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TQS Lab activities

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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.

Key points

- Unit testing is when you (as a programmer) write test code to verify units of (production) code. A unit represents some small subset of a much larger end-to-end-behavior. A true “unit” does not have dependencies on other (external) 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), v8 or v11. 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.
- Java capable IDE, such as IntelliJ IDEA.

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.

   Note: use the IDE features. If you are not sure if the IDE can generate a maven-compatible structure, consider using this starter project.

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

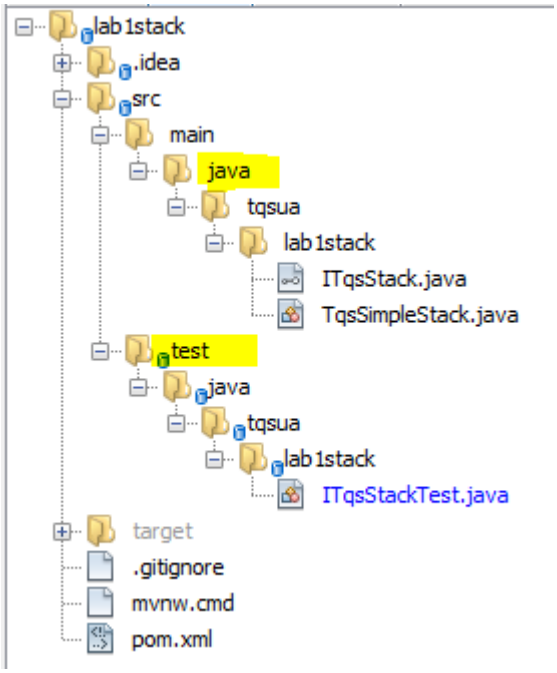
c) Write the unit tests that will verify the TqsStack contract.

