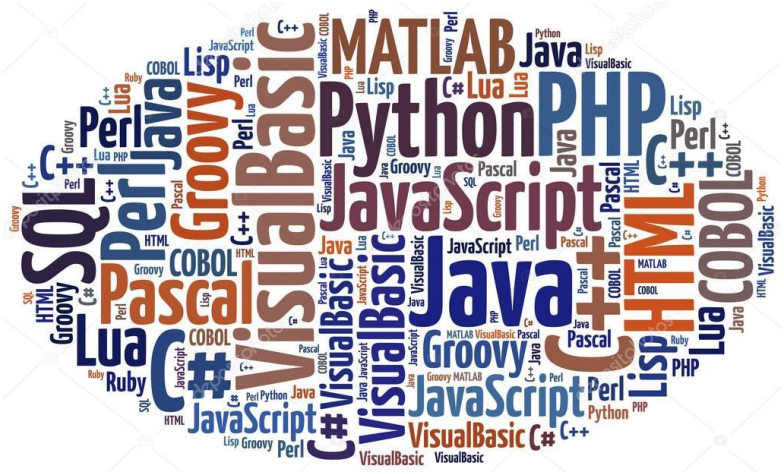
ASSIGNMENT 5

CS 474: Object-Oriented Languages and Environments / Fall 2021



Description

In this assignment, you will re-implement portions of the interpreter presented in Lecture 16, 17, and 18 in a programming language of your choice. You will submit the code you wrote, together with a screen-cast explaining it. The code you submit should run online, and you are encouraged to use https://repl.it/ to work on this project. This website supports many popular languages.

Basic Expressions – 60%

Your submission should implement **all the basic expressions** listed below. Each expression implemented is worth 10% as listed here. To claim the points for each expression, your video must show the implementation of that expression, and a sample program that shows the behavior of that expression. It is OK to show many expressions in the same program.

- Lecture 16
  - Integer Constants: 10%
  - Binary Operations: 10%
  - Introducing and reading variables (let and variable): 10%
- Lecture 17
  - Comparison: 10%
  - Conditional execution (if): 10%
  - Function definition and invocation (non first-class): 10%

Bonus Expressions – 30%

Your submission can implement **more expressions** listed below. You have to implement all the expressions in each line to claim the bonus. Each line implemented is worth 10% as listed here. To claim the points for each expression, you can submit an extra video that shows the implementation of each line, and a sample program that shows the behavior of that expression. It is OK to show many expressions in the same program.

Lecture 17

- First-class functions: 10%

Lecture 18

- Sequencing + Set statements: 10%
- Loop + Return statements: 10%

To claim points for these expressions, you have to use them in a program that you must write. You can reuse any program from class, translated to your language.

Video submission – 40%

Together with the code, you should submit two (or three) video screen-cast (**through Gradescope**) that explains your implementation.

Video 1 will claim points for each expression in your submission by showing its implementation (very briefly) and by executing a sample program that uses the expression. The sample program should make it clear that an expression is correctly implemented (e.g., conditional execution only executes one side).

Video 2 must answer the following questions about your implementation:

- How do you represent expressions? 10%
- Do you implement lexical or dynamic scope? 10%
- Show me one thing we saw in class in the language you choose that is just like Java. 10%
- Show me one thing we saw in class in the language you choose that is different from Java. 10%

For the last two points, avoid trivial differences simply due to syntax but doing the same. For instance, saying that C++ extends classes with `class Child: Parent` is just a syntactic difference. However, saying that C++ supports multiple inheritance is a major difference.

Video 3 will claim points for each extra expression in your submission by showing its implementation (very briefly) and by executing a sample program that uses the expression. The sample program should make it clear that an expression is correctly implemented (e.g., first class functions can be saved/read in variables).

The maximum length for each video is 5 minutes, instructors will stop watching at the 5 minute mark (nothing past that point in the video will be graded). Videos past 5 minutes will have a 25% penalty. Videos should be a screencast of your IDE open on the code submitted, and you should highlight the code. Note that longer videos are not better videos, and you should record a video as short as needed to show all the expressions and answer the questions above.

You can record such a video without installing any software by using the following website: https://screenapp.io/#/

Language Features

Inheritance and reflection

To use the solution presented in class directly in another language, that language needs to have the following features: **Inheritance** (to extend `Expression`), **reflection** (to get the name of each expression class), and **switching on strings** (to evaluate each expression based on its name).

Enums and arrays

A simpler implementation can use **enums** and **arrays**. You can represent each expression as an array. The first element of this array is an enum that tells you what the type of the expression is. The rest of the elements are the data that you need to evaluate that expression. Note that you can have nested expressions.

