**CSE340 Project 1: Lexical Analysis**

Due: **Sunday, February 11th 2024, by 11:59 pm MST**

The goal of this project is to give you hands-on experience with lexical analysis. You will extend the provided lexical analyzer to support more token types. The next section lists all new token types that you need to implement.

**1. Token Types**

Modify the lexer to support the following 3 token types:

REALNUM = NUM DOT digit digit\*

BASE08NUM = ((pdigit8 digit8\*) + 0) (x) (08) BASE16NUM = ((pdigit16 digit16\*) + 0) (x) (16)

Where

digit16 = 0 + 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + A + B + C + D + E + F pdigit16 = 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 + A + B + C + D + E + F digit = 0 + 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9

pdigit = 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 digit8 = 0 + 1 + 2 + 3 + 4 + 5 + 6 + 7 pdigit8 = 1 + 2 + 3 + 4 + 5 + 6 + 7

Note that NUM and DOT are already defined in the lexer, but here are the regular expressions for the sake of completeness:

NUM = (pdigit digit\*) + 0

DOT = '.'

Note that DOT is a single dot character, the quotes are used to avoid ambiguity.

The list of valid tokens including the existing tokens in the code would be as follows:

IF WHILE DO THEN PRINT PLUS MINUS DIV MULT EQUAL COLON COMMA

SEMICOLON LBRAC RBRAC LPAREN RPAREN NOTEQUAL GREATER LESS

LTEQ GTEQ DOT NUM ID

REALNUM BASE08NUM BASE16NUM

This list should be used to determine the token if the input matches more than one regular expression.

Follow these steps:

Download the lexer.cc , lexer.h , inputbuf.cc and inputbuf.h files accompanying this project description. Note that these files might be a little different than the code you've seen in class or

elsewhere.

Add your code to the files to support the token types listed in the

previous section.

Compile your code using GCC compiler in Ubuntu 19.04 or higher. 22.04 is the latest version and you can use that version also. You will need to use the g++ command to compile your code in a terminal window.

**Note that you are required to compile and test your code in Ubuntu 19.04 or higher using the GCC compilers.** You are free to use any IDE or text editor on any platform, however, using tools available in Ubuntu 19.04 g++ version 4.9 (or tools that you could install on Ububntu 19.04 could save time in the development/compile/test cycle. See next section for more details on how to compile using GCC.

Test your code to see if it passes the provided test cases. You will need to extract the test cases from the zip file and run the test script test1.sh . More details on this in the next section.

Submit your code in canvas before the deadline:

For this project you need to update lexer.cc and lexer.h. The updates that you need to do in lexer.h are minimal and are already implemented in the submission website. So you do not need to upload the lexer.h file in CANVAS. But you still do need to update lexer.h if you want to compile locally.

**3.1 Compiling Code with GCC**

You should compile your programs with the GCC compilers which are available in g++ 4.9 in Ubuntu 19.04. The GCC is a collection of compilers for many programming languages. There are separate commands for compiling C and C++ programs:

Use gcc command to compile C programs

Use g++ to compile C++ programs

Here is an example of how to compile a simple C++ program:

$ g++ test\_program.cpp

If the compilation is successful, gcc will generate an executable file named a.out in the same folder as the program. You can change the output file name by specifying the -o switch:

$ g++ test\_program.cpp -o hello.out

To enable all warning messages of the GCC compiler, use the -Wall

switch:

$ g++ -Wall test\_program.cpp -o hello.out

The same options can be used with gcc to compile C programs.

**Compiling projects with multiple files**

If your program is written in multiple source files that should be linked together, you can compile and link all files together with one command:

$ g++ file1.cpp file2.cpp file3.cpp

Or you can compile them separately and then link:

$ g++ -c file1.cpp

$ g++ -c file2.cpp

$ g++ -c file3.cpp

$ g++ file1.o file2.o file3.o

The files with the .o extension are object files but are not executable. They are linked together with the last statement and the final executable will be a.out .

**NOTE:** you can replace g++ with gcc in all examples listed above to compile C programs.

**3.2 Testing your code with I/O Redirection**

Your programs should not explicitly open any file. You can only use the **standard input** e.g. std::cin in C++, getchar() , scanf() in C and **standard output** e.g. std::cout in C++, putchar() , printf() in C for

input/output.

However, this restriction does not limit our ability to feed input to the program from files nor does it mean that we cannot save the output of the program in a file. We use a technique called standard IO redirection to achieve this.