   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.

   Important: for maven based projects, check the proper POM.xml dependencies for JUnit 5. If you get an error saying that the 1.5 version is no longer supported, specify the target compiler version in the POM.

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

d) 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).
e) Correct/add the missing implementation to the TqsStack;
f) Run the unit tests.
g) Iterate from steps d) to f) and confirm that all tests pass.



Stack operations:

- 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]:

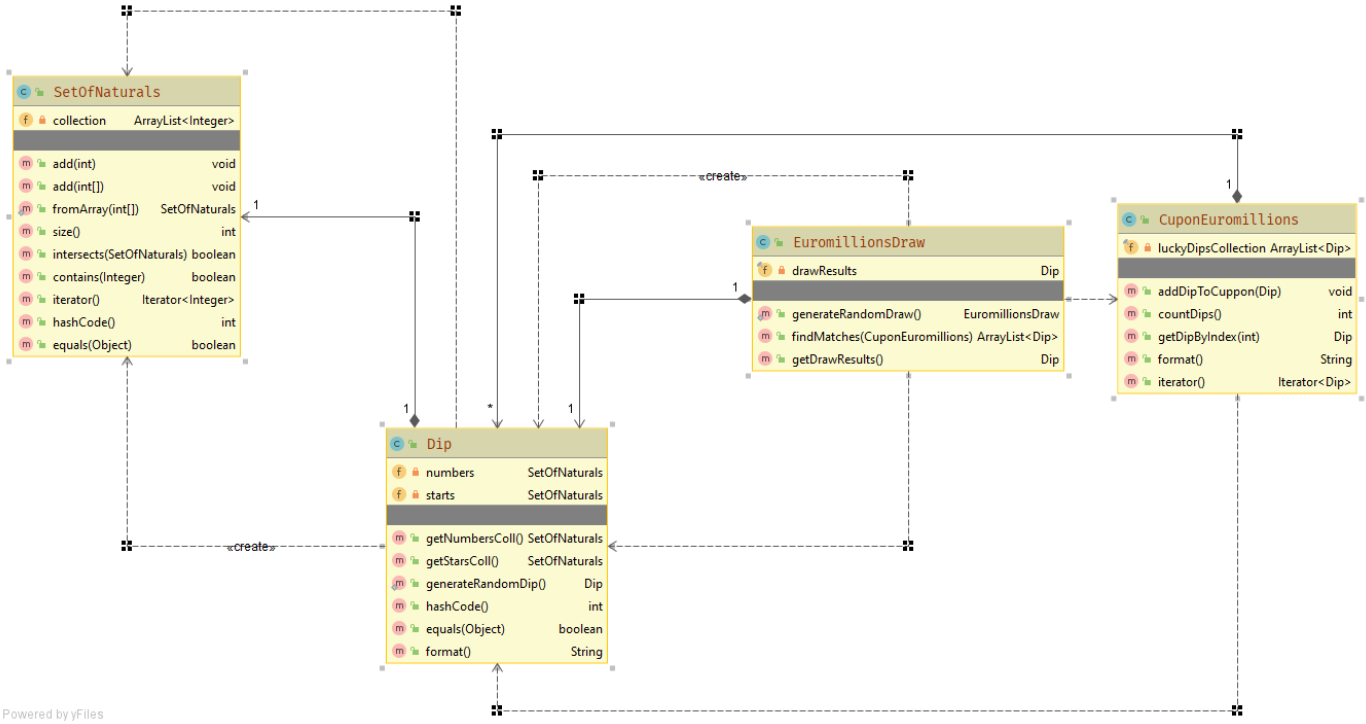
a) A stack is empty on construction.
b) A stack has size 0 on construction
c) After n pushes to an empty stack, n > 0, the stack is not empty and its size is n
d) If one pushes x then pops, the value popped is x.
e) If one pushes x then peeks, the value returned is x, but the size stays the same
f) If 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

