PMAT 402 - Systems Programming Assignment -2 Simplified Pascal Compiler in C++

Gandholi Sarat - 23008

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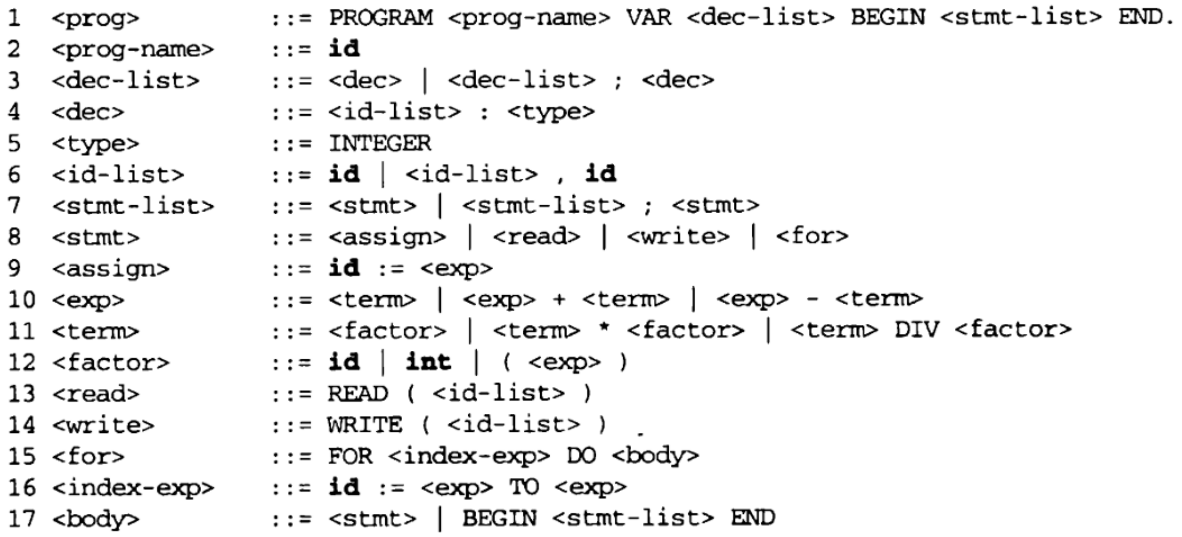
Contents

I Objective

To design and implement (as an entire class of students) a recursive descent parser in C++ for a simple programming language resembling Pascal, incorporating lexical analysis, syntax rules, and parsing functions to validate program input.

II Pascal Grammar Given



```
1  <prog>         ::= PROGRAM <prog-name> VAR <dec-list> BEGIN <stmt-list> END.
2  <prog-name>    ::= id
3  <dec-list>     ::= <dec> | <dec-list> ; <dec>
4  <dec>          ::= <id-list> : <type>
5  <type>         ::= INTEGER
6  <id-list>      ::= id | <id-list> , id
7  <stmt-list>    ::= <stmt> | <stmt-list> ; <stmt>
8  <stmt>         ::= <assign> | <read> | <write> | <for>
9  <assign>       ::= id := <exp>
10 <exp>          ::= <term> | <exp> + <term> | <exp> - <term>
11 <term>         ::= <factor> | <term> * <factor> | <term> DIV <factor>
12 <factor>       ::= id | int | ( <exp> )
13 <read>         ::= READ ( <id-list> )
14 <write>        ::= WRITE ( <id-list> )
15 <for>          ::= FOR <index-exp> DO <body>
16 <index-exp>    ::= id := <exp> TO <exp>
17 <body>         ::= <stmt> | BEGIN <stmt-list> END
```

Figure 1: Pascal Grammar

III Code Explanation

The parser code is written in C++ and consists of several main components:

III.I Lexical Mapping

The `lex` map defines token-to-integer associations for keywords, symbols, and identifiers. This simulates the output of a lexical analyzer.

```
map<string, int> lex = {
    {"PROGRAM", 1}, {"VAR", 2}, {"BEGIN", 3}, ..., {"int", 23}
};
```

III.II Tokenization

The `tokenize` function splits the input string into words and converts them into token integers using the `lex` map. If an unknown token is encountered, an error is displayed and the program exits.

