scalc

cmput415

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The goal of this assignment is to implement a compiler for a simple imperative language called *SCalc*. This compiler will directly generate code for the following three backends:

- *x86* assembly
- *MIPS* assembly
- *ARM* assembly

You must also create an *interpreter* for *SCalc*

For the interpreter you will be computing the value of the expressions as you traverse the tree. However, when generating assembly code for each of the backends **you are not allowed to perform any computations in the compiler**. You must create assembly code to perform all of the computations that appear in the input file.

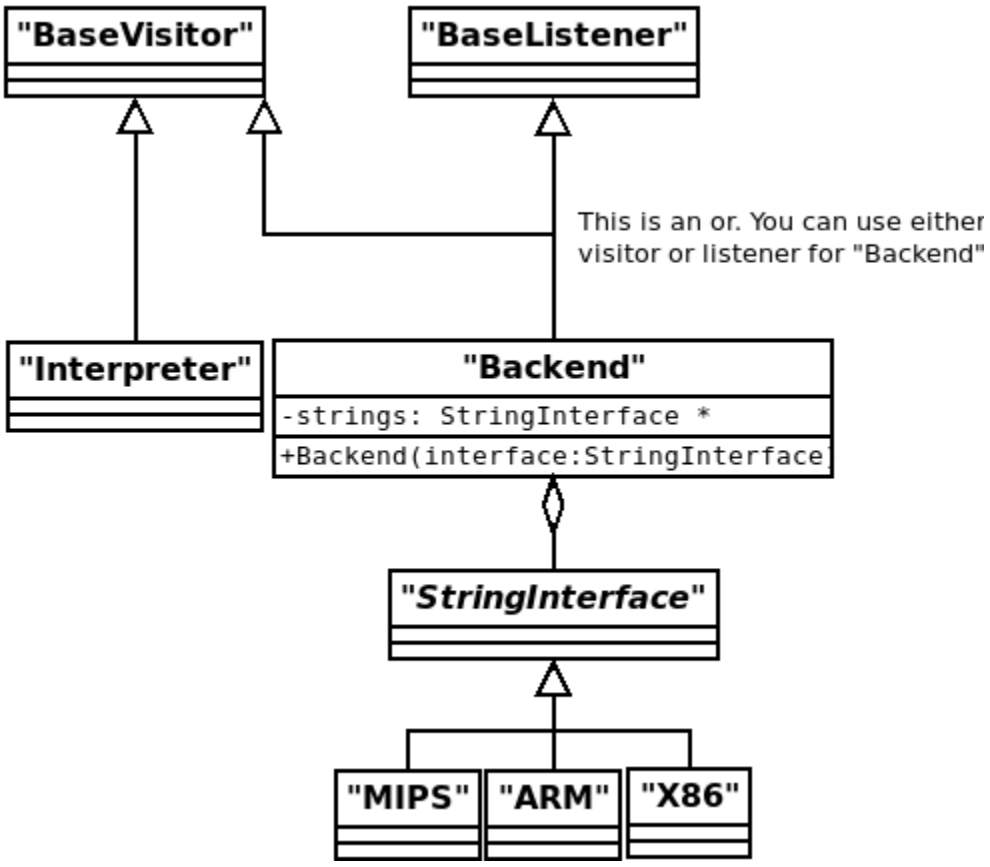
MIPS assembly will be run using *SPIM*

x86 assembly will be assembled using the nasm assembler and run natively.

ARM assembly will be compiled using the *ARM* toolchain (assembler `arm-none-eabi-as`, linker `arm-none-eabi-gcc`) and then run using an *ARM* simulator (*qemu-arm*).

Your compiler will produce the assembly text files, not binaries. **You must generate your assembly using**inja. Inja is a string template engine which allows you to make use of formatted strings. Its syntax is similar to *Python*'s jinja. You won't need any advanced features to complete this assignment.

Your classes should follow a pattern of classes matching the following UML diagram (structure only, names should be reasonably changed):



Note that you must use the visitor pattern for the interpreter as it is impossible to revisit nodes during a loop when using the listener pattern.

