Lab Exercise 5: Exceptions
CS 2334

September 21, 2017

Introduction

This lab focuses on the use of Exceptions to catch a variety of errors that can occur, allowing your program to take appropriate corrective action. You will implement a simple calculator program that allows the user to specify an operator and up to two operands (arguments / parameters). Your program will parse these inputs, perform the operation and print out the result. If an error occurs during any of these steps, your program will catch the errors and provide appropriate feedback to the user.

Learning Objectives

By the end of this laboratory exercise, you should be able to:

1. Create a program that interacts with a user through text
2. Implement and throw a custom Exception
3. Robustly handle Exceptions with a try/catch/finally block

Proper Academic Conduct

This lab is to be done individually. Do not look at or discuss solutions with anyone other than the instructor or the TAs. Do not copy or look at specific solutions from the net.

Preparation

1. Download the lab5 partial implementation:
   `http://www.cs.ou.edu/~fagg/classes/cs2334/labs/lab5/lab5.zip`

User Interaction

Each line that is typed by the user is interpreted as a potential expression. Valid expressions consist of a sequence of one, two or three tokens (each token is separated from the preceding token by one or more spaces), and may take on one of the following forms:

- 1 token: [**quit**]. The program responds by exiting
- 2 tokens: [**UOP N**], where N is an integer and UOP is a unary operator ("-"). The program responds by displaying the negative of the given integer
- 3 tokens: [**N1 BOP N2**], where N1 and N2 are integers and BOP is a binary operator ("+" or "/" only). The program responds by displaying the result of applying the designated operator to the two arguments

Inputs resulting in an illegal integer operation or not following one of these formats result in the display of a specific error message.

Below is an example interaction with a user. Note that both the user's input and the program's response are shown.

```
4 + 2
The result is: 6
Input was: 4 + 2
42+7
Illegal input: Illegal Argument
Input was: 42+7
4 / 2
The result is: 2
Input was: 4 / 2
foo + 2
Illegal input: Illegal Argument
Input was: foo + 2
42 ^ 3
Illegal input: Illegal Operator
Input was: 42 ^ 3

Illegal input: Illegal Argument
Input was:
32 ^ baz
Illegal input: Illegal Argument
Input was: 32 ^ baz
foobar ^ 3
Illegal input: Illegal Argument
Input was: foobar ^ 3
4 / 0
Tried to divide by zero
Input was: 4 / 0
-4
Illegal input: Illegal Argument
Input was: -4
- 4
The result is: -4
Input was: - 4
1 + 2 + 3
Illegal input: Illegal Token Length
Input was: 1 + 2 + 3
45+ 2
Illegal input: Illegal Operator
Input was: 45+ 2
45 +2
Illegal input: Illegal Operator
Input was: 45 +2
QUIT
Quitting
```

Class Design

Below is the UML representation of the set of classes that you are to implement for this lab. It is important that you adhere to the instance variables and method

names provided in this diagram (we will be executing our own JUnit tests against your code). In this diagram, you are seeing some new notation: the dashed open arrow means that there is some loose relationship between the classes. It is not an *is-a* relationship (class inheritance), or even a *has-a* relationship (a class or instance variable referring to another class). This relationship is much more nebulous – here, we are acknowledging that one class has local variables that reference another class.

The *Exception* class is provided by the Java API. The *CalculatorException* class is derived from *Exception*. Note that we do not add any extra functionality to this class. It exists simply so that our try/catch/finally blocks can check for the particular exception. By making a new *Exception* type, we enable the program to pass more detailed information about what errors have occurred, just by having a more specific class. To provide even further granularity to our errors, we also construct the following classes:

