Problem Set 3: Tokenizer for Little C
Due: 11:59 PM, Wednesday, October 2, 2019

For this assignment, you will be implementing a tokenizer (*i.e.*, lexical analyzer) in C for a language called *lC* (little C). You will later be using this tokenizer as the first stage in a larger program that will perform a full syntax analysis (*i.e.*, parse) a *lC* program.

The tokenizer, and especially the parser to come, are quite complex programs. Even though the quantity of code you will write is only on the order of a couple hundred lines, it will take some thought and planning. As such, you are encouraged to form groups of 2 or 3 for this assignment and the next.

You can find and run the executable for my solution code for this program on `noreaster.teresco.org` in `/home/cs340/probsets/tokenizer/`.

Commit and push often, and use meaningful commit messages. It's only a small part of the grade, but it's The Right Thing To Do.

Getting Set Up

You will receive an email with the link to follow to set up your GitHub repository for this problem set (`ps3-yourgitname`). If you are working on this problem set with a partner, **one** member of the group should follow the link to set up the repository on GitHub. Your problem set partner will receive a subsequent email with a link to follow that will grant them the rights to clone the repository and commit and push changes to the origin on GitHub.

By 4:00 PM, Friday, September 27, 2019, all repositories must be created and if working in a group, the partner who did not create the repository must have write access to the repository. Your name(s) must be in the repository by this deadline as well.

The *lC* Language

lC is a smaller, simpler version of the C programming language. Several familiar C features, such as arrays and functions (other than `main`) are not present in *lC*, but since *lC* is a proper subset of C, any *lC* program should compile correctly with a C compiler.

We describe the language with BNF rules (taken from *C: A Reference Manual*, by Harbison and Steele, Jr., 4th Edition, Tartan Inc., 1995, with revisions).

- `[ ]` denotes an optional part (there are no `[ ]` brackets in this language)

- the top level (*i.e.*, root, or starting) production of the language is `<program>`

```
<add-op> ::= + | -

<additive-expression> ::= <multiplicative-expression> [ <add-op> <additive-expression> ]

<assignment-expression> ::= IDENT = <conditional-expression>

<compound-statement> ::= { [<declaration-list>] [<statement-list>] }

<conditional-expression> ::= <logical-or-expression>

<conditional-statement> ::= if ( <conditional-expression> ) <statement> [ else <statement> ]

<constant> ::= INT_LIT | FLOAT_LIT

<declaration> ::= <type-specifier> <initialized-declarator-list> ;

<declaration-list> ::= <declaration> [ <declaration-list> ]

<equality-op> ::= == | !=

<equality-expression> ::= <relational-expression> [ <equality-op> <equality-expression> ]

<expression-statement> ::= <assignment-expression> ;

<floating-type-specifier> ::= float

<for-statement> ::= for <for-expressions> <statement>

<for-expressions> ::= ( <assignment-expression> ; <conditional-expression> ; <assignment-expression> )

<initialized-declarator-list> ::= IDENT [, <initialized-declarator-list> ]

<integer-type-specifier> ::= int

<iterative-statement> ::= <while-statement> | <for-statement>

<logical-and-expression> ::= <equality-expression> [ && <logical-and-expression> ]

<logical-or-expression> ::= <logical-and-expression> [ || <logical-or-expression> ]

<multiplicative-expression> ::= <primary-expression> [ <mult-op> <multiplicative-expression> ]

<mult-op> ::= * | / | %

<null-statement> ::= ;

<parenthesized-expression> ::= ( <conditional-expression> )

<primary-expression> ::= IDENT | <constant>
          | <parenthesized-expression>

<program> ::= void main () <compound-statement>

<relational-expression> ::= <additive-expression> [ <relational-op> <relational-expression> ]

<relational-op> ::= < | <= | > | >=

<statement> ::= <expression-statement> | <compound-statement>
          | <conditional-statement> | <iterative-statement>
          | <null-statement>

<statement-list> ::= <statement> [ <statement-list> ]

<type-specifier> ::= <floating-type-specifier> | <integer-type-specifier>

<while-statement> ::= while ( <conditional-expression> ) <statement>
```

In the above, you will identify several types of operators and other punctuation, as well as several keywords. Your tokenizer should match each of these with a unique token.

