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TQS Lab activities

v2024-02-14

Introductory notes and setup

Work submission

You should create a personal (git) repository for your TQS **individual portfolio** into which you will be pushing your solutions for the labs, named ***TQS_1235678*** (the number being your student number). Keep a **clean organization** that maps the exercises structure, e.g.: 🗁lab1/lab1_1; 🗁lab1/lab1_2; 🗁lab2/lab2_1; ...

You are expected to keep your repo (portfolio) up to date and complete. Teachers will select a few exercises later for assessment [not all, but representative samples].

Lab activities

Be sure that your developer environment meets the following requirements:

- Java development environment (Long-term support JDK recommended; v17 suggested). Note that you should install it into a path without spaces or special characters (e.g.: avoid \Users\José Conceição\Java).
- Maven configured to run in the command line. Check with:

  ```
  $ mvn --version
  ```

- Java capable IDE, such as IntelliJ IDEA (version "Ultimate" suggested) or VS Code.

Lab 1 Unit testing (with JUnit 5)

Learning objectives

- Identify relevant unit tests to verify the contract of a module.
- Write and execute unit tests using the JUnit 5 framework.
- Link the unit tests results with further analysis tools (e.g.: code coverage)

Key points

- Unit testing is when you (as a programmer) write test code to verify units of (production) code. A unit is a small-scoped, coherent subset of a much larger solution. A true "unit" should not depend on the behavior of other (collaborating) modules.
- Unit tests help the developers to (i) understand the module contract (what to construct); (ii) document the intended use of a component; (iii) prevent regression errors; (iv) increase confidence in the code.
- JUnit and TestNG are popular frameworks for unit testing in Java.

Useful resources

- Book: JUnit in Action. Note that you can access it from the OReilly on-line library.
- Book: "Mastering Software Testing with JUnit 5" and associated GitHub repository with examples
- JetBrains Blog on Writing JUnit 5 tests (with vídeo).

1.1 Simple Stack contract

In this exercise, you will implement a stack data structure (TqsStack) with appropriate unit tests.
Be sure to force a **write-the-tests-first** workflow as described:

a) Create a new project (**maven project** for a Java standard application).

Add the required dependencies to run JUnit 5 tests.

- Note the elements: **junit-jupiter** and **maven-surefire-plugin** in the side illustration.
- You may adapt from a starter project for Maven.

```
<dependencies>
    <!-- ... -->
    <dependency>
        <groupId>org.junit.jupiter</groupId>
        <artifactId>junit-jupiter</artifactId>
        <version>5.10.2</version> <!-- can be omitted when using the BOM -->
        <scope>test</scope>
    </dependency>
    <!-- ... -->
</dependencies>
<build>
    <plugins>
        <plugin>
            <artifactId>maven-surefire-plugin</artifactId>
            <version>3.1.2</version>
        </plugin>
        <plugin>
            <artifactId>maven-failsafe-plugin</artifactId>
            <version>3.1.2</version>
        </plugin>
    </plugins>
</build>
```

b) Create the required class definition (**just the "skeleton"**, do not implement the methods body yet!). The **code should compile** (you may need to add dummy return values).

c) Write unit tests that will verify the TqsStack contract.

d) You may use the IDE features to generate the testing class; note that the IDE support will vary. Be sure to use JUnit 5.x.

[Mixing JUnit 4 and JUnit 5 dependencies will prevent the test methods to run as expected!]

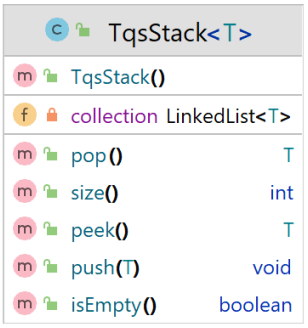
e) Your tests will verify several assertions that should evaluate to true for the test to pass.

f) Run the tests and prove that TqsStack implementation is not valid yet (the tests should **run** and **fail** for now, the first step in Red-Green-Refactor).

g) Correct/add the missing implementation to the TqsStack;

h) Run the unit tests.

i) Iterate from steps f) to h) and confirm that all tests are passing.



Suggested stack contract:

- push(x): add an item on the top
- pop: remove the item at the top
- peek: return the item at the top (without removing it)
- size: return the number of items in the stack
- isEmpty: return whether the stack has no items

What to test[1]:

a) A stack is empty on construction.

b) A stack has size 0 on construction.

[1] Adapted from http://cs.lmu.edu/~ray/notes/stacks/

c) After n pushes to an empty stack, n > 0, the stack is not empty and its size is n

d) If one pushes x then pops, the value popped is x.

