LAB 9 – Recursive Decent Parser Program

An Advanced Introduction to Unix/C Programming

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Scanner / Parser

Scanner reads one character at a time and returns a token.

Parser will reads one token at a time and matches the token with the grammar.

TOKEN

Scanner reads one character at a time and returns a token.

A token is defined as:

```
typedef union
{
   long        integral;
   double    floating_point;
   char      *string;
   char       op;
} TOKEN_VALUE;

typedef struct token {
    TOKEN_TYPE      type;       // IDENTFIER_TOKEN, INT_TOKEN, LPAREN_TOKEN, ADDOP_TOKEN…
    TOKEN_VALUE    val;         // token->val.op, token->val.string, token->val.integral, …
} TOKEN;
```

AST Node

Parser will reads one token at a time and matches the token with the grammar.

```
typedef struct node
{
        NODE_TYPE    type;    // PROGRAM_NODE, ASSIGN_STMT_NODE, NUMBER_NODE
        union
        {
                char          *identifier;      // firstVar
                NUMBER         number;          // type=INT_TYPE, value=100
                char           op;              // +, -, *, /, %
        } data;
        struct node    *leftChild;              // Points to left child AST Node
        struct node    *rightChild;             // Points to right child AST Node
} NODE;
```

input.txt

```
john@oho:~/LAB9.1line$ cat input.txt
firstVar = 100;
print (firstVar);
second2var = 0.15;
print (second2var);
repeat (2)
    firstVar = firstVar + 1;
print (+firstVar);
repeat(10)
    print (-101.725) ;
```

Grammar

<program> ::= <statement> <EOF> |
<statement> <program>

<statement> ::= <assignStmt> | <printStmt> |
<repeatStmt>
<assignStmt> ::= <ident> = <expr> ;
<printStmt> ::= print <expr> ;
<repeatStmt> ::= repeat (<expr>) <statement>

<expr> ::= <term> | <expr> <addOp> <term>
<term> ::= <factor> | <term> <multOp> <factor>
<factor> ::= <ident> | <number> | <addOp> <factor> |
(<expr>)

<ident> ::= <letter> | <ident> <letter> | <ident> <digit>

<number> ::= <integer> | <float>

<integer> ::= <digit> | <integer> <digit>
<float> ::= <digit> . | <digit> <float> | <float> <digit>

<addOp> ::= + | -
<multOp> ::= * | / | %

<letter> ::= a-z | A-Z | _ | $
<digit> ::= 0-9

Grammar Used for: firstVar = 100;

<program> ::= <statement> <EOF>

<statement> ::= <assignStmt>

<assignStmt> ::= <ident> = <expr> ;

<expr> ::= <term>

<term> ::= <factor>

<factor> ::= <ident> | <number>

<ident> ::= <letter> | <ident> <letter>

<number> ::= <integer>

<integer> ::= <digit> | <integer> <digit>

<letter> ::= a-z | A-Z | _ | $

<digit> ::= 0-9

Grammar used for firstVar = 100;

cat 1.txt; run

```
john@oho:~/LAB9.1line$ ls
1.txt  eval.c  eval_test.c  parse.c  print.c  print_test.c  sample_code.c  scan.h
a.out  eval.h  input.txt    parse.h  print.h  run           scan.c

john@oho:~/LAB9.1line$ more run
gcc -g parse.c scan.c eval.c eval_test.c

john@oho:~/LAB9.1line$ cat 1.txt
firstVar = 100;

john@oho:~/LAB9.1line$
```