Beyond these constraints you are allowed to use any internal representation that you wish, as well as emit any code that you wish, as long as the output is correct.

SCalc has integer variables, conditionals, loops, prints, and various integer expressions.

CHAPTER

ONE

RESERVED KEYWORDS

The following Keywords are reserved in *SCalc*:

- `if`
- `fi`
- `loop`
- `pool`
- `int`
- `print`

CHAPTER

TWO

BOOLEANS

In this assignment, booleans can only be produced using comparison operators, there is no literal to express them. As well, they are ephemeral: there is no way to store them. They can only exist when created using one of the comparison operators.

When printed, booleans take on a value of 1 (true) or 0 (false). For example:

```
print(1 == 1);
print(1 == 0);
```

produces the following output:

```
1
0
```

As well booleans *are* usable in expressions and must be *upcast* to an integer. This means if a boolean is used in an arithmetic expression it takes on the integer value described above. For example:

```
print(1 + (1 == 1));
print(1 + (1 == 0));
```

produces the following output:

```
2
1
```

CHAPTER

THREE

INTEGERS

In this assignment, integers are the *only* numerical type (there is no floating point type). As well, they are the only type that you can store.

In this assignment integer literals are defined as being a string that contains only the numerals 0-9 with no spaces.

Assertion: All integer literals will be ≥ 0. (*nonnegative-literals*)
Examples of valid integers:

```
1
123
5234
01
10
```

Examples of invalid integers:

```
1.0
one
1_1
1o
```

As well, integers *are* usable in conditions and must be *downcast* to booleans. This means in a condtional, an integer that *is not* zero will be considered true and an integer that *is* zero will be considered false. For example:

```
if (999)
  print(999);
fi;
if (0)
  print(0);
fi;
```

produces the following output:

```
999
```

CHAPTER

FOUR

IDENTIFIERS

For the purpose of this assignment, identifiers are simple. They must start with an alphabetical character. This character may be followed by numbers or alphabetical characters. A keyword cannot be used as an identifier.

Examples of valid identifiers:

```
hello
h
h3llo
Hi
h3
```

Examples of invalid identifier:

```
3d
a-bad-variable-name
no@twitter
we.don't.like.punctuation
or_spelling
```

CHAPTER

FIVE

EXPRESSIONS

An expression is composed of integers, identifiers, and operators.

5.1 Operators

Operators are listed in descending precedence order. Operators without a horizontal line dividing them have equal precedence. For example, addition and subtraction have an equal level of precedence.

Class	Operation	Symbol	Usage	Associativity
Arithmetic	multiplication	*	`expr * expr`	left
	division	/	`expr / expr`	left
	addition	+	`expr + expr`	left
	subtraction	-	`expr - expr`	left
Comparison	less than	<	`expr < expr`	left
	greater than	>	`expr > expr`	left
	is equal	==	`expr == expr`	left
	is not equal	!=	`expr != expr`	left

Clarification: There is no remainder operator in SCalc. (*no-rem*)
Clarification: There is no exponentiation operator in SCalc. (*no-pow*)
Clarification: Division is integer division. (*int-div*)

5.2 Valid Expressions

Valid formats for expressions are

```
(<expr>)
<expr> <op> <expr>
<int>
<id>
```

- `expr` is an expression.
- `int` is an integer.
- `id` is the identifier of a variable.

Assertion: All expressions will result in a value that fits in a 32 bit signed integer. (*expression-size*)
Assertion: No expression will contain a division by 0. (*zero-divide*)

Examples of valid expressions are

```
i * 2 * 10 + 4
2 - 4 * 5
```

5.3 Precedence

Precedence determines what order operations are evaluated in. Precedence works as defined in the following table:

Precedence	Operations
HIGHER	* /
	+ -
	< >
LOWER	== !=

CHAPTER

SIX

STATEMENTS

In *SCalc* there are five types of statements:

- *Declaration*
- *Assignment*
- *Conditional*
- *Loop*
- *Print*

Each statement ends with a semicolon. White space is not important in *SCalc*.

