

Object Oriented Software Design - I

Unit Testing

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1 Why unit testing

2 Testing with JUnit

- Testing can never be exhaustive
 - you can never discover all the program bugs by running tests, simply because (except in trivial cases), the number of tests to be executed is badly exponential
 - nevertheless, testing is useful because you can catch **some** bugs, the most evident and probably the most important bugs in a program
 - also, tests give some evidence that the program is conforming with the specification, and this is useful for the customer
 - therefore, even if testing does not prove correctness, it proves something, and something is better than nothing!
 - Every programmer acknowledges that testing is an important activity in coding
- There are many types of testing:
 - Unit testing, functional testing, integration testing, etc.
- Here we discuss Unit Tests, a tool for the programmer

Unit testing

- Unit testing is a method by which individual units of source code are tested to determine if they are fit for use
- A **unit** is the smallest testable part of an application, typically a class or a function
- Unit tests are written by programmers as part of their coding work
 - The idea is to test an unit (a small piece of code) in isolation
- The goal is to:
 - 1 Find bugs in code
 - 2 Be able to refactor (i.e. change the code) later, and check that the unit continues to work
 - 3 Check that modifications to other units (on which the unit under test depends upon) will not break the assumption and invalidate the behaviour of the unit
- item 2 and 3 are also called *regression testing*, and are fundamental to check properties (as the Liskov Substitution Principle, for example)

The problem with test

- Writing tests is a boring activity
 - It works against human nature
 - it is a lot of additional code to write (set up the environment and all the necessary objects, write the testing code, run the test, check the result, etc.)
 - the test code needs to be maintained and kept constantly in sync with the tested code
 - most of this work is not very funny, whereas a programmer wants to write useful application code (a more inventive and rewarding activity)

Testing is boring

- As a consequence, most programmer simply do not test
 - Testing is time consuming
 - There is never enough time, so the programmer concentrates on *important* things, like producing application code
 - Tests are code, and we may introduce bugs in testing code, producing “false positives”
 - and many other excuses
- Forcing programmers to write tests is not the right approach
 - It is against human nature, so after a while, he will stop anyway

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 - ... unless ...

Making testing more attractive

- The first rule is to make the make the testing activity automatic
- The programmer should not spend time in *checking* the output of the test to see if everything is OK
 - Let the PC automatically check the outcome
 - the only thing the programmer wants to see is: **OK**, or **FAIL**, and not endless screens of text output to be checked
- Then, make it easy to run suites of tests
 - All tests should be grouped in test suites, and it should be possible to compile and execute them with one single command
 - as soon as a new test is written, it is added to the test suite and executed along with the other tests

Run tests often

- Tests should be written by the programmer *before* coding the unit
 - In other words, first write the test, then write the functionality
 - Run the test after compiling
- “Run tests often” means “Run tests every time you compile”
 - The habit of running tests should be automatically embedded in the development tool
 - in addition to “I should make my program compile”, the objective is now also “I should make all the tests run smoothly”

- Substitute “debugging” with “testing”
 - Testing is done while coding, while debugging is done later,
 - Testing **is** a special kind of coding, while debugging means slowly going through existing code in a painful way and under pressure
 - Tests are there to stay, and can be run automatically at any time, while debugging does not stay, it is wasted time
- Certainly, you will be convinced that testing may be more funny than debugging
- Maybe you will also become convinced that testing may be very productive
 - If you can drastically reduce the amount of time spent in debugging, more that the time you spend in testing, then you productivity increases

Testing to addressing change

- Testing is a fundamental tool to address the “need for change”
- If you need to change existing code (or add additional code/functionality), you want to make sure that existing tests do not break
- if they do break,
 - Maybe you introduced a bug in the code that breaks existing code
 - Maybe you violated an assumption made by existing code (see LSP)
 - Maybe you need to change the test because the specification has changed and the test is not valid any more
- In any case, since you test every time you compile, you can immediately spot the error
 - As opposed to discovering the bug during integration testing, when you will need to trace back the problem and debug your code to find where the problem is
- which alternative is more time-consuming?

