

Lecture 11

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Coding style
Refactoring
How to refactor

Testing. Refactoring

Lect. PhD. Arthur Molnar

Babes-Bolyai University

Overview

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What is testing?

Testing is observing the behavior of a program over many executions.

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- We execute the program for some input data and compare the result we obtain with the known correct result.
- **Questions:**
 - How do we choose input data?
 - How do we know we have run enough tests?
 - How do we know the program worked correctly for a given test? (known as the oracle problem)

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- Testing cannot prove program correctness, and cannot identify all defects in software. However, what it **can** prove is incorrectness, if at least one test case gives wrong results.
- **Problems with testing**
 - We cannot cover a function's input space
 - We have to design an oracle as complex as the program under test
 - Certain things are practically outside of our control (e.g. platform, operating system and library versions, possible hardware faults)

Testing Approaches

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Exhaustive testing

- Check the program for all possible inputs.
- Impractical for all but mostly trivial functions.
- Sometimes used with more advanced techniques (e.g. symbolic execution) for testing small, but crucial sections of a program (e.g. an operating system's network stack)

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Boundary value testing

- Test cases use the extremes of the domain of input values, typical values, extremes (inside and outside the domain).
- The idea is that most functions work the same way for most possible inputs, and to find most of those possibilities where functions use different code paths.

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Random testing, pairwise (combinatorial) testing, equivalence partitioning

- And the list goes on...

Testing Methods

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Black box testing

- The source code is not available (it is in a "black", non-transparent box)
- The selection of test case data for testing is decided by analyzing the specification.

White box testing

- The source code is readily available (it is in a transparent box) and can be consulted when writing test cases.
- Selecting test case data is done by analyzing program source code. We select test data such that all code, or all execution paths are covered.
- When we say "*have 95% code coverage*" (assignment bonus) it is white-box testing.

Demo

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White and Black-box testing

Examine the test code in `ex39_black_box_white_box.py`

Advantages and drawbacks

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Black box testing

- + Efficient for large code-bases
- + Access to source code is not required
- + Separation between the programmer's and the tester's viewpoint
 - You do not know how the code was written, so test coverage might be low, testing might be inefficient

Advantages and drawbacks

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White box testing

- + Knowing about the code makes writing it **AND** testing it easier
- + Can help find hidden defects or to optimize code
- + Easier to obtain high coverage
 - Problems with code that is completely missing
 - Requires access to source code
 - Requires good knowledge of source code

White and Black-box testing

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NB!

It's not a matter of which box is better, it's more like you have to make do with what you've got!

Testing levels

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Testing Levels

Tests are frequently grouped by where they are added in the software development process, or by the level of specificity of the test

Testing levels

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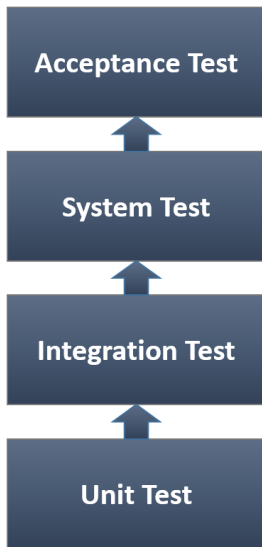
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Unit Test

- Refers to tests that verify the functionality of a specific section of code, usually at function level.
- Testing is done in isolation. Test small parts of the program independently

Integration Test

- Test different parts of the system in combination
- In a bottom-up approach, it is based on the results of unit testing.

Testing levels

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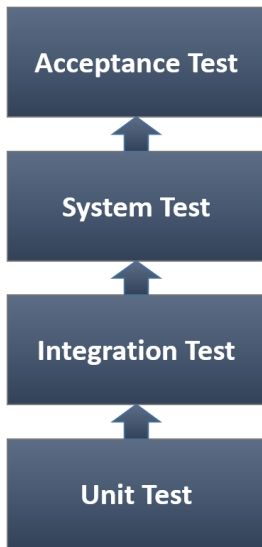
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System Test

- Considers the way the program works as a whole.
- After all modules have been tested and corrected we need to verify the overall behavior of the program

Acceptance Test

- Check that the system complies with user requirements and is ready for use

Automated testing

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Automated testing

- Test automation is the process of writing a computer program to do testing that would otherwise need to be done manually.
- Use of software to control the execution of tests, comparison of actual outcomes to predicted outcomes, setting up test preconditions

PyUnit - Python unit testing framework

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The unittest¹ module supports:

- Test automation
- Sharing setup and shutdown code for tests
- Aggregation of tests into collections
- Independence of tests from the reporting framework
(another instance of the *single responsibility principle*)

¹<https://docs.python.org/3/library/unittest.html>

Demo

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PyUnit

Run the unit test in **ex40_pyunit.py** in an IDE that supports this (e.g. PyCharm CE)

NB! This has to be run as a unit-test, and not a regular Python program

PyUnit - Python unit testing framework

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The unittest module supports:

- Tests are implemented using classes derived from **unittest.TestCase**
- Test methods should start with the characters **test**
- We now use special methods instead of **assert** statements directly - **assertTrue()**, **assertEqual()**, **assertRaises()** and many more²
- The **setUp()** and **tearDown()** methods are run before and after each test method, respectively.

²<https://docs.python.org/3/library/unittest.html#assert-methods> 🔍 🔍 🔍

Automated testing

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How can we know when our test are "good enough" ?

The Coverage module

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One (of the simpler) ways is to use code coverage

- Measure how much of the entire code was executed during the tests
- 0% coverage means no lines of code were executed
- 100% means **ALL** lines of code were executed at least once
- There exist tools which can measure and report this automatically

The coverage module

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- PyCharm Professional can be used to gather coverage information by installing the *coverage*³ module.