Assertion: Whitespace is guaranteed to be a space, a tab, a carriage return, or a new line. (*simple-whitespace*)

6.1 Declaration

A variable declaration in *SCalc* has the following form:

```
int <id> = <expr>;
```

- `id` is the identifier of a variable.
- `expr` is an expression.

Variables have a few properties:

- cannot be used before being declared.
- cannot be declared without initialisation.
- cannot be declared more than once in an *SCalc* program.

Examples of valid declarations are:

```
int i = 9;
int j = 9 * 4 + 10;
int k = i * j;
```

Examples of invalid declarations are:

```
int i;
int j =;
```

6.2 Assignment

Variable assignment is similar to variable declaration but it allows variables to be assigned new values. An assignment in *SCalc* has the following form:

```
<id> = <expr>;
```

- `id` is the identifier of an already declared variable.
- `expr` is an expression.

6.3 Conditional

A conditional in *SCalc* has the following form:

```
if (<expr>)
  <statement-1>
  <statement-2>
  ...
  <statement-n>
fi;
```

- `expr` is an expression. The body of the `if` statement is executed if and only if this expression evaluates to a non-zero value.
- `statement-*` is any type of statement *except* a declaration. This means there can be assignments, nested loops, nested conditionals, and prints. There does not have to be any statements in the conditional.

Clarification: Declarations in conditionals can lead to undefined values due to global scoping. (*no-decl-cond*)

6.4 Loop

A loop in *SCalc* has the following form:

```
loop (expr)
  <statement-1>
  <statement-2>
  ...
  <statement-n>
pool;
```

- `expr` is an expression. The body of the `loop` statement is repeatedly evaluated as long as this expression is non-zero. The expression is evaluated prior to running the body similar to a *C* `while` loop.
- `statement-*` is any type of statement *except* a declaration. This means there can be assignments, nested loops, nested conditionals, and prints. There does not have to be any statements in the loop, but without side effects a loop will be infinite (unless it is never entered).

Clarification: Declarations in loops can lead to undefined or repeatedly defined values due to global scoping. (*no-decl-loop*)

6.5 Print

Print statements print the integer value of an expression followed by a newline. A print statement in *SCalc* has the following form:

```
print(<expr>);
```

- `expr` is an expression.

For example, the input:

```
int i = 0;
loop (i < 5)
  print(i);
  i = i + 1;
pool;
```

should print:

```
0
1
2
3
4
```

CHAPTER

SEVEN

BACKENDS

SCalc. This compiler will directly generate code for the following three backends:

- *x86* assembly
- *MIPS* assembly
- *ARM* assembly

You must also create an *Interpreter* for *SCalc*

7.1 MIPS

We recommend that you implement variables in the `.data` segment of your assembly code using `.word` entries. The general syntax for MIPS assembly is as follows:

```
.data
_newline: .asciiz "\n"
var1: .word 0
var2: .word 0
...

.text
main:
   <your generated code goes here>
   li   $v0, 10
   syscall
```

This reference has a table of syscalls. To print integers you should use the print int syscall (`1`). To print strings, you should use the print string syscall (`4`) in combination with the address of a string you've defined in the `.data` section containing only a new line character (see above).

If you save the *MIPS* output as `program.s` then you can run it with the command:

```
spim -file program.s
```

If you wish to debug you may also launch spim with the command:

```
spim
```

and then at the spim prompt you can load your file with:

```
load "program.s"
```

The double quotes are necessary. You can type `help` to see the commands that spim provides.

7.2 x86

You should use the Intel syntax for *x86*, and your compiler's output must work with the nasm assembler. Your *x86* output should look something like this:

```
global main
extern printf

section .data
var1: DD 0
var2: DD 0
...

section .text
  main:
    <your generated code goes here>
    mov eax, 0 ; Set return value
    ret        ; Return
```

Print will use `printf`, which we will link in later to make it easier to implement the `print` statement. Printing consists of three steps:

1. Push the arguments onto the stack in reverse order.
2. Call `printf`.
3. Clean up the stack.

For instance, the following segment of code contains a call to `printf`:

```
global main
extern printf
section .data
_format_string: DB "Hello! Here is a number: %d",0xA,0x0

section .text
  main:
    push dword 7        ; Second argument
    push _format_string ; First argument (remember stacks are FILO)
    call printf         ; Make the call to printf
    add esp, 8          ; Pop the stack, we are done!

    mov eax, 0
    ret
```

`_format_string` deserves a quick explanation. The `DB` declares a datatype of bytes, which is appropriate for characters. The string is converted to its character components and placed at the label. The values in commas after it are appended to the array. `0xA` is the ASCII value of a newline in hexadecimal. The `0x0` is the null terminator for the string.