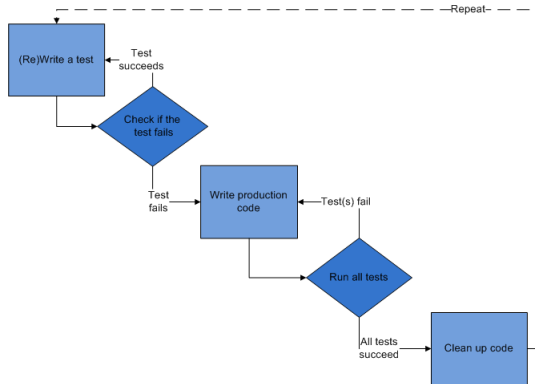
Testing coverage

- Of course, you can never do a complete testing coverage in the unit test, because it is too time consuming
- However, you can try to write **a few** meaningful tests
- for example, checking boundary conditions (the source of most errors)
 - what if the function needs a file, and the file does not exist?
 - what if I try to extract from an empty container?
 - what if I pass a negative value (while the function expects a positive one?)
 - etc.
 - Also, check a couple of “normal” cases
- Of course, testing can never completely substitute debugging
 - Since you cannot be exhaustive, it may happen that your tests do not spot a subtle bug
 - Don't worry: when you discover it by debugging, add immediately a unit test to checks that the error will never occur again in future modifications

- When writing tests, you concentrate on the interface
 - while writing tests, you wear the “client hat”
 - while writing code, you wear the “implementer hat”
 - writing tests is similar to writing a specification for the code
- The test is useful as “documentation”
 - If you want to know how to use a function, you can sometimes look at the test
- You have a clear point at which you are done: when the all tests work!

Test Driven Development

- The practice of writing tests first is called *Test Driven Development* (TDD), and it is one of the main points of the Extreme Programming (XP) methodology proposed by Kent Beck



- Another related practice is Continuous Integration
 - This consists in automatic compilation, testing and commit in the repository in one development cycle
 - committing on the server automatically compiles and test the code
 - therefore, an integration step is performed at every commit!
- Of course, an appropriate tool support is needed to automate all steps
- Also, a certain rigorous and structured approach is needed to impose the practice to all programmers

1 Why unit testing

2 Testing with JUnit

Tests, test suites and fixtures

- Testing should be automatic:
 - No need to manually check the results of the test, it should only say **OK** or **FAIL**
- Tests are grouped into **Suites**
 - A test suite is just a set of tests on the same “portion” of code
 - for example, a set of tests on the same class, or on the same package
- What if you have two or more tests that operate on the same or similar sets of objects?
 - Tests need to run against the background of a known set of objects, called a **test fixture**.

- JUnit is a library written by Kent Beck
- Its goal is to make the job of writing tests and running them as easier as it is possible
- It uses **annotations** to make the writing easier
 - Java annotations are lines of code beginning with a @
 - An example is the **@Override** annotation
 - *It indicates that a method declaration is intended to override a method declaration in a superclass. If a method is annotated with this annotation type but does not override a superclass method, compilers are required to generate an error message.*
 - Annotations are processed by the compiler, and usually do not produce extra code
 - However, they can be processed by other tools to produce extra code or data
 - It is possible to define new annotations
 - See [the Java documentation](#)

Structure of the test case

- A Test case is just a class with a very simple structure:

```
import junit.framework.TestCase;
import org.junit.*;

public class TestFoobar extends TestCase {
    @BeforeClass
    public static void setUpClass() throws Exception {
        // Code executed before the first test method
    }
    @AfterClass
    public static void tearDownClass() throws Exception {
        // Code executed after the last test method
    }
    @Before
    public void setUp() throws Exception {
        // Code executed before each test
    }
    @After
    public void tearDown() throws Exception {
        // Code executed after each test
    }
    @Test
    public void myTest() {
        // test code
    }
    @Test
    public void anotherTest() {
        // test code
    }
}
```

Assertion

- When writing a test, it is important to check that everything goes well
 - This can be achieved through *assertions*
- Example:

```
@Test
public void testAddLeft() {
    tree.addLeft(leftTree);
    assertTrue(tree.getLeftSubtree().getRootElem() == "L");
}
```

- The function `assertTrue` checks that the condition evaluates to `True`
 - If it evaluates to `False`, it throws an exception
- There are many other assertions that can be used