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

For 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).

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



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 provided code 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" bad-smell.

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

- Book: JUnit in Action.
- Vogel's tutorial on JUnit. Useful to compare between JUnit 4 and JUnit 5.
- Working effectively with unit testing (podcast).

Lab 2: Mocking dependencies in unit testing

Learning objectives

- Prepare a project to run unit tests (JUnit 5) and mocks (Mockito 3.x), with mocks injection (@Mock).
- Write and execute unit tests with mocked dependencies.
- Play with mock behaviors: strict/lenient verifications, advanced verifications, etc.

Lab activities

1a/ Implement the test case illustrated with the following classes, with respect to the **StockPortfolio#getTotalValue()** method. The method is expected to calculate the value of the portfolio by summing the current value (looked up in the stock market) of the owned stocks.
Be sure to use:

- Maven-based Java application project;
- Mockito framework (mind the maven dependencies).

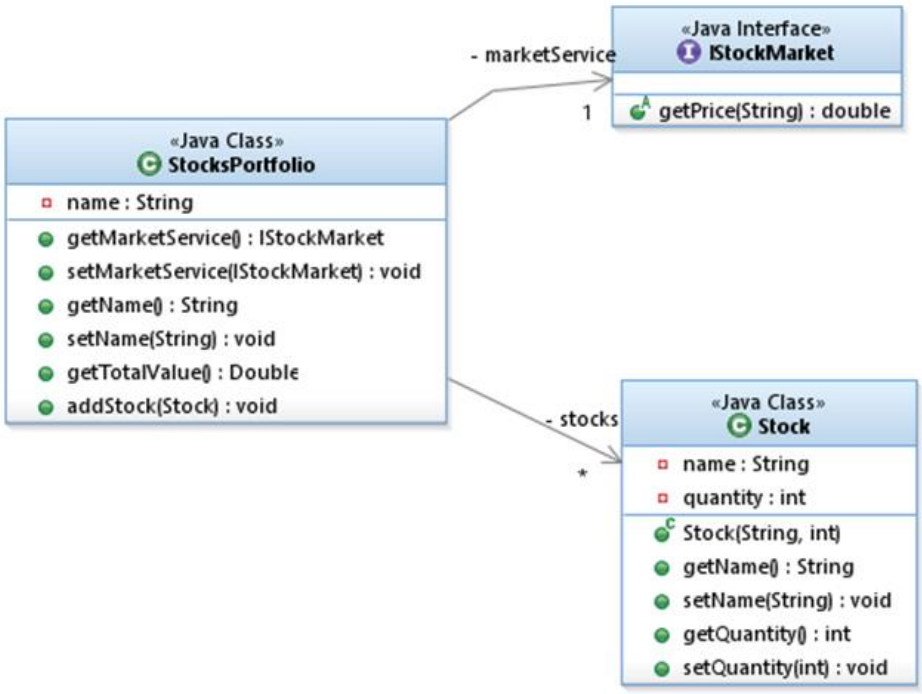


Figure 1: Classes for the StocksPortfolio use case.

a) Create the classes. You may write the implementation of the services before or after the tests.

b) Create the test for the getTotalValue(). As a guideline, you may adopt this outline:

```
1. Prepare a mock to substitute the remote service (@Mock annotation)
2. Create an instance of the subject under test (SuT) and use the mock to set the
   (remote) service instance (you may prefer to use @InjectMocks)
3. Load the mock with the proper expectations (when...thenReturn)
4. Execute the test (use the service in the SuT)
5. Verify the result (assert) and the use of the mock (verify)
```

Notes:

- Mind the JUnit version. For JUnit 5, you should use the @ExtendWith annotation to integrate the Mockito framework.
- Some IDE may not support JUnit 5 integration; you may need to further configure the POM.
- See a quick reference of Mockito syntax and operations.

1b/ Instead of the JUnit core asserts, you may use the Hamcrest library to create more human-readable assertions. Consider using this library in the previous example, in particular, assertThat(), is().

2/ Consider an application that needs to perform reverse geocoding to find a zip code for a given set of GPS coordinates. This service can be obtained in the Internet (e.g.: using the MapQuest API).

a) Create the objects represented in Figure 1. TqsHttpClient represents a service to initiate HTTP requests to remote servers. **You don't need to implement TqsHttpBasic**; in fact, you should provide a substitute for it.

b) Consider that we want to verify the AddressResolver#findAddressForLocation, which invokes a remote geocoding service, available in a REST interface, passing the site coordidates. Which is the service to fake?

c) To create a test for findAddressForLocation, you will need to know the exact response of the geocoding service for a sample request. Assume that we will use the MapQuest API. Use the browser or an HTTP client to try some samples so you know what to test for (example 1).

d) Implement a test for AddressResolver#findAddressForLocation using a mock.

e) Besides de "success" case, consider also testing for alternatives (e.g.: invalid coordinates should raise an exception).

This getting started project can used in your implementation.