You won't need to know more of the *x86* calling conventions than what was demonstrated above.

If you save the *x86* output as `program.s` you can assemble an executable and run it by executing the following commands:

```
nasm -felf -o program.o program.s
gcc -m32 -o program program.o
./program
```

Try this on the `printf` example and make sure that it works!

7.3 ARM

The *ARM* assembly output should look something like this:

```
.arch armv7-a
.data
_format_string: .asciz "%d\n"
var1: .word 0
var2: .word 0
...

.text
.globl main
main:
  push {ip, lr}      // Save link and scratch registers.

  <your generated code goes here>

  pop  {ip, lr}      // Load link and scratch registers.
  mov  r0, #0        // Set return value.
  bx   lr            // Return.
```

We will also be using `printf` with *ARM*. The *ARM* calling convention is different from *x86*: the first argument is passed in r0, and the second argument is passed in r1. The following code demonstrates a call to `printf` in *ARM* assembly:

```
.arch armv7-a
.data
_format_string: .asciz "Hello! Here is a number: %d\n"

.text
.globl main
main:
  push {ip, lr}      // Save link and scratch registers.

  ldr r0, =_format_string // Load the address of the format string into the first␣
↪argument.
  mov r1, #7         // Place the literal 7 into the second argument.
  bl printf          // Call printf.

  pop  {ip, lr}      // Load link and scratch registers.
  mov  r0, #0        // Set return value.
  bx   lr            // Return.
```

Aside from the difference in calling convention, this code is very similar to the *x86* example. As well, declaring the `_format_string` is a lot easier because it has a null-terminated string directive and can parse `\n` like *MIPS*.

ARMv7-A lacks a division instruction. Therefore, we have to call the subroutine `__aeabi_idiv` to perform integer division. The following code demonstrates a call to `__aeabi_idiv` in *ARM* assembly:

```
.arch armv7-a
.data

.text
.globl main
main:
  push {ip, lr}      // Save link and scratch registers.

  mov r0, #5         // Move the literal 5 into the first argument (the dividend).
  mov r1, #3         // Move the literal 3 into the second argument (the divisor).
  bl __aeabi_idiv(PLT) // Divide 5 by 3, return the result in r0.

  pop  {ip, lr}      // Load link and scratch registers.
  mov  r0, #0        // Set return value.
  bx   lr            // Return.
```

In order to assemble and run an executable you may run the following commands:

```
arm-none-eabi-as -o program.o program.s
arm-none-eabi-gcc -specs=rdimon.specs -o program program.o
qemu-arm ./program
```

Try this on the `printf` example and make sure that it works!

7.4 Interpreter

You should be able to execute a program without compiling by implementing an interpreter. This should work similarly to the generator assignment.

CHAPTER

EIGHT

INPUT

The input processed by your compiler will be in a file specified on the command line. You will also receive a value signifying which mode your compiler should be run in. The command to run your compiler will take this form:

```
scalc <mode> <input_file_path> <output_file_path>
```

Mode can be one of these four values:

- `mips`
- `x86`
- `arm`
- `interpreter`

You should open the file `input_file_path` and parse it. The input file will be a valid scalc file.

CHAPTER

NINE

OUTPUT

Output is to be written to a file specified on the command line. Your compiler will be invoked with the following command:

```
scalc <mode> <input_file_path> <output_file_path>
```

You should open the file `output_file_path` and write to it. The output file should be overwritten if it already exists.

Output content is standardized to ensure everyone can pass everyone's tests. Follow these specifications:

- Each number printed should be on its own line followed by a new line.
- There *must* be a new line after each `print` statement's printed value.
- There *must not* be any trailing space after the final number and before the newline.
- There *must* be an empty line at the end of your output.