III.III Token Management

The current token is managed using a global variable `TOKEN`, and the function `get_NextToken()` retrieves the next token from the token stream.

```
int get_NextToken() {
    if (index1 < tokens.size()) {
        return tokens[index1++];
    }
    return -1;
}
```

III.IV Parsing Functions

Each function corresponds to a non-terminal symbol in the grammar. These functions recursively validate the input token sequence.

- `prog()` parses the full program structure.
- `stmt()` identifies whether a statement is an assignment, read, write, or for-loop.
- `exp()`, `term()`, and `factor()` handle expressions based on operator precedence.

For example, `assign()` checks if a statement is in the form `i := expression`:

```
bool assign() {
    if (TOKEN == 22) {
        TOKEN = get_NextToken();
        if (TOKEN == 15) {
            TOKEN = get_NextToken();
            if (exp()) {
                return true;
            }
        }
    }
    return false;
}
```

III.V Parsing Entry Point

The `parse()` function is the entry point. It calls `tokenize()` and begins the syntax validation process. The current configuration uses `stmt()` as the top-level non-terminal to validate single or compound statements.

```
void parse(string input) {
    tokens = tokenize(input);
    index1 = 0;
    TOKEN = get_NextToken();
    if (stmt() && index1 == tokens.size()) {
        cout << "Valid syntax\n";
    } else {
        cout << "Invalid syntax\n";
    }
}
```

III.VI Main Function

The `main()` function reads user input and passes it to `parse()` for validation.

```
int main() {
    string input;
    cout << "Enter input string: ";
    getline(cin, input);
    parse(input);
    return 0;
}
```