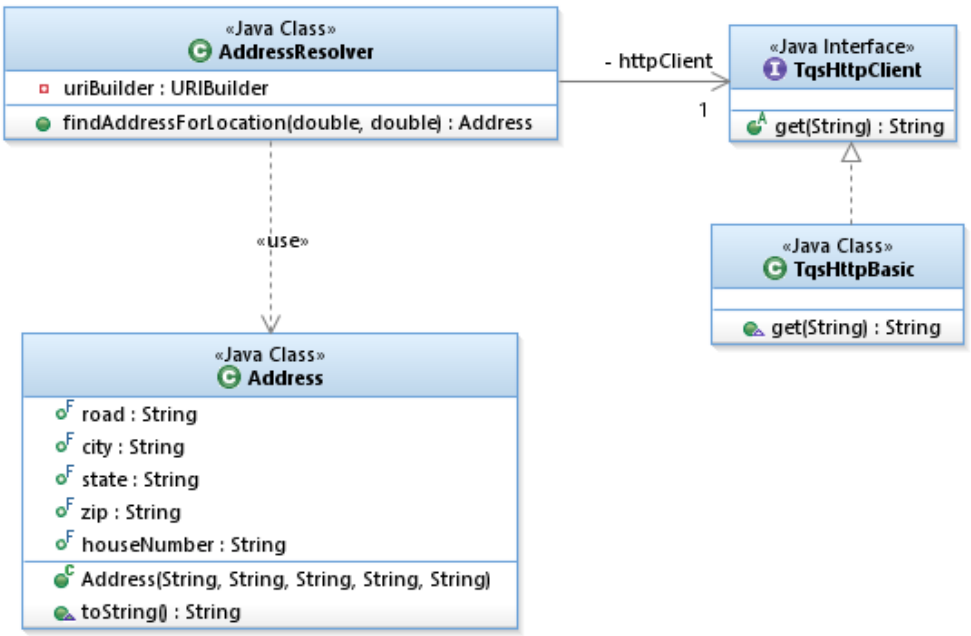


Figure 2: Classes for the geocoding use case.

3/ Consider you are implementing an integration test, and, in this case, you would use the real implementation of the module, not the mocks, in the test.
Create new test class and be sure its name end with "IT" (e.g.: GeocodeTestIT).
Copy the tests from the previous exercise into this new test class.
Remove all support for mocking (no dependencies on Mockito imports).
Correct the test implementation, so it used the real module.

If the “failsafe” maven plugin is configured, you should get different results with:
$ mvn test
$ mvn package failsafe:integration-test

Explore

JUnit 5 cheat sheet.

Lab 3: Functional testing with web automation

Prepare

— Selenium and separation of concerns

Key Points

— Acceptance tests (or functional test) exercise the user interface of the system, as if a real user was using the application. The system is treated as a black box.

— Browser automation (control the browser interaction from a script) is an essential step to implement acceptance tests on web applications. There are several frameworks for browser automation (e.g.: Puppeteer); for Java, the most used framework is the WebDriver API, provided by Selenium (that can be used with JUnit or TestNG engines).

— The test script can easily get "messy" and hard to read. To improve the code (and its maintainability) we could apply the Page Objects patterns.

— Web browser automation is also very handy to implement “smoke tests”.

Lab

Selenium works with multiple browsers but, for sake of simplicity, the samples will be discussed with respect to Chrome/Chromium; you may adapt for Firefox.

Suggested setup:
Install Chrome/Chromium in your system (if needed), using the default installation paths.
Download the ChromeDriver and make sure it is available available in the PATH. (GeckoDriver for Firefox)
Install the “Selenium IDE” browser plugin. (or, alternatively, the Katalon Recorder).

In this lab:

1. Create a web automation with Selenium IDE recorder
2. Run the test as a Java project (JUnit 5 + Selenium)
3. Use the Web Page Object pattern

1/ Create a web automation with Selenium IDE recorder

Access the Redmine demo site and create a temporary account (http://demo.redmine.org)
Be sure to logout before recording the test.
Create (record) an automation macro with the Selenium IDE recorder tool to test login (a quick start for Katalon is available, which is similar to Selenium IDE):

a) Open http://demo.redmine.org
b) Sign-in with your credentials
c) Assert that you have successfully logged in (by verifying the presence of the username)
d) Logout

... and Stop recording. Test your macro (replay).

Add a new step, at the end, to confirm that, after logout, the home shows the “Sign in” option present. Enter this assertion “manually” (in the editor, but not recording).

2a/ Run the test as a Java project (JUnit 5, Selenium)

Prepare a (new) project to run JUnit tests and Selenium (sample POM.xml available).

Take note of the information in this page under “quick reference”; then, in the section “Local browsers”, pick the example that suites your setup and run the test (as you usually do with JUnit). You will have to deploy the WebDriver implementation (binary) for you browser [→ download browser driver]. Be sure to include in the system PATH.

2b/ Export and run the test (Webdriver)

Export the test from Selenium IDE into a Java test class and include it in the previous project. Refactor the code that was generated to be compliant with JUnit 5 and the Selenium-Jupiter extension.

Run the test (programmatically).

3/ Use the Web Page Object pattern

Consider the example discussed here.
Implement the “Page object pattern” for a cleaner and more readable test, as suggested.

Explore

- Puppeteer - a Node library which provides a high-level API to control headless Chrome/Chromium.