parse.h
scan.h

john@oho:~/LAB9.CODE$ **cat parse.h**

```
#ifndef __PARSE_H
#define __PARSE_H

#include <stdio.h>
#include <stdlib.h>
#include "scan.h"

typedef enum
{
   PROGRAM_NODE,
   STATEMENT_NODE,
   ASSIGN_STMT_NODE,
   REPEAT_STMT_NODE,
   PRINT_STMT_NODE,
   EXPR_NODE,
   TERM_NODE,
   FACTOR_NODE,
   IDENT_NODE,
   NUMBER_NODE
} NODE_TYPE;

typedef enum
{
   INT_TYPE,
   FLOAT_TYPE
} NUMBER_TYPE;

typedef union
{
   long integral;
   double floating_point;
} NUMBER_VALUE;

typedef struct
{
   NUMBER_TYPE type;
   NUMBER_VALUE value;
} NUMBER;
```

```
typedef struct node
{
   NODE_TYPE type;
   union
   {
      char *identifier;
      NUMBER number;
      char op;
   } data;
   struct node *leftChild;
   struct node *rightChild;
} NODE;

TOKEN *getNextToken(TOKEN
**currToken);

NODE *program();
NODE *statement();
NODE *assignStmt(TOKEN
**currToken);
NODE *repeatStmt(TOKEN
**currToken);
NODE *printStmt(TOKEN
**currToken);
NODE *expr(TOKEN **currToken);
NODE *term(TOKEN **currToken);
NODE *factor(TOKEN **currToken);
NODE *ident(TOKEN **currToken);
NODE *number(TOKEN
**currToken);

void freeParseTree(NODE **node);

void error(char *errorFormat, ...);
```

john@oho:~/LAB9.CODE$ **cat scan.h**

```
#ifndef __SCAN_H
#define __SCAN_H

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <stdbool.h>

typedef enum
{
   NO_TOKEN_TYPE,  // 0
   INVALID_TOKEN,  // 1
   REPEAT_TOKEN,   // 2
   PRINT_TOKEN,    // 3
   IDENT_TOKEN,    // 4
   INT_TOKEN,      // 5
   FLOAT_TOKEN,    // 6
   ASSIGNMENT_TOKEN, // 7
   LPAREN_TOKEN,   // 8
   RPAREN_TOKEN,   // 9
   ADD_OP_TOKEN,   // 10
   MULT_OP_TOKEN,  // 11
   SEMICOLON_TOKEN,  // 12
   EOF_TOKEN       // 13
} TOKEN_TYPE;

typedef union
{
   long integral;
   double floating_point;
   char *string;
   char op;
} TOKEN_VALUE;

typedef struct token
{
   TOKEN_TYPE type;
   TOKEN_VALUE val;
} TOKEN;

TOKEN *scanner();
void freeToken(TOKEN **);
void printToken(TOKEN **);
void ungetToken(TOKEN **);

#define BUF_SIZE 128
```

main.c

```
#include "eval.h"

int main(int argc, char **argv)
{
   freopen(argv[1], "r", stdin);

   NODE *fullProgram = program();          ← Call program();
   printf("Done parsing...\n");
   evalProgram(fullProgram);
   freeParseTree(&fullProgram);
   cleanUpSymbolTables();

   exit(0);
}
```

TOKEN *getNextToken

```
TOKEN *getNextToken(TOKEN **token)
{
   freeToken(token);
   TOKEN* tok = scanner();
   // uncomment the line below if desired for debugging purposes.
   printToken(&tok); fflush(stdout);
   return tok;
}
```

NODE *program()

```
NODE *program()                                    // <program> ::= <statement> <EOF>
{
 printf("ENTER: program()\n");
   NODE *node = calloc(sizeof(NODE), 1);
   node->type = PROGRAM_NODE;
   node->leftChild = statement();
   if (node->leftChild != NULL)
   {
      printf("program(): node->rightChild = program();\n");
      node->rightChild = program();
   }
   else
   {
      printf("program(): leftChild = free(node); node=NULL\n");
      free(node);
      node = NULL;
   }
   return node;
}
```