Suppose we have an executable program a.out , we can run it by issuing the following command in a terminal (the dollar sign is not part of the command):

$ ./a.out

If the program expects any input, it waits for it to be typed on the keyboard and any output generated by the program will be displayed on the terminal screen.

Now to feed input to the program from a file, we can redirect the standard input to a file:

$ ./a.out < input\_data.txt

Now, the program will not wait for keyboard input, but rather read its input from the specified file. We can redirect the output of the program as well:

$ ./a.out > output\_file.txt

In this way, no output will be shown in the terminal window, but rather it will be saved to the specified file. Note that programs have access to another standard interface which is called standard error e.g. std::cerr in C++, fprintf(stderr, ...) in C. Any such output is still

displayed on the terminal screen. However, it is possible to redirect standard error to a file as well, but we will not discuss that here.

Finally, it's possible to mix both into one command:

$ ./a.out < input\_data.txt > output\_file.txt

Which will redirect standard input and standard output to input\_data.txt

and output\_file.txt respectively.

Now that we know how to use standard IO redirection, we are ready to test the program with test cases.

**Test Cases**

A test case is an input and output specification. For a given input there is an *expected* output. A test case for our purposes is usually represented by two files:

test\_name.txt test\_name.txt.expected

The input is given in test\_name.txt and the expected output is given in

test\_name.txt.expected .

To test a program against a single test case, first we execute the program with the test input data:

$ ./a.out < test\_name.txt > program\_output.txt

The output generated by the program will be stored in program\_output.txt . To see if the program generated the expected output, we need to compare program\_output.txt and test\_name.txt.expected . We do that using a general

purpose tool called diff :

$ diff -Bw program\_output.txt test\_name.txt.expected

The options -Bw tells diff to ignore whitespace differences between the two files. If the files are the same (ignoring the whitespace differences), we should see no output from diff , otherwise, diff will

produce a report showing the differences between the two files.

We would simply consider the test passed if diff could not find any differences, otherwise we consider the test failed.

Our grading system uses this method to test your submissions against multiple test cases. There is also a test script accompanying this project test1.sh which will make your life easier by testing your code

against multiple test cases with one command.

Here is how to use test1.sh to test your program:

Store the provided test cases zip file in the same folder as your project source files

Open a terminal window and navigate to your project folder using

cd command

Unzip the test archive using the unzip command:

$ unzip test\_cases.zip

**NOTE:** the actual file name is probably different, you should replace test\_cases.zip with the correct file name.

Store the test1.sh script in your project directory as well

Mark the script as executable once you download it:

$ chmod +x test1.sh

Compile your program. The test script assumes your executable is called a.out

Run the script to test your code:

$ ./test1.sh

The output of the script should be self explanatory. To test your code after each change, you will just perform the last two steps afterwards.

**4. Requirements**

Here are the requirements of this project:

You should submit your code in CANVAS, no other submission forms will be accepted.

You should use C/C++, no other programming languages are allowed.

You should familiarize yourself with the Ubuntu 19.04 environment and the GCC compiler. Programming assignments in this course might be very different from what you are used to in other classes.

**5. Evaluation**

The submissions are evaluated based on the automated test cases on the submission website. Your grade will be proportional to the number of test cases passing. If your code does not compile on the submission website, you will not receive any points.

Two ways to check your grade

1. Gradescope

Submit a zip file with all your code

Make sure the zip file only has your code files and no other subfolders.

1. IMPACT webpage

The submission site is: <http://10.218.107.121/index2.html>

In order to access the submission site you need to first login to sslvpn.asu.edu using you ASU ID and password. You will be asked to download cisco vpn. Please do so. For any subsequent time you want to access the submission site you have to login to sslvpn.asu.edu.

In the site there will be an option to upload one file. Please rename your lexer.cc as lexer\_YOUR LAST NAME.cc. Such as lexer\_Banerjee.cc. Then please hit upload. Wait for 5 seconds and then you can see the evaluation of your code on the grading test cases. To access the evaluation please type in

[http://10.218.107.121/lexer\_YOUR LAST NAME.output](http://10.218.107.121/lexer_YOUR%20LAST%20NAME.output)

such as

<http://10.218.107.121/lexer_Banerjee.output>

Then download the text file and open with any text editor. If your code passed one test case then the corresponding test case will show “NO ERRORS HERE”

If it failed a given test case then it will print “------------------------------”

At the end of the file the total number of test cases you passed will be displayed.