], tempFirst);

followSet.insert(tempFirst.begin(), tempFirst.end());

if (tempFirst.find('e') != tempFirst.end()) {

if (left != symbol) {

set<char> tempFollow;

computeFollow(left, tempFollow, processed);

followSet.insert(tempFollow.begin(), tempFollow.end());

}

}

}

}

}

}

}

```

```

}
}

}

}

}

follow[symbol] = followSet;

}

vector<pair<char, string>> SLRParser::closure(const vector<pair<char, string>>& kernel) {

vector<pair<char, string>> result = kernel;

bool changed;

do {

changed = false;

vector<pair<char, string>> newItems;

for (const auto& [left, right] : result) {

auto dotPos = right.find('.');

if (dotPos != right.length() - 1) {

char nextSymbol = right[dotPos + 1];

if (isupper(nextSymbol)) {

for (const auto& prod : productions[nextSymbol]) {

pair<char, string> newItem = {nextSymbol, "." + prod};

if (find(result.begin(), result.end(), newItem) == result.end() && find(newItems.begin(), newItems.end(), newItem) == newItems.end()) {

newItems.push_back(newItem);

changed = true;

}

}

}

}

}

result.insert(result.end(), newItems.begin(), newItems.end());

} while (changed);

return result;

}

void SLRParser::buildItemSets() {

vector<pair<char, string>> initialItem = {{startSymbol, "." + productions[startSymbol][0]}};

itemsets.push_back(closure(initialItem));

for (size_t i = 0; i < itemsets.size(); i++) {

map<char, std::vector<pair<char, std::string>>> symbolGroups;

for (const auto& [left, right] : itemsets[i]) {

auto dotPos = right.find('.');

```

```

if (dotPos != right.length() - 1) {
    char nextSymbol = right[dotPos + 1];
    string newRight = right;
    swap(newRight[dotPos], newRight[dotPos + 1]);
    symbolGroups[nextSymbol].push_back({left, newRight});
}
}

for (const auto& [symbol, group] : symbolGroups) {
    auto newItemset = closure(group);
    auto it = find(itemsets.begin(), itemsets.end(), newItemset);
    if (it == itemsets.end()) {
        gotoTable[{i, symbol}] = itemsets.size();
        itemsets.push_back(newItemset);
    } else {
        gotoTable[{i, symbol}] = distance(itemsets.begin(), it);
    }
}
}

void SLRParser::buildParsingTable() {
    for (size_t i = 0; i < itemsets.size(); i++) {
        for (const auto& [left, right] : itemsets[i]) {
            auto dotPos = right.find('.');
            if (dotPos == right.length() - 1) { // Reduction case
                if (left == startSymbol && right == productions[startSymbol][0] + ".") {
                    actionTable[{i, '$'}] = "acc";
                } else {
                    string productionRight = right.substr(0, right.length() - 1);
                    int ruleNumber = -1;
                    // Find the rule number
                    for (size_t j = 0; j < productionRules.size(); j++) {
                        if (productionRules[j].left == left && productionRules[j].right == productionRight) {
                            ruleNumber = j + 1;
                        }
                    }
                    break;
                }
            }
            for (char terminal : follow[left]) {
                actionTable[{i, terminal}] = "r" + to_string(ruleNumber); // Use rule number
            }
        }
    }
}

```

```
}
} else { // Shift case

char nextSymbol = right[dotPos + 1];

if (find(terminals.begin(), terminals.end(), nextSymbol) != terminals.end()) {

stringstream ss;

ss << "s" << gotoTable[ {i, nextSymbol} ];

actionTable[ {i, nextSymbol} ] = ss.str();

}

}

}

for (char nonTerminal : nonTerminals) {

auto it = gotoTable.find( {i, nonTerminal} );

if (it != gotoTable.end()) {

stringstream ss;

ss << it->second;

actionTable[ {i, nonTerminal} ] = ss.str();

}

}

}

}

void SLRParser::buildParser() {

for (char nonTerminal : nonTerminals) {

set<char> firstSet;

computeFirst(nonTerminal, firstSet);