Clarification: Empty input should result in empty output. (*empty-input*)

CHAPTER

TEN

ASSERTIONS

ALL input test cases will be valid. It can be a good idea to do error checking for your own testing and debugging, but it is *not necessary*. If you encounter what you think is undefined behaviour or think something is ambiguous then *do* make a forum post about it to clarify.

What does it mean to be valid input? The input must adhere to the specification. The rules below give more in-depth explanation of specification particulars.

1. **undef-behaviour**:

   A test case *will not* take advantage of undefined behaviour. Undefined behaviour is functionality that does not have an outcome described explicitly by this specification.

2. **nonnegative-literals**:

   All integer literals will be ≥ 0. For example, the following tests would be considered invalid:

   ```
   int i = -1;
   ```

3. **literal-size**:

   All integer literals will fit in 31 unsigned bits. This means an integer literal can be anywhere in the range $[0, 2^{31} - 1]$ or $[0, 2147483647]$. For example, the following tests would be considered invalid:

   ```
   int i = 2147483648;
   ```

4. **expression-size**:

   All expressions will result in a value that will fit in 32 signed bits. This means the result of an expression can be anywhere in the range $[-2^{31}, 2^{31} - 1]$ or $[-2147483648, 2147483647]$. Any operation that results in underflow or overflow will render the input invalid. For example, the following tests would be considered invalid:

   ```
   int i = 2147483647 + 1;
   int j =  0 - 2147483647 - 2;
   ```

5. **zero-divide**:

   No expression will contain a division by 0. The result of a division by zero is indeterminate so we will not handle it. For example, the following tests would be considered invalid:

   ```
   int i = 1 / 0;
   int j = 1 / (1 - 1);
   ```

6. **simple-whitespace**:

   Whitespace is guaranteed to be a space, a tab, a carriage return, or a new line. Any other whitespace characters will render the input invalid. The following ANTLR rule will ensure you adhere to this:

```
WS: [ \t\r\n]+ -> skip;
```

CHAPTER

ELEVEN

CLARIFICATIONS

These clarifications are meant to add more information to the specification without cluttering it.

1. **no-rem**:

   There is no remainder operator in SCalc. For example, the following tests would be considered invalid:

   ```
   int i = 5 % 2;
   ```

2. **no-pow**:

   There is no exponentiation operator in SCalc. For example, the following tests would be considered invalid:

   ```
   int i = 2 ^ 2;
   ```

3. **int-div**:

   Division is integer division. This means that any decimal portion of a division operation result is truncated (not rounded). No extra work is required: this is the default in C++, MIPS, ARM, and X86. For example:

   ```
   print(5 / 3);
   print((0 - 5) / 3);
   ```

   produces the following output:

   ```
   1
   -1
   ```

4. **no-decl-cond**:

   Declarations in conditionals can lead to undefined values due to global scoping. Because of the potentially conditional nature of the execution, it is possible to violate the property of variables stating that *variables must be defined before being used* (not just declared) by never executing the definition. For example, the following test would break this property and is therefore invalid:

   ```
   if (1 < 0)
     int i = 0;
   fi
   int j = i;
   ```

5. **no-decl-loop**:

   Declarations in loops can lead to undefined or repeatedly defined values due to global scoping. Because of the potentially conditional nature of the execution, it is possible to violate the property of variables stating that *variables must be defined before being used* (not just declared) by never executing the definition. For example, the following test would break this property and is therefore invalid:

```
loop (1 < 0)
  int i = 0;
pool
int j = i;
```

As well, because of the potentially repeated nature of the execution, it is possible to violate the property of variables stating that *variables can only be defined once* by repeating the declaration. For example, the following test would break this property and is therefore invalid:

```
int i = 0;
loop (i < 2)
  int j = 0;
  i = i + 1;
pool;
```

6. **empty-input**:

   Empty input should result in empty output. This is in keeping with all of the output rules defined. There are no `print` statements so there would be no numbers, newlines or output of any kind. All that you are left with is a single empty line, which matches "*should* be an empty line at the end of your output".