1. QuitException: thrown when the user inputs "quit" to end the program (case insensitive).

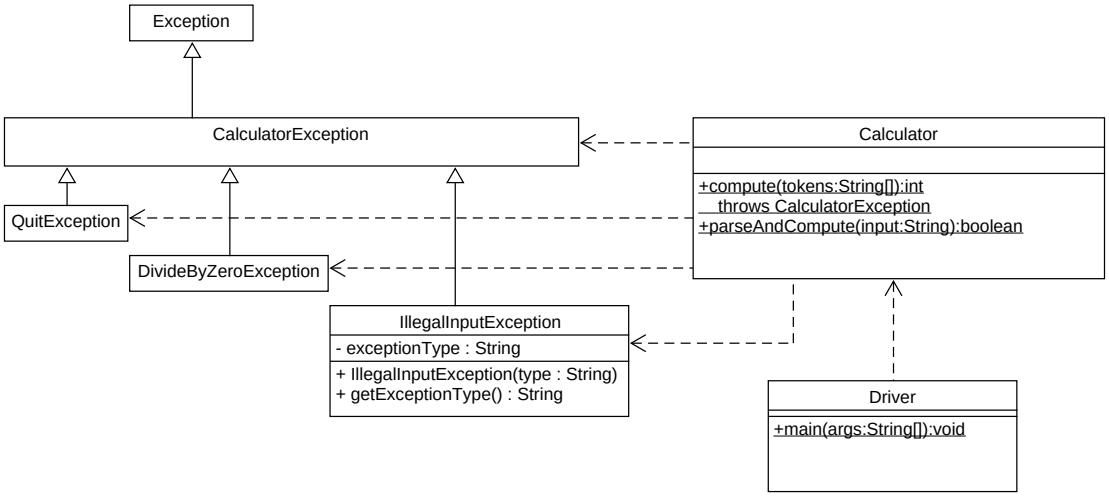
2. DivideByZeroException: thrown when the program attempts to divide by 0.

3. IllegalInputException: thrown when the input does not match with a format that we expect. This exception also has a private String variable *exceptionType* and a getter for the variable. *exceptionType* is set through the IllegalInputException constructor and gives some more detail about what kind of input error occurred. Valid strings to give are:

   (a) "Illegal Token Length": when the number of tokens is less than 1 or greater than 3.

   (b) "Illegal Argument": when a token does not match the type of token expected in its position. For example, in the input "1 + a", "a" is an illegal argument, as it is not an int.

   (c) "Illegal Operator": when a token in an operator position is not supported by the program. The program only accepts the "+" and "/" operators for binary operations. So, "1 * 2" would yield this error.



The *Calculator* class provides two methods. The following method is responsible for taking as input a single String that is to be interpreted as an expression:

```
public static boolean parseAndCompute(String input)
```

This method:

1. Separates the String into a set of tokens (substrings that are separated by one or more spaces)
2. Calls *compute()* to evaluate the expression
3. Prints out one line with the result or an error message. What error message is printed is dependent on what exception type is caught. We have the following possibilities for printing:
   (a) No Exception Caught: "The result is: " + result
   (b) QuitException Caught: "Quitting"
   (c) IllegalInputException Caught: "Illegal input: " + e.getExceptionType()
   (d) CalculatorException Caught (DivideByZeroException is the only remaining case): "Tried to divide by zero". We catch the more general exception here to make the code coverage measure happy.

4. Prints out a second line with what the input was, even when returning (while we would like to use a *finally* block for this, the code coverage measure will not be happy if you do).

5. Returns a boolean to indicate whether the program should terminate

The *compute()* method is responsible for interpreting the set of tokens and producing a result:

```
public static int compute(String[] tokens) throws CalculatorException
```

If there are two or three tokens that make up a valid expression, then this method returns the int result. In all other cases, this method throws a *CalculatorException*, selecting the appropriate type (*QuitException*, *DivideByZeroException*, or *IllegalInputException*) to throw. When there is exactly one token that is equal to the String "quit" with any casing, a QuitException is thrown. The details for the appropriate exception message are given in the code skeleton that we provide.

You must implement your own JUnit test class called *CalculatorTest*. We have provided *CalculatorSampleTest* that gives a few hints as to how to test with Exceptions.

The *Driver* class is provided and is responsible for opening an input stream from the user and repeatedly reading and evaluating lines of input until a *quit* has been received.