There are three token types which can match a variety of lexemes: `IDENT`, `INT_LIT`, and `FLOAT_-LIT`. An `IDENT` is a lexeme that begins with a letter or underscore, and is followed by 0 or more letters, numbers, and underscores. An `INT_LIT` consists exclusively of a sequence of numbers. A `FLOAT_LIT` consists of a sequence of 0 or more digits, followed by a decimal point, followed by a sequence of 0 or more digits, with the restriction that there must be at least one digit before or after the decimal point. Note that we specifically disallow negative `INT_LIT` and `FLOAT_LIT` values.

Tokenizer Requirements

Your tasks are

1. Write a C program `tokenizer.c` that takes as its input a single command-line parameter, the name of a file that contains a *lC* program. It should follow the model of the "front" example from the text and in class in how it scans the input, builds lexemes, and prints out the tokens and lexemes it finds. A copy of `front.c` is included in your starter repository for reference.

2. Develop at least 3 nontrivial *lC* example programs. These programs should compile with your favorite C compiler and should, as a group, test all of the token types needed by the grammar for *lC*, and all major forms of the tokens whose lexemes vary (`IDENT`, `INT_LIT`, `FLOAT_LIT`).

If you use the "front" example as a guide (or better yet as a starting point), you will find that you need to introduce several new token types and extend the `lex` function significantly. You will also need to add a capability to differentiate between identifiers and keywords and the `lookup` function will need to be expanded to handle multi-character operators.

It does not matter which specific token codes you assign to token types. Just don't reuse any. However, you may find it useful to group them as is done in the "front" example, where token codes that start with 1 are for one category, start with 2 are for operators and punctuation. Perhaps a separate code grouping for keywords would be appropriate.

Remember that your tokenizer need not be concerned with whether a sequence of tokens is valid *lC* code, just whether the tokens themselves are valid and what they are. For example, if your input consist of

```
if } ( + * 23.4 while float ;;;;
```

this would be perfectly fine with the tokenizer. The parser will certainly not be happy, though (when we get to that part).

A slow and steady approach will be essential here. You will definitely need to ask questions. You will definitely need to discuss your approach with your partner(s). No one piece is huge, though, so tackle it one step at a time and keep making progress.

General Requirements

Your code should be commented appropriately throughout. Please also include a longer comment at the top of your program describing your implementation. And, of course, it should include your name(s).

Your program should compile without warnings using `gcc` on noreaster when the `-Wall` flag is included. This flag turns on extra warnings that will help you avoid some of the pitfalls of C programming. If you encounter any warnings that you don't know how to fix, ask!

Include a `Makefile` that compiles the program with the `-Wall` flag. This `Makefile` should produce an executable program called `tokenizer`. My `Makefile` is on `noreaster.teresco.org` in `/home/cs340/probsets/tokenizer/` . Please feel free to use or modify as you see fit.

Bonus Opportunities

You can earn up to 9 points of bonus credit for handling the following (1.5 points each):

- negative `INT_LIT` values

- negative `FLOAT_LIT` values

- octal `INT_LIT` values

- hexadecimal `INT_LIT` values

- e notation `INT_LIT` values

- e notation `FLOAT_LIT` values

Submission

Commit and push!

Grading

This assignment will be graded out of 75 points.

Problem	Value	Score
New character classes and token codes	4	
Match new one-character operators and punctuation	6	
Match multi-character operators	8	
Match integer literals	4	
Match floating point literals	6	
Match keywords as appropriate tokens	7	
Report correct lexemes	5	
Command-line parameter for file name	1	
Appropriate output format	3	
Git commit frequency and message quality	3	
Program documentation	7	
Program efficiency, style, and elegance	5	
Working `Makefile`	1	
3 valid example *lC* programs	3	
Programs cover all token types	6	
Programs cover all major cases for `IDENT`, `INT_LIT`, `FLOAT_LIT`	6	
Bonus opportunity	up to 9	
Total	75	