³<https://coverage.readthedocs.io/en/coverage-5.3/>

The coverage module

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... or we can use it in command line

- 1 pip install coverage # installs the **coverage.py** module
- 2 open a **cmd/terminal** into your project's folder
- 3 **coverage** run -m unittest discover -p *.py && **coverage** report⁴
- 4 **coverage** html produces pretty printed output

⁴<https://stackoverflow.com/questions/47497001/python-unit-test-coverage-for-multiple-modules>

Test Driven Development Steps

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Test Driven Development (TDD)

TDD requires developers to create automated unit tests that clarify code requirements before writing the code.

- Steps to apply TDD⁵:
 - 1 Create automated test cases
 - 2 Run the test (will fail)
 - 3 Write the minimum amount of code to pass that test
 - 4 Run the test (will succeed)
 - 5 Refactor the code

⁵Kent Beck. *Test Driven Development: By Example*. Addison-Wesley Longman, 2002. See also Test-driven development. http://en.wikipedia.org/wiki/Test-driven_development

Writing functions for TDD

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1 Create a test

- Define a test function (`test_f()`) which contains test cases written using assertions.
- Concentrate on the **specification** of **f**.
- Define *f*: name, parameters, precondition, post-condition, and an empty body.

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- 2 Run all tests and see that the new one fails
 - Your program has many functions, so it will also have many **test functions**
 - At this stage, ensure the new **test_f() fails**, while previously written test function pass
 - This shows that the test is actually executed and that it tests the correct function

Writing functions for TDD

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3 Write the body of function **f()**

- Writing the test before the function obliged you to clarify its specification
- Now you concentrate on correctly implementing the function code
- At this point, do not concentrate on technical aspects such as duplicated code or optimizations

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- 4 Run all tests and see them succeed
 - Re-run the test you created at step 1
 - Now, you can be confident that the function meets its specification

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5 Refactor code

- **Code refactoring** is a "disciplined technique for restructuring an existing body of code, altering its internal structure without changing its external behavior"⁶.
- **Code smell** is any symptom in the source code of a program that possibly indicates a deeper problem:
 - **Duplicated code**: identical or very similar code exists in more than one location.
 - **Long method**: a method, function, or procedure that has grown too large.

⁶Martin Fowler. *Refactoring. Improving the Design of Existing Code*. Addison-Wesley, 1999. See also <http://refactoring.com/catalog/index.html>

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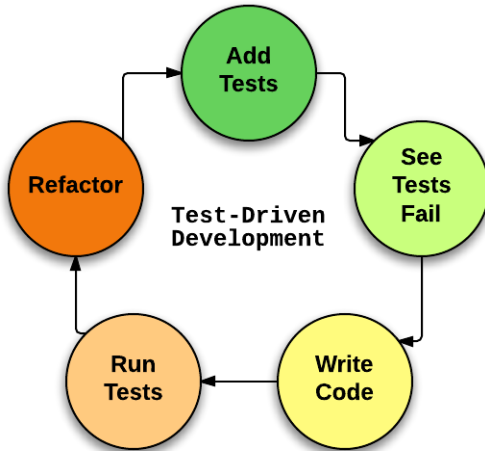
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Test Driven Development

ex41_tdd_1.py

Test Driven Development

ex42_tdd_2.py

Thoughts on TDD

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- TDD is designed to take you out of the mindset of writing code first, and thinking later
- It forces you to **think** what each part of the program has to do
- It makes you analyse boundary behaviour, how to handle invalid parameters before writing any code

Program inspection

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- Anyone can write code that computers understand. It's about writing code that humans also understand!
- Programming style consist of all the activities made by a programmer for producing code easy to read, easy to understand, and the way in which these qualities are achieved

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- Readability is considered the main attribute of style.
- A program, like any publication, is a text must be read and understood by another programmer. The element of coding style are:
 - Comments
 - Text formatting (indentation, white spaces)
 - Specification
 - Good names for entities (classes, functions, variables) of the program
 - Meaningful names
 - Use naming conventions

Naming conventions

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- Specific to each language, for Python they are encoded in the PEP-0008⁸
- Class names use camel case notation: Student, StudentRepository
- Variable names: student, nr_elem
- Function names: get_name, get_address, store_student
- constants are capitalized: MAX_LENGTH

⁸<https://www.python.org/dev/peps/pep-0008> 

Refactoring

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Refactoring

The process of changing the software system in such a way that it does not alter the external behaviour of the code yet improves its internal structure.

- It is a disciplined way to clean up code that minimizes the chances of introducing bugs.
- When you need to add a new feature to the program, and the program's code is not structured in a convenient way for adding the new feature, first refactor the code to make it easy to add a feature, then add the feature

Why refactoring

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- Improves the design of the software
- Makes software easier to understand
- Helps you find bugs
- Helps you program faster

Bad smells

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When is refactoring needed?

- Duplicated code
- Long method/class
- Long parameter list (more than 3 parameters is seen as unacceptable)
- Comments

Sample code to refactor

The following file contains some examples of code that is good candidate for refactoring **ex43_refactoring.py**

Refactoring methods

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- 1 Rename Method** - *The name of a method does not reveal its purpose.*
- 2 Consolidate Conditional Expression** - *You have a sequence of conditional tests with the same result.*
Combine them into a single conditional expression and extract it.
- 3 Consolidate Duplicate Conditional Fragments** - *The same fragment of code is in all branches of a conditional expression.* Move it outside the expression.

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- 4 **Decompose Conditional** - *You have a complicated conditional (if-then-else) statement.* Extract methods from the condition, then part, and else parts.
- 5 **Inline Temp** - *You have a temp that is assigned to once with a simple expression, