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Name(s): **Matthew Nolan**
Programme: **Compiler Construction Assignment**
Module Code: **CA4003**
Assignment Title: **CCALL Language Parser**
Submission Date: **3/11/2019**
Module Coordinator: **David Sinclair**

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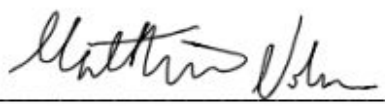
Name(s):  Date: 03/11/2019

CCAL Parser Description

In section one I defined two options for the parser; IGNORE_CASE and JAVA_UNICODE_ESCAPE. The IGNORE_CASE option was specified in the language definition as the CCAL language was not case sensitive and the JAVA_UNCODE_ESCAPE option was used to make sure the parser does unicode escapes the same was as a Java Compiler does. In section two I defined the tokeniser of the parser. For the user code I reused the code from the "JavaCC" Notes. I added these lines at the bottom to show whether or not the file was parsed correctly.

```
try {
    tokeniser.program();
    System.out.println("Parse successful");
} catch (ParseException e) {
    System.out.println(e.getMessage());
    System.out.println("Parse failure");
}
```

I used the default method for skipping newlines, spaces, tabs and mult-line comments that were in also in the notes. For single line comments I added the line : **<"//" (~["\n"])* "\n">.** This regular expression will find a string starting with "**//**" and ending with a newline character. Next I defined the keywords and tokens listed in the language definition. I had a minor issue here with the naming the token for the skip keyword as "SKIP" is already defined in JavaCC's token manager. Next I implemented the values recognised by the language.They were digits, numbers, letters and IDs. This is how I implemented them:

```
TOKEN : /* VALUES */
{
     <NUM : "0" | ((<MINUS>)? ["1" - "9"] (<DIGIT>)*) >
    |<#DIGIT: ["0"-"9"] >
    |<ID : <LETTER> (<LETTER> | <DIGIT> | <UNDERSCORE>)* >
    |<#LETTER: ["A"-"Z", "a"-"z"] >
}
```

Once I was finished with the tokens I implemented the grammar based off the definitions within the CCAL language definition. After I finished writing out the grammar I ran the code using the "javacc" command in the terminal.

Left Recursion

I got 2 warnings that there was left recursion present in the grammar. The first one was in the expression function; "expression → fragment → expression", the second one was in the condition function; "condition → condition". To fix left recursion in the expression function I put the grammar defined in the fragment function into the expression function and added a reference to expression within fragment. This made it easier to find the alpha and beta in the function in order to eliminate the recursion. I split the expression function into two separate functions. This eliminated the left recursion within the expression function. Similarly for the condition function I split it up into two functions but i had to add an expanded terminal function.

```
void expression() : {}
{
    choice_expression() expression_arith()
}

void choice_expression() : {}
{
     (<MINUS>)? <ID>  (LOOKAHEAD(1) <LBRACKET> arg_list() <RBRACKET>)?
    |<NUM>
    |<TRUE>
    |<FALSE>
    |<LBRACKET> expression() <RBRACKET>
}

void expression_arith() : {}
{
    binary_arith_op() expression()
    |{}
}

void fragment() : {}
{
    expression()
}
```

```
void condition() : {}
{
    choice_condition() condition_simple()
}

void choice_condition() : {}
{
     <AND> condition()
    |<OR> condition()
    |{}
}

void condition_simple() : {}
{
     <TILDE> condition()
    |LOOKAHEAD(1) <LBRACKET>  condition() <RBRACKET>
    |expression() comp_op() expression()
}
```

Left Factoring

I noticed that i could factor a number of common prefixes throughout the grammar which I factored out. First and second line of the statement function both begin with "**<ID>**". I factored this by adding a separate function which is called after the "**<ID>**".

```
void statement() : {}
{
     <ID> choice_statement()
    |<LBRACE> statement_block() <RBRACE>
    |<IF> condition() <LBRACE> statement_block() <RBRACE> <ELSE> <LBRACE>
    statement_block() <RBRACE>
    |<WHILE> condition() <LBRACE> statement_block() <RBRACE>
    |<SKIPTOKEN> <SEMICOLON>
}

void choice_statement() : {}
{
     <ASSIGNMENT> expression() <SEMICOLON>
    |<LBRACKET> arg_list() <RBRACKET> <SEMICOLON>
}
```

Within the expression function I noticed two common prefixes.The lines "**<ID>**" and "**<MINUS> <ID>**" which I factored to "**(<MINUS>)? <ID>**". The other lines were"**<ID>**" and "**<ID> <LBRACKET> arg_list() <RBRACKET>**", which I factored to **"<ID> (<LBRACKET> arg_list() <RBRACKET>)?".** After factoring these lines I realised that I could factor them one more time into this:

```
void choice_expression() : {}
{
     (<MINUS>)? <ID>  (LOOKAHEAD(1) <LBRACKET> arg_list() <RBRACKET>)?
    |<NUM>
    |<TRUE>
    |<FALSE>
    |<LBRACKET> expression() <RBRACKET>
}
```

LookAheads

After the left recursion and left factoring had been resolved and completed, I had two choice conflicts due to the ambiguity of the language. After running the file with the javacc command it recommend to add a LOOKAHEAD(2) into the expression function and a LOOKAHEAD(3) into the condition function both due to a due to a common prefix of "(".

With proper placement of the lookaheads I only need a LOOKAHEAD(1) for each choice conflict.

```
void choice_expression() : {}
{
     (<MINUS>)? <ID>  (LOOKAHEAD(1) <LBRACKET> arg_list() <RBRACKET>)?
    |<NUM>
    |<TRUE>
    |<FALSE>
    |<LBRACKET> expression() <RBRACKET>
}
```

```
void condition_simple() : {}
{
     <TILDE> condition()
    |LOOKAHEAD(1) <LBRACKET>  condition() <RBRACKET>
    |expression() comp_op() expression()
}
```

This file is run by compiling the "**Assignment1.jj**" file with the javacc command. Then you must compile the java file with the Java compiler, compile the "CCALTokeniser.java" with javac command, then run the CCALTokeniser with the java command.