Implementation Steps

1. Complete the implementation of the *QuitException* class.

2. Complete the implementation of the *DivideByZeroException* class.

3. Complete the implementation of the *IllegalInputException* class.

4. Complete the implementation of the *Calculator* class.

5. Implement a JUnit test for the *Calculator* class.

Final Steps

1. Generate Javadoc using Eclipse.

- Select *Project/Generate Javadoc...*
- Make sure that your **lab5** project is selected, as are all of your java files
- Select your *doc* directory
- Select *Private* visibility
- Use the default destination directory
- Click *Finish*

2. Open the *lab5/doc/index.html* file using your favorite web browser or Eclipse (double clicking in the package explorer will open the web page). Check to make sure that all of your classes are listed and that all of your documented methods have the necessary documentation.

3. If you complete the above instructions during lab, you may have your implementation checked by one of the TAs.

Submission Instructions

Before submission, finish testing your program by executing your unit tests. If your program passes all tests and your classes are covered completely by your test classes, then you are ready to attempt a submission. Here are the details:

- All required components (source code and compiled documentation) are due at 7pm on Saturday, September 23) **Submission must be done through the Web-Cat server.**

- Use the same submission process as you used in lab 1. You must submit your implementation to the *Lab 5: Exceptions* area on the Web-Cat server.

Hints

- Recall that a try/catch/finally block can have multiple catch statements. This allows you to check for different errors and respond in kind.

- Be careful not to deviate from the specification. It is okay to have empty exception classes, as these exceptions when thrown give more specific information to the program and the user about what error occurred.

- It is bad coding style for a *catch* statement to catch all *Exceptions* (unless you really mean to catch all exceptions). Instead, you should only catch the specific exceptions that you expect to happen. This way, other, unexpected exceptions will still result in a halt of your program, making it easier to track down problems.

- Although Java allows *switch* statements to be used with Strings, code coverage computations do not work properly for these cases. Instead, you should use if/else cascades to implement a sequence of tests of this type.

Rubric

The project will be graded out of 100 points. The distribution is as follows:

Correctness/Testing: 45 points

The Web-Cat server will grade this automatically upon submission. Your code will be compiled against a set of tests (called *Unit Tests*). These unit tests will not be visible to you, but the Web-Cat server will inform you as to which tests your code passed/failed. This grade component is a product of the fraction of **our tests** that your code passes and the fraction of **your code** that is covered by *your tests*. In other words, your submission must perform well on both metrics in order to receive a reasonable grade.

Style/Coding: 20 points

The Web-Cat server will grade this automatically upon submission. Every violation of the *Program Formatting* standard described in Lab 1 will result in a subtraction of a small number of points (usually two points). Looking at your submission report on the Web-Cat server, you will be able to see a notation for each violation that describes the nature of the problem and the number of subtracted points.

Design/Readability: 35 points

This element will be assessed by a grader (typically sometime after the lab deadline). Any *errors* in your program will be noted in the code stored on the Web-Cat server, and two points will be deducted for each. Possible errors include:

- Non-descriptive or inappropriate project- or method-level documentation (up to 10 points)
- Missing or inappropriate inline documentation (2 points per violation; up to 10 points)
- Inappropriate choice of variable or method names (2 points per violation; up to 10 points)
- Inefficient implementation of an algorithm (minor errors: 2 points each; up to 10 points)
- Incorrect implementation of an algorithm (minor errors: 2 points each; up to 10 points)

If you do not submit compiled Javadoc for your project, 5 points will be deducted from this part of your score.

Note that the grader may also give *warnings* or other feedback. Although no points will be deducted, the issues should be addressed in future submissions(where points may be deducted).

Bonus: up to 5 points

You will earn one bonus point for every two hours that your assignment is submitted early.

Penalties: up to 100 points

You will lose ten points for every minute that your assignment is submitted late. For a submission to be considered *on time*, it must arrive at the server by the designated minute (and zero seconds). For a deadline of 9:00, a submission that arrives at 9:00:01 is considered late (in this context, it is one minute late).

After 15 submissions to Web-Cat, you will be penalized one point for every additional submission.

For labs, the server will continue to accept submissions for three days after the deadline. In these cases, you will still have the benefit of the automatic feedback. However, beyond ten minutes late, you will receive a score of zero.

The grader will make their best effort to select the submission that yields the highest score.