TQS Lab activities

v2021-03-15

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 framework.
- Link the unit tests results with further analysis tools (e.g.: code coverage)

Preparatory readings

- The test piramyd concept.
- Optional: TDD & Unit testing in IntelliJ tutorial (replace JUnit 4 with JUnit 5).

Key points

- Unit testing is when you (as a programmer) write test code to verify units of (production) code. A unit represents a small subset of a much larger solution. A true “unit” does not have depend of the behavior of other (collaborating) components.
- 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 on the code.
- When following a TDD approach, typically you go through a cycle of Red-Green-Refactor. You’ll run a test, see it fail (go red), implement the simplest code to make the test pass (go green), and then refactor the code so your test stays green and your code is sufficiently clean.
- JUnit and TestNG are popular frameworks for unit testing in Java.

> **JUnit best practices: unit test one object at a time**
> A vital aspect of unit tests is that they’re finely grained. A unit test independently examines each object you create, so that you can isolate problems as soon as they occur. If you put more than one object under test, you can’t predict how the objects will interact when changes occur to one or the other. When an object interacts with other complex objects, you can surround the object under test with predictable test objects. Another form of software test, integration testing, examines how working objects interact with each other. See chapter 4 for more about other types

Lab activities

Be sure that your developer environment meets the following requirements:

- Java development environment (JDK; v11 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. Note: some projects include the Maven wrapper utility (*mvnw*); in these cases, Maven wrapper will download maven as needed.
- Java capable IDE, such as IntelliJ IDEA (version "Ultimate" suggested).

1.1

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

a) Create a new **Maven-based,** Java standard application.

b) Add the required dependencies to run Junit tests[1]. Here are some examples:
   - JUnit documentation
   - starter project for Maven[2].

c) Create the required classes definition (**just the "skeleton"**, do not implement the methods body yet; you may need to add dummy return values). The **code should compile**, though the **implementation is incomplete** yet.

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

   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.

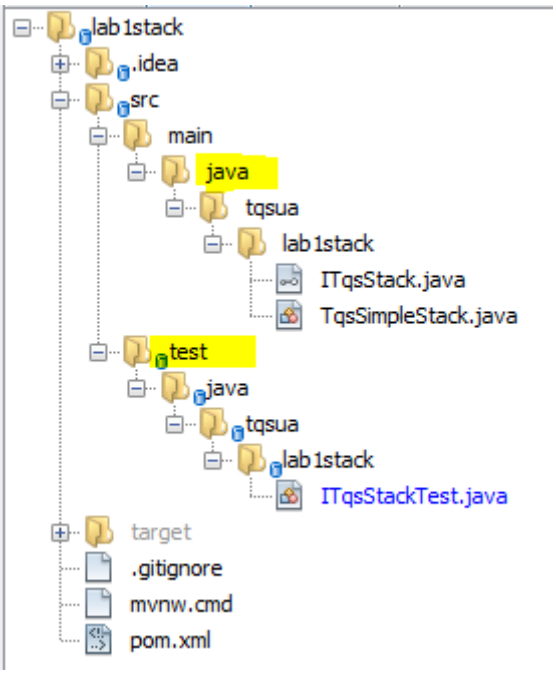
   Your tests will verify several assertions that should evaluate to true for the test to pass. See some examples.

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

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

g) Run the unit tests.

h) Iterate from steps d) to f) and confirm that all tests pass.



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[3]:

a) A stack is empty on construction.

b) A stack has size 0 on construction.

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.

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[1] If using IntelliJ: you may skip this step and ask, later, the IDE to fix JUnit imports.
[2] Delete the "pom-JITPACK.xml" and "pom-SNAPSHOT.xml", specially before importing into an IDE.
[3] Adapted from http://cs.lmu.edu/~ray/notes/stacks/

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]