NODE *statement()

```
NODE *statement()                                   // <statement> ::= <assignStmt>
{
   TOKEN *token = getNextToken(NULL);
   if (token == NULL) {
      return NULL;
   }
   else if (token->type == EOF_TOKEN) {
      freeToken(&token);
      return NULL;
   }

   NODE *node = calloc(sizeof(NODE), 1);
   node->type = STATEMENT_NODE;

   switch(token->type) {
      case IDENT_TOKEN:
         node->leftChild = assignStmt(&token);
         break;
      default:  // see the TOKEN_TYPE enum to see which numbers mean what...
         error("60 Invalid token at start of statement : ");
         printToken(&token);
         fflush(stdout);
   }
   return node;
}
```

NODE *assignStmt()

```
NODE *assignStmt(TOKEN **currToken)                    // <assignStmt> ::= <ident> = <expr>;
{
   NODE *node = calloc(1, sizeof(NODE));
   node->type = ASSIGN_STMT_NODE;
   node->leftChild = ident(currToken);

   if ((*currToken)->type != ASSIGNMENT_TOKEN) {       // Must be an equal sign, =
      error("Missing ASSIGNMENT_TOKEN, =.");
   }

   *currToken = getNextToken(currToken);
   node->rightChild = expr(currToken);

   *currToken = getNextToken(currToken);
   if ((*currToken)->type != SEMICOLON_TOKEN) {        // Must be a semicolon, ;
     error("Missing SEMICOLON_TOKEN in assignment statement.");
   }
   freeToken(currToken);
   return node;
}
```

NODE *ident()

```
NODE *ident(TOKEN **currToken)
{
   NODE *node = calloc(1, sizeof(NODE));
   node->type = IDENT_NODE;

   if ((*currToken)->type != IDENT_TOKEN) {
      error("Identifier not found.");
   }

   node->data.identifier = strdup((*currToken)->val.string);

printf("147 ident(): node->leftChild = %p\n", node->leftChild);
printf("148 ident(): node->rightChild = %p\n", node->rightChild);

   *currToken = getNextToken(currToken);

   return node;
}
```

NODE *expr()

```
NODE *expr(TOKEN **currToken)          // <expr> ::= <term>
{
   // TODO
   NODE *node = calloc(1, sizeof(NODE));
   node->type = EXPR_NODE;
   node->leftChild = term(currToken);
   return node;
}
```