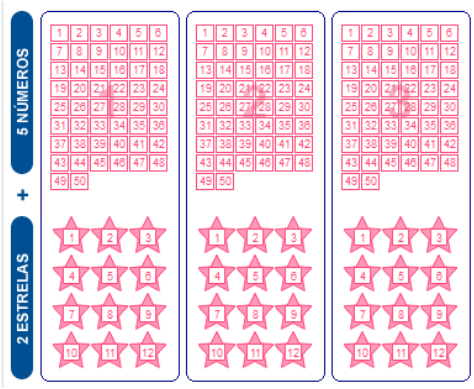
e) If one pushes x then peeks, the value returned is x, but the size stays the same

f) If the size is n, then after n pops, the stack is empty and has a size 0

g) Popping from an empty stack does throw a NoSuchElementException [You should test for the Exception occurrence]

h) Peeking into an empty stack does throw a NoSuchElementException

i) For bounded stacks only: pushing onto a full stack does throw an IllegalStateException

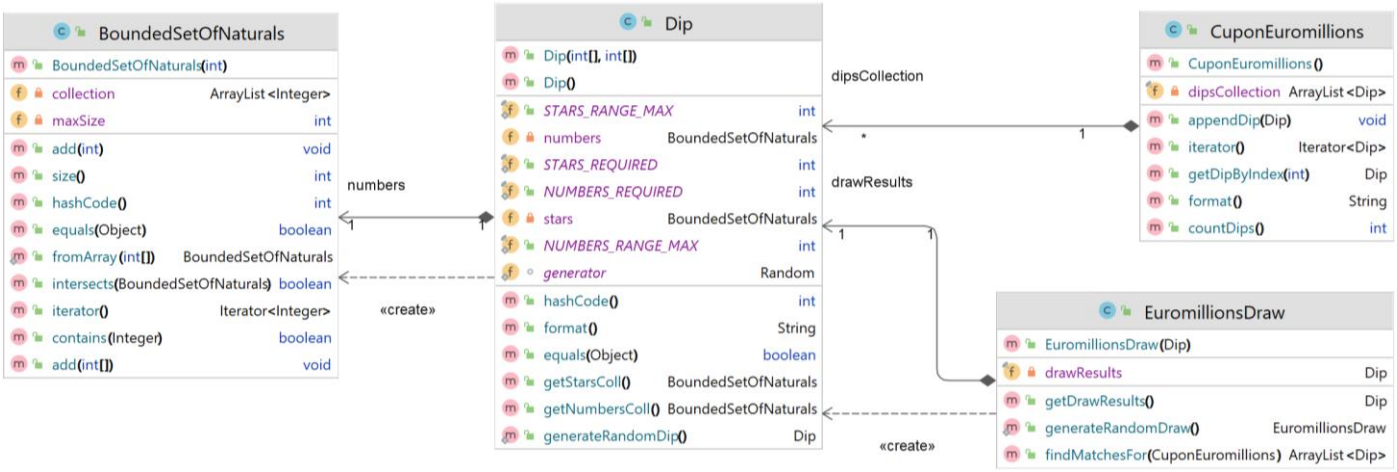


1.2 EuroMillions

Let us consider the "Euromilhões" use case.

2a/ Pull the "euromillions-play" project
The supporting implementations is visualized in the class diagram that follows.
Get familiar with the solution and existing tests.

Class	Purpose
BoundedSetOfNaturals	Reusable set data structure no duplicates allowed (it is a Set) only natural numbers in the range [1, +∞]. the max size of the set (count of elements) is bounded to a limit allows set operations (contains element?, append element, calculate intersection with another set,...)
Dip	A collection of 5 "numbers" and 2 "stars" (a "column" in the Euromillions playing coupon)
CouponEuromillion	One or more Dips, representing a bet from a player.
EuromillionsDraw	Holds the winning dip and can find matched for a given player coupon.



2b/ Make the necessary changed for the existing (non-disabled) unit tests pass.

For the (failing) test:	**You should:**
testConstructorFromBadRanges	Change Dip implementation. Be sure to raise the expected exception if the arrays have invalid numbers (out of range numbers)

Note: you may suspend temporary a test with the @Disabled tag (useful while debugging the tests themselves).

2c/ **Assess the coverage** level in project "Euromillions-play".
Configure the maven project to run Jacoco analysis.
Run the maven "test" goal and then "jacoco:report" goal. You should get an HTML report under *target/jacoco*.

```
$ mvn clean test jacoco:report
```

Analyze the results accordingly. Which classes/methods offer less coverage? Are all possible [decision] branches being covered?
Collect evidence of the coverage for "BoundedSetOfNaturals".

Note: IntelliJ has an integrated option to run the tests with the coverage checks (without setting the Jacoco plugin in POM). But if you do it at Maven level, you can use this feature in multiple tools.

2c/
Consider the class BoundedSetOfNaturals and its expected contract.
What kind of unit test are worth writing for proper validation of BoundedSetOfNaturals?
Complete the project, adding the tests you have identified. (You may also enhance the implementation of BoundedSetOfNaturals, if necessary.)

2d/
Run Jacoco coverage analysis and compare with previous results. In particular, compare the "before" and "after" for the BoundedSetOfNaturals class.

Troubleshooting some frequent errors

Problem/Symptom	**Solution**
Tests run from the IDE but not from command line	Be sure to configure the Surefire plug-in in Maven to a recent version (example).