IV Full Code

```
#include <iostream>
#include <string>
#include <map>
#include <sstream>
#include <vector>

using namespace std;

map<string, int> lex = {
    {"PROGRAM", 1}, {"VAR", 2}, {"BEGIN", 3}, {"END", 4}, {"END.", 5},
    {"INTEGER", 6}, {"FOR", 7}, {"READ", 8}, {"WRITE", 9}, {"TO", 10},
    {"DO", 11}, {";", 12}, {":", 13}, {",", 14}, {":=", 15},
    {"+", 16}, {"-", 17}, {"*", 18}, {"DIV", 19}, {"(", 20}, {")", 21},
    {"i", 22}, {"int", 23}
};

vector<int> tokens;
int index1 = 0;
int TOKEN = -1;

vector<int> tokenize(string input) {
    vector<int> tokenList;
    stringstream ss(input);
    string word;
    while (ss >> word) {
        if (lex.find(word) != lex.end()) {
            tokenList.push_back(lex[word]);
        } else {
            cout << "Error: Unknown token ’" << word << "’\n";
            exit(1);
        }
    }
    return tokenList;
}
```

```

int get_NextToken() {
    if (index1 < tokens.size()) {
        return tokens[index1++];
    }
    return -1;
}

bool prog();
bool prog_name();
bool dec_list();
bool type();
bool id_list();
bool stmt_list();
bool stmt();
bool assign();
bool exp();
bool term();
bool factor();
bool read();
bool write();
bool for_stmt();
bool index_exp();
bool body();

bool prog() {
    if (TOKEN == 1) { // PROGRAM
        TOKEN = get_NextToken();
        if (prog_name()) {
            if (TOKEN == 2) { // VAR
                TOKEN = get_NextToken();
                if (dec_list()) {
                    if (TOKEN == 3) { // BEGIN
                        TOKEN = get_NextToken();
                        if (stmt_list()) {
                            if (TOKEN == 4) { // END
                                TOKEN = get_NextToken();
                                if (TOKEN == 5) { // END.
                                    TOKEN = get_NextToken();
                                    return index1 == tokens.size();
                                }
                            }
                        }
                    }
                }
            }
        }
    }
    return false;
}

bool prog_name() {
    return TOKEN == 22; // i
}
```

```

bool dec_list() {
    if (id_list()) {
        if (TOKEN == 13) { // :
            TOKEN = get_NextToken();
            if (type()) {
                return true;
            }
        }
    }
    return false;
}

bool type() {
    return TOKEN == 6; // INTEGER
}

bool id_list() {
    if (TOKEN == 22) { // i
        TOKEN = get_NextToken();
        while (TOKEN == 14) { // ,
            TOKEN = get_NextToken();
            if (TOKEN != 22) return false;
            TOKEN = get_NextToken();
        }
        return true;
    }
    return false;
}

bool stmt_list() {
    if (stmt()) {
        while (TOKEN == 12) { // ;
            TOKEN = get_NextToken();
            if (!stmt()) return false;
        }
        return true;
    }
    return false;
}

bool stmt() {
    return assign() || read() || write() || for_stmt();
}

bool assign() {
    if (TOKEN == 22) { // i
        TOKEN = get_NextToken();
        if (TOKEN == 15) { // :=
            TOKEN = get_NextToken();
            if (exp()) {
                return true;
            }
        }
    }
    return false;
}

bool exp() {
    if (term()) {
        while (TOKEN == 16 || TOKEN == 17) { // + or -
            TOKEN = get_NextToken();
            if (!term()) return false;
        }
        return true;
    }
    return false;
}

bool term() {
    if (factor()) {
        while (TOKEN == 18 || TOKEN == 19) { // * or DIV
            TOKEN = get_NextToken();
            if (!factor()) return false;
        }
        return true;
    }
    return false;
}

bool factor() {
    if (TOKEN == 22 || TOKEN == 23) { // i or int
        TOKEN = get_NextToken();
        return true;
    } else if (TOKEN == 20) { // (
        TOKEN = get_NextToken();
        if (exp()) {
            if (TOKEN == 21) { // )
                TOKEN = get_NextToken();
                return true;
            }
        }
    }
    return false;
}

bool read() {
    if (TOKEN == 8) { // READ
        TOKEN = get_NextToken();
        if (TOKEN == 20) { // (
            TOKEN = get_NextToken();
            if (id_list()) {
                if (TOKEN == 21) { // )
                    TOKEN = get_NextToken();
                    return true;
                }
            }
        }
```

```cpp
    }
    return false;
}

bool write() {
    if (TOKEN == 9) { // WRITE
        TOKEN = get_NextToken();
        if (TOKEN == 20) { // (
            TOKEN = get_NextToken();
            if (id_list()) {
                if (TOKEN == 21) { // )
                    TOKEN = get_NextToken();
                    return true;
                }
            }
        }
    }
    return false;
}

bool for_stmt() {
    if (TOKEN == 7) { // FOR
        TOKEN = get_NextToken();
        if (index_exp()) {
            if (TOKEN == 10) { // TO
                TOKEN = get_NextToken();
                if (exp()) {
                    if (TOKEN == 11) { // DO
                        TOKEN = get_NextToken();
                        if (body()) {
                            return true;
                        }
                    }
                }
            }
        }
    }
    return false;
}

bool index_exp() {
    if (TOKEN == 22) { // i
        TOKEN = get_NextToken();
        if (TOKEN == 15) { // :=
            TOKEN = get_NextToken();
            if (exp()) {
                return true;
            }
        }
    }
    return false;
}

bool body() {
    return stmt() || (TOKEN == 3 && stmt_list() && TOKEN == 4); // BEGIN stmt-list END
}

void parse(string input) {
    tokens = tokenize(input);
    index1 = 0;
    TOKEN = get_NextToken();
    if (stmt() && index1 == tokens.size()) { // Changed from prog() to stmt()
        cout << "Valid syntax\n";
    } else {
        cout << "Invalid syntax\n";
    }
}

int main() {
    string input;
    cout << "Enter input string: ";
    getline(cin, input);
    parse(input);
    return 0;
}
```

Listing 1: SIC Instruction Parser in C++

V Code Output

```
Enter input string: i := i * i
Valid syntax

Enter input string: i := i DIV i
Valid syntax

Enter input string: READ ( i , i , i )
Valid syntax

Enter input string: WRITE ( i , i )
Valid syntax

Enter input string: i := i DIV
Invalid syntax

Enter input string: WRITE ( i ,
Invalid syntax
```