}

for (char nonTerminal : nonTerminals) {

set<char> followSet, processed;

computeFollow(nonTerminal, followSet, processed);

}

buildItemSets();

buildParsingTable();

}

void SLRParser::displayResults() const {

cout << "FIRST sets:\n";

for (const auto& [symbol, set] : first) {

cout << symbol << ": {";

for (auto it = set.begin(); it != set.end(); ++it) {

if (it != set.begin()) std::cout << ", ";

cout << *it;

}
```

```
}

cout << "}\n";

}

cout << "\nFOLLOW sets:\n";

for (const auto& [symbol, set] : follow) {

cout << symbol << ": {";

for (auto it = set.begin(); it != set.end(); ++it) {

if (it != set.begin()) cout << ", ";

cout << *it;

}

cout << "}\n";

}

cout << "\nItem Sets:\n";

for (size_t i = 0; i < itemsets.size(); i++) {

cout << "I" << i << ":\n";

for (const auto& [left, right] : itemsets[i]) {

cout << " " << left << " -> " << right << "\n";

}

cout << "\n";

}

cout << "Parsing Table:\n";

cout << " ";

for (char terminal : terminals) cout << terminal << "\t";

for (char nonTerminal : nonTerminals) cout << nonTerminal << "\t";

cout << "\n";

for (size_t i = 0; i < itemsets.size(); i++) {

cout << i << " ";

for (char symbol : terminals) {

auto it = actionTable.find({i, symbol});

if (it != actionTable.end()) {

for(const auto &action : it->second){

cout << action << " ";

}

}

cout << "\t";

}

for (char symbol : nonTerminals) {

auto it = actionTable.find({i, symbol});

if (it != actionTable.end()) {
```

```

for(const auto &action : it->second){
    cout << action << " ";
}
}

cout << "\t";

}

cout << "\n";

}

}

int main() {
    vector<SLRParser::Production> productions = {
        {'E', "E+T"},
        {'E', "T"},
        {'T', "T*F"},
        {'T', "F"},
        {'F', "(E)"},
        {'F', "T"}
    };

    productions.insert(productions.begin(), {'A', "E"});

    SLRParser parser(productions, 'A');

    parser.buildParser();

    parser.displayResults();

    return 0;
}

```

```

FIRST sets:
A: {(, i}
E: {(, i}
F: {(, i}
T: {(, i}

FOLLOW sets:
A: {$}
E: {$, ), +}
F: {$, ), *, +}
T: {$, ), *, +}

```



Item Sets:

I0:  
A -> .E  
E -> .E+T  
E -> .T  
T -> .T\*F  
T -> .F  
F -> .(E)  
F -> .i

I1:  
F -> (.E)  
E -> .E+T  
E -> .T  
T -> .T\*F  
T -> .F  
F -> .(E)  
F -> .i

I2:  
A -> E.  
E -> E.+T

I3:  
T -> F.

I4:  
E -> T.  
T -> T.\*F

I5:  
F -> i.

I6:  
F -> (E.)  
E -> E.+T

I7:  
E -> E+.T  
T -> .T\*F  
T -> .F  
F -> .(E)  
F -> .i

I8:  
T -> T\*.F  
F -> .(E)  
F -> .i

I9:  
F -> (E).

I10:  
E -> E+T.  
T -> T.\*F

I11:  
T -> T\*F.

Parsing Table:

+	*	(	)	i	\$	A	E	T	F			
0		s	1		s	5			2	4	3	
1		s	1		s	5			6	4	3	
2	s	7				a	c	c				
3	r	5	r	5		r	5		r	5		
4	r	3	s	8		r	3		r	3		
5	r	7	r	7		r	7		r	7		
6	s	7		s	9							
7		s	1		s	5			1	0	3	
8		s	1		s	5				1	1	
9	r	6	r	6		r	6		r	6		
10	r	2	s	8		r	2		r	2		
11	r	4	r	4		r	4		r	4		