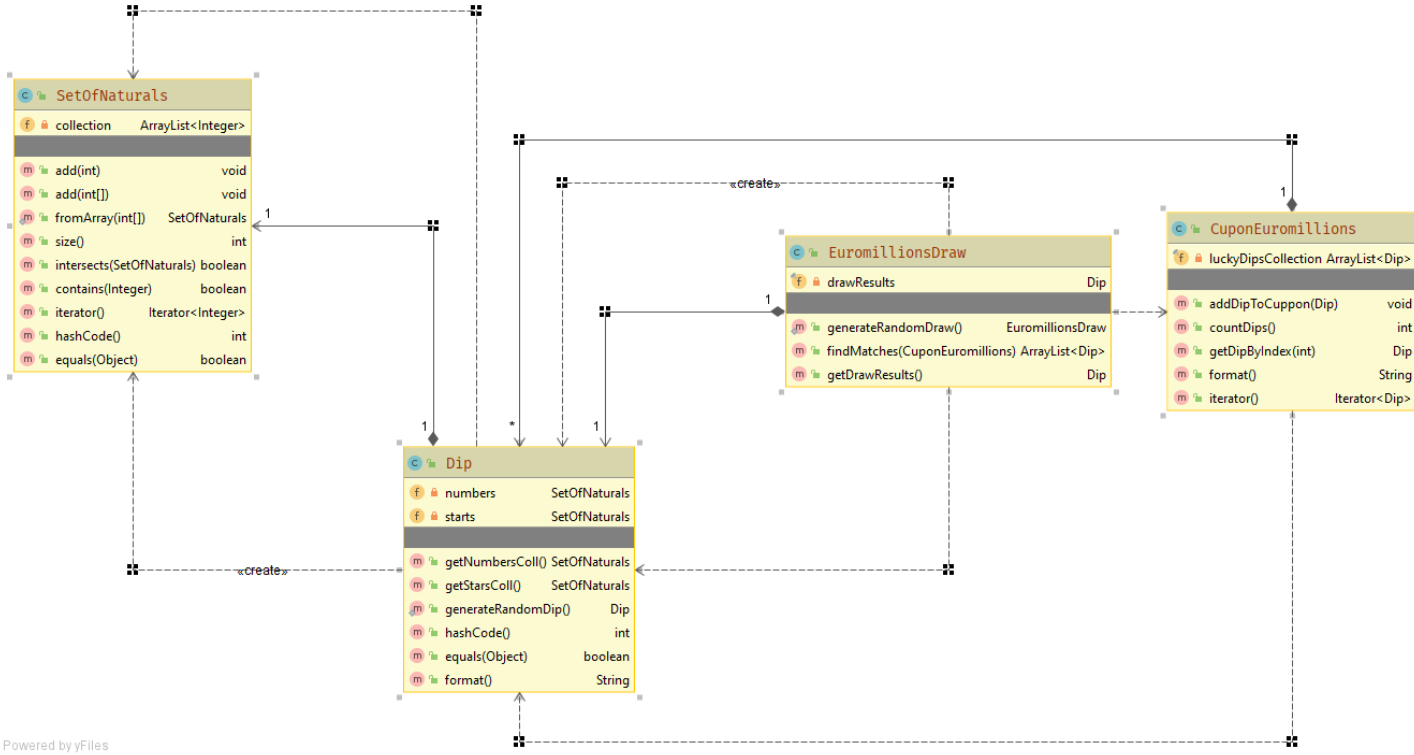
h) Peeking into an empty stack does throw a NoSuchElementException

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

2a/ Pull the "euromillions-play" project and correct the code (or the tests themselves, if needed) to have the existing unit tests passing.

For the (failing) test:	**You should:**
testFormat	Correct the implementation of Dip#format so the tests pass.
testConstructorFromBadArrays	Implement new test logic to confirm that an exception will be raised if the arrays have invalid numbers (wrong count of numbers of starts)

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



2b/ The class SetOfNaturals represents a set (no duplicates should be allowed) of integers, in the range [1, +∞]. Some basic operations are available (add element, find the intersection…).
What kind of unit test are worth writing for the entity SetOfNaturals?
Complete the project, adding the new tests you identified.

2c/ Note that the code provided includes "magic numbers" (2 for the number of stars, 50 for the max range,…). Refactor the code to extract constants and eliminate the "magic numbers".

2d/ 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.
Interpret the results accordingly. Which classes/methods offer less coverage? Are all possible decision branches being covered?

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.

Explore

- JetBrains Blog on Writing JUnit 5 tests (with vídeo).
- Book: JUnit in Action. Note that you can access it from the OReilly on-line library, using the University of Aveiro SSO.
- Vogel’s tutorial on JUnit. Useful to compare between JUnit 4 and JUnit 5.
- Working effectively with unit testing (podcast).