CHAPTER

TWELVE

DELIVERABLES

Your submission will be **the latest commit before the deadline** to your github repository. Your submission will be automatically snapshotted by the GitHub classroom at the submission time.

Do no submit your binaries, they will be built just before being tested. The solutions will be built using the lab machines. You should make sure your solution builds in a lab environment prior to the submission time.

Your tests also should be committed to your github repository. We will pull both your submission and tests directly from your repository.

You do not need to submit anything on eclass or anywhere else.

CHAPTER

THIRTEEN

TIPS AND HINTS

- Review the Tips and Hints from the generator assignment: much of it applies to this assignment as well. In particular, the style and design sections are necessary.
- Write tests *before* you implement the things they will test. The testing script provided is designed to handle failed test cases. You can reduce output in the testing tool by passing the `-q` flag.
- As with the generator assignment, the ANTLR visitor pattern is best for implementing the interpreter.
- The MIPS, ARM, and x86 compilers can be built using either the visitor or the listener pattern. The listener may be more appropriate so it is the suggested method.
- A single listener or visitor should be able to handle the x86, MIPS, and ARM code generation. All that should change is the templated strings.
- In addition to the previous tips, here's how to stay stylish in this assignment:
  - There is no specified syntax guide for use with *inja*, thus you **could** write your strings in any style that you choose. I suggest you use implicit string concatenation to delineate your strings. For example, this may be a format string for literal division:

```
std::string literalDivision =
  "\n  # Div.\n"
  "  addi $t0, $0, {{ dividend }} # Set dividend.\n"
  "  addi $t1, $0, {{ divisor }} # Set divisor.\n"
  "  div  $t1, $t0      # Divide.\n"
  "  mflo $t0           # Get result.\n";
```

- This assignment will be extended to build a calculator that handles vectors in the next assignment. For that assignment you will need to do type checking. Therefore you are advised to:
  - Read that assignment now.
  - Include type checking in this solution even though you are only required to handle integers in this assignment.
- You are allowed to use MIPS pseudo-instructions.

CHAPTER

FOURTEEN

PROJECT LAYOUT

For the tools provided to work your project should be in the specified layout.

```
+-- cmake
|   +-- antlr_generate.cmake
|   +-- get_antlr.cmake
|   +-- get_antlr_manual.cmake
|   +-- symlink_to_bin.cmake
+-- CMakeLists.txt
+-- grammar
|   +-- SCalc.g4
+-- include
|   +-- inja.hpp
|   +-- nlohmann
|   |   +-- json.hpp
|   +-- placeholder.h
+-- LICENSE.md
+-- README.md
+-- src
    +-- CMakeLists.txt
    +-- main.cpp
+-- tests
    +
    +-- input
        +-- ...
    +-- output
    |   +-- ...
    +-- SCalcConfigCS.json
    +-- SCalcConfigInterpreterOnly.json
```

CHAPTER

FIFTEEN

SETTING UP CLION

CLion requires a little bit of setup.

1. Open up CLion. From the welcome screen select `Import Project from Sources` or, if you've been using CLion and it opens to previous project, from the `File` menu select `Import Project...`. Navigate to where your project is located an choose it. Choose `Open Project` *not* `Overwrite CMakeLists.txt`. If you already have a project open, you can choose to use your current window or create another one.
2. CLion doesn't make use of your command line environment, it has its own storage place. Therefore we need to add `ANTLR_INS` to CLion's environment.
    1. Open your settings. On Linux this is `File` → `Settings...`, while on MacOS this is `CLion` → `Preferences...`.
    2. From the left menu, expand `Build, Execution, Deployment`.
    3. Select `CMake` from the newly expanded options.
    4. In the right pane, select the `...` to the right of the empty text field to the right of `Environment`.
    5. In the new pane, select the + symbol to add a new entry in the environment. On Linux this is in the top right of the pane, while on MacOS this is in the bottom left of the pane.
    6. In the new text field under `Name` enter `ANTLR_INS`. In the field under `Value` enter the path to your `antlr_install` directory. If you've forgotten it but your terminal is set up correctly, or if you're using the lab machines, then you can enter the following command to print it:

        ```
        echo $ANTLR_INS
        ```

    7. Apply all of your changes while closing the settings.
3. Make sure you're building the `all` target, not just the `scalc` target. From the drop down menu in the top right of the IDE you can choose your build target. Change this to `Build All`.
4. CLion may not automatically pick up ANTLR's generated sources as your project's. We can fix this by telling CLion where the files are. Build once to have the `gen` directory appear in the project manager pane. Right click on the directory, near the bottom of the menu find `Mark directory as`, within that menu select `Project Sources and Headers`.