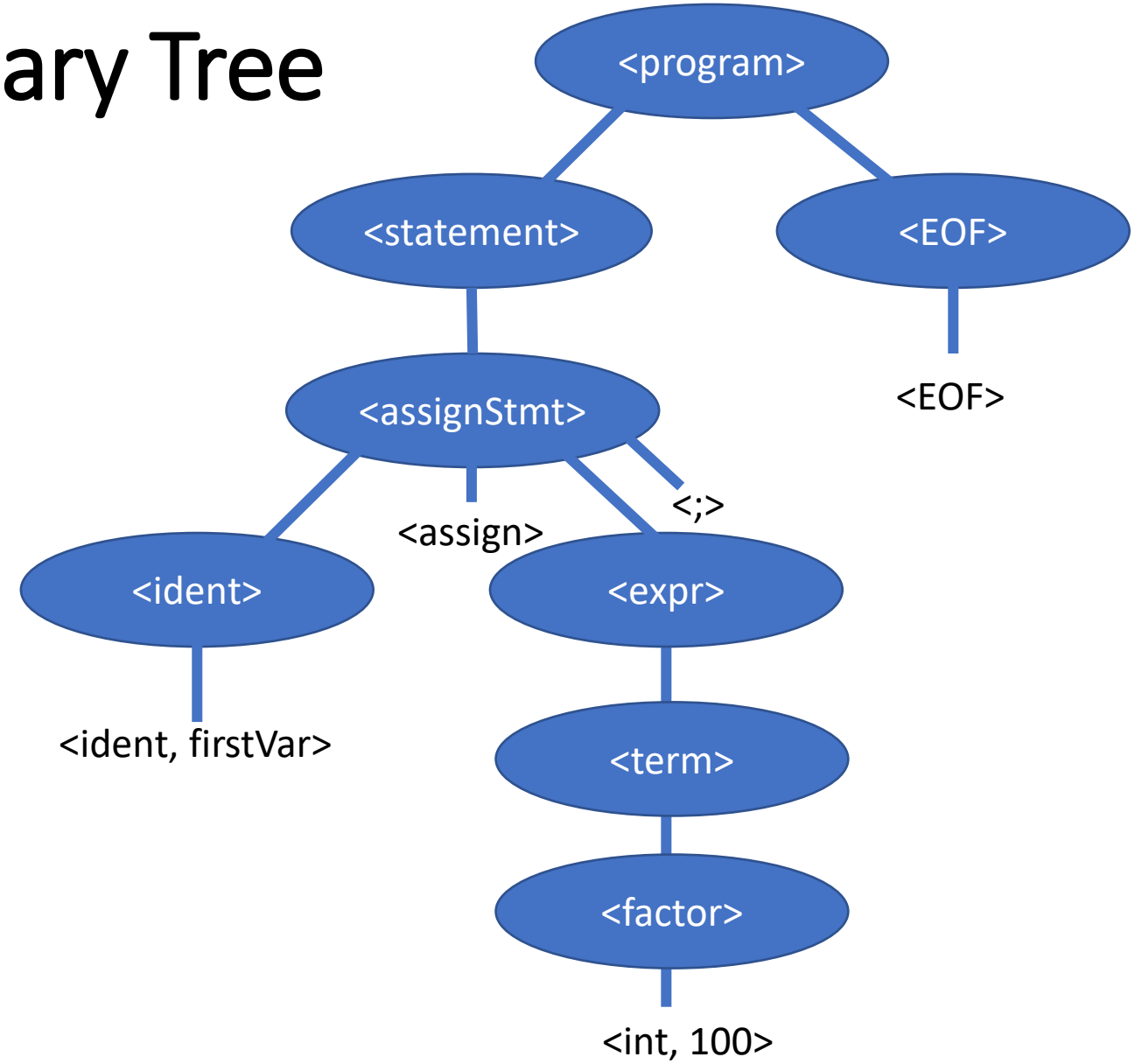
NODE *term()

```
NODE *term(TOKEN **currToken)
{
   // TODO
   NODE *node = calloc(1, sizeof(NODE));
   node->type = TERM_NODE;

   node->leftChild = factor(currToken);

   if ((*currToken)->type == MULT_OP_TOKEN) {
      node->data.op = (*currToken)->val.op;
      *currToken = getNextToken(currToken);
      node->rightChild = term(currToken);
   }

   return node;
}
```

NODE *ident()

```
NODE *ident(TOKEN **currToken)
{
   NODE *node = calloc(1, sizeof(NODE));
   node->type = IDENT_NODE;

   if ((*currToken)->type != IDENT_TOKEN) {
      error("Identifier not found.");
   }

   node->data.identifier = strdup((*currToken)->val.string);

printf("147 ident(): node->leftChild = %p\n", node->leftChild);
printf("148 ident(): node->rightChild = %p\n", node->rightChild);

   *currToken = getNextToken(currToken);

   return node;
}
```

AST Binary Tree



a.out < 1.txt

```
john@oho:~/LAB9.1line$ cat 1.txt
firstVar = 100;

john@oho:~/LAB9.1line$ run; a.out < 1.txt
ENTER: program()
<IDENT, firstVar>
147 ident(): node->leftChild = (nil)
148 ident(): node->rightChild = (nil)
<ASSIGN>
<INT, 100>
<SEMICOLON>
program(): node->rightChild = program();
ENTER: program()
<EOF>
program(): leftChild = free(node); node=NULL
Done parsing...

john@oho:~/LAB9.1line$
```