For instance, you can start by translating the code below to the language you choose:

```
enum Expression { INT_CONST, BIN_OP }
enum Operation { PLUS, MINUS, TIMES, DIV }

Value eval(Object[] c) {
  Expression e = (Expression) c[0];
  switch (e) {
    case INT_CONST: {
      int value = (Integer) c[1];
      return new IntValue(value);
    }
    case BIN_OP: {
      Operation op = (Operation) c[1];
      IntValue left  = (IntValue) eval(c[2]);
      IntValue right = (IntValue) eval(c[3]);
      switch (op) {
        case PLUS: return new IntValue(left.v + right.v);
        ...
      }
    }
}
```

```
// Sample program
Object[] p = new Object[]{
     BIN_OP,
     PLUS,
     new Object[]{ INT_CONST, 400 },
     new Object[]{ INT_CONST, 74  }
};

// Should get an IntValue with 474
eval(p);
```

Tagged unions and Pattern-Matching

Choosing a language that supports tagged unions and pattern-matching results in the most compact submission. These are sophisticated language features that minimize the boilerplate code needed for your submission. The code below shows an example in F#. This code has a simple error that you have to fix by finishing the implementation of `BinOp` for all the operations.

```
type Operator = PLUS | MINUS | TIMES | DIV

type Expression =
  | IntConstant of int32
  | BinOp of Operator * Expression * Expression

type Value =
  | IntValue of int32

let rec eval c =
  match c with
  | IntConstant(value) -> (IntValue value)
  | BinOp(op,left,right) ->
    let (IntValue l) = eval left
    let (IntValue r) = eval right
    match op with
    | MINUS  -> IntValue (l - r)
    // Finish implementing BinOp here

let p = BinOp(
          PLUS,
          IntConstant(400),
          IntConstant(74))

printfn "Value: %A" (eval p)
```

Memory management

You are **discouraged from using** a language with manual memory management for this assignment, such as **C or C++**. Choosing such a language will make your implementation much more complicated than it needs to be.

Sample Programs

This section shows some sample programs (in pseudo-code) that you can translate to your interpreter to show different features. Note that each program shows many features, and you can show a single program in your submission video (the highest possible number that your submission supports).

Program name	Features	Program	Result
P1	• Constants	`474`	474
P2	• Constants • Binary operation	`(400 + 74) / 3`	158
P3	• Constants • Binary operation • Comparison	`((400 + 74) / 3) == 158`	True

P4	• Constants
	• Binary operation
	• Comparison
	• Conditional execution
		`if (((400 + 74) / 3) == 158)`
		`then 474`
		`else 474/0`
			474, no divide by zero error

P5	• Constants
	• Binary operation
	• Comparison
	• Conditional execution
	• Variables
		`let bot = 3 in`
		`  (let bot = 2 in bot)`
		`  +`
		`  (if (bot == 0) then 474/0 else (400+74)/bot)`
			160 or 239 , no divide by zero error

P6	• Constants
	• Binary operation
	• Comparison
	• Conditional execution
	• Variables
	• Functions
		`function f(top,bot) :`
		`  if (bot == 0) then 0 else top/bot`
		
		`let bot = 3 in`
		`  (let bot = 2 in bot)`
		`  +`
		`  (f(400+74,bot) + f(470+4,0))`
			160 or 239, no divide by zero error

Due Date

This assignment is due on **December 4 2021** (Saturday) at **5pm CST**. There is no late policy. There is no opportunity to resubmit this assignment. Together with your submission, you will have to submit (on Gradescope) the screen-casts described above.

Piazza Bonus Points – 10%

This assignment has a total of **10% bonus points**, which you can earn by using Piazza as described in the syllabus. Your posts should be public, tagged with the `assignment5` label, and non-anonymous to the instructors to count towards the bonus.

Submission and Grading

This assignment is submitted Gradescope, and graded manually after the submission date.

Errors and Omissions

If you find an error or an omission, please post it on Piazza as soon as you find it.

Hardcoding and Academic Integrity

Any hardcoding will result in a 0% grade. Hardcoding is when you submit code that detects which test is being run, and simply outputs the expected result. For instance, detecting that test 22 is running, and replacing the usual execution of your submission with `System.out.println("expected result");`.

The academic integrity policy described in the syllabus applies to this assignment. You are responsible for writing all the code that you submit. We will use an automatic tool that detects plagiarism on all submitted code, and we will investigate all instances where plagiarism is more than likely.

Please refer to the syllabus for the full academic integrity policy.