CHAPTER

SIXTEEN

USING INJA

Inja is the string templating library you'll be using in this assignment. You'll only need the most basic string replacement functionality, even though it can be much more advanced.

String templating looks like this:

```
#include "nlohmann/json.hpp"
#include "inja.hpp"

#include <string>
#include <iostream>

using JSON = nlohmann::json;

int main() {
  std::string name;
  int age;
  std::cout << "What's your name?\n";
  std::cin >> name;
  std::cout << "How old are you?\n";
  std::cin >> age;

  JSON data;
  data["name"] = name;
  data["age"] = age;

  std::string strTemplate =
    "Hi, {{ name }}!\n"
    "You are {{ age }} years old!\n";

  std::cout << inja::render(strTemplate, data);

  return 0;
}
```

Let's deconstruct the example. First we have the includes that give us access to the `json` class that *inja* uses to store data as well as the inja tools.

```
#include "nlohmann/json.hpp"
#include "inja.hpp"
```

Next we have a statement that's purely for convenience purposes. It aliases the `json` class to `JSON`. If we didn't use this we could refer to the `json` class using the fully qualified name `nlohmann::json`.

```
using JSON = nlohmann::json;
```

Now we create our data object and fill it. If you have keys `key1` and `key2` that map to values `value1` and `value2` respectively, the general syntax is:

```
JSON data;
data["key1"] = value1;
data["key2"] = value2;
...
```

Almost done. You need to define your format string using the inja syntax. To have the value replace the key in the string you need to surround the key double braces like so: `{{ keyname }}`.

```
std::string strTemplate = "{{ key1 }} {{ key2 }}";
```

Finally, you need to `render` the data into the template:

```
std::string result = inja::render(strTemplate, data);
```

CHAPTER

SEVENTEEN

TESTING

17.1 Testing Tool

Inside the `tests` directory, a testing configuration file, `SCalcConfigInterpreterOnly.json`, is provided. You need to edit `inDir` with the absolute path of `.../tests/input`, `outDir` with the absolute path of `.../tests/output`, and finally `testedExecutablePaths` with your ccid and the absolute path of `.../bin/scalc`.

This configuration will run *only your interpreter* and can be run on your local machine.

Another configuration is provided in `SCalcConfigCS.json`. This is for use on the machines in CSC either by being physically logged on or via ssh. Again, you need to edit `inDir` with the absolute path of `.../tests/input`, `outDir` with the absolute path of `.../tests/output`, and finally `testedExecutablePaths` with your ccid and the absolute path of `.../bin/scalc`.

This configuration will run the *MIPS, x86, ARM, and interpreter* configurations of your compiler against all of your tests.

Running the tester should now run your tests with your solution. Note that the output files will not be cleaned up so it might be wise run your tests in a directory that is not your repository. If you would still like to run them in the same directory, just know that the output files do not need to be tracked by git and can be safely deleted.

```
tester <path_to_config>
```

For more information about the testing tool and how it works, see the Tester README.

If you feel like running the full configuration (or a larger partial configuration) you'll first need to install the extra tools yourself and then understand how to pull the relevant parts out of the full configuration (binary path changes may be needed, arguments should be the same).

17.2 Generating Test Cases

A Python script `fuzzer.py` is available for automatic generation of random test cases.

More information is available in the README file included with the script, but an example usage of the script is as follows:

```
python fuzzer.py config.json test
```

The above command will generate two files: `test.in` and `test.out`, where `test.in` contains the SCalc source code of the test case and `test.out` contains the expected output. These files can be placed in your `tests` directory for use with the *Testing Tool*.