Compilers Project

Decaf compiler

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Phase 1 and 2

Our objective for phase 1 & 2 is to implement the syntax analyzer and parser for the Decaf programming Language. Analyzer should be able to parse all valid programs and give an error for invalid program. Check Decaf manual to get an idea about the language.

Tools used:

1. **Flex:** Flex (fast lexical analyzer generator) is a free and open-source software alternative to lex. It is a computer program that generates lexical analyzers (also known as "scanners" or "lexers").

   In simple words we can consider it as a tool which provides an easy way to specify the regular expressions corresponding to lexemes expected in source file. It also provides us a way to specify the action to be taken when we encounter a particular lexeme. In action part we can do operations like printing the lexeme (text matched) or returning corresponding token to the parser program. Check the following example. Here we have defined the regex for “if” and returning corresponding token in action part.

```
%{
        /* Global declarations and control information*/
%}
IF      "if"
%%
        {IF}      { foutlex<<"IF"<<"\n";yylval.sval = strdup(yytext); return If; }
%%
```

   The token we are returning here are specified in the parser file (bison file) explained below. We pass this .l file to flex to generate corresponding C code for lexical analyzer which can scan any text for the lexemes specified in .l file. The output file from flex is named “lex.yy.c”.

2. **Bison:** It is a parser generator that is part of the GNU Project. Bison reads a specification of a context-free language, warns about any parsing ambiguities, and generates a parser (either in C, C++, or Java) which reads sequences of tokens and decides whether the sequence conforms to the syntax specified by the grammar. Bison by default generates LALR parsers but can also create GLR parsers. We specify the grammar and tokens that are needed for that grammar in a .y file. We provide this .y file to bison as input and it generates two files “.tab.h” (to be included in flex code, it contains all the terminal token declarations that flex will return when it encounters the

lexeme corresponding to that token) and ".tab.c" (contains the parser code). To understand how to specify the grammar specifications, consider following dummy grammar which contains just one string "x y".

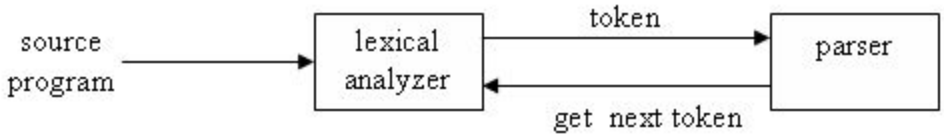
```
%{
        /* Global declarations and control information */
%}

// Union for data types of tokens that can be returned by flex
%union
{
        int ival;
        char *sval;
}

// Different tokens that can be returned by flex
%token <sval> X Y
%%
        // Grammar that'll be parsed by bison
        Program         :       X Y     {fout <<"PROGRAM ENCOUNTERED\n"; };
%%
```

In this grammar we are expecting just two lexemes or terminals: "x" and "y". Both are specified as tokens. The same are used in the only production rule. The parser generated will work in bottom up manner i.e. it'll first try to match X then Y, if it is able to complete the rule "X Y", reduction will happen and matched rule will be replaced by corresponding LHS i.e. "Program" in this case. The moment it is able to reduce to start symbol, parser stops successfully. Whenever it reduces, the corresponding statements specified in the action part will be executed. If any unexpected symbol is encountered it calls the error handler "yyerror()".

For complete codes for flex and bison check git repository link at the end.



Basic diagram to understand the interaction between lexical analyzer and parser.

Issues faced:

1. It took some time to understand how lex and bison interact with each other.
2. **Shift/reduce warnings:** These warnings can occur whenever grammar contains productions which can be reduced to a non-terminal and also one more symbol can be shifted instead of reducing it. If we don't specify the precedence and associativity of operators then there will be many shift/reduce warnings. The token specified earlier has lower precedence than that of specified later. For specifying associativity , we can use *%left, %right* and *%noassoc*. E.g. following three tokens are left associative.

   %left Multiplication Division Remainder

2. **Same lexeme to be used in two different contexts (binary/unary minus):** Both the minus are represented by '-' but we can't return two different tokens from flex corresponding to same string '-'. We need a way to use same token as per context. It can be done by specifying a dummy token for Unary minus just to specify that it has higher precedence than binary minus. Same is specified in the production using %prec. Check following example for better understanding:

   ...
   %left '+' '-'
   %left ''*
   %left UMINUS

   Now the precedence of UMINUS can be used in specific rules:

   exp:
   ...
   | *exp '-' exp*
   ...
   | *'-' exp %prec UMINUS*

References:

1. https://en.wikipedia.org/wiki/Flex_(lexical_analyser_generator)
2. https://en.wikipedia.org/wiki/GNU_bison
3. http://www.gnu.org/software/bison/manual/html_node/Contextual-Precedence.html

Code repository

https://github.com/thegame61916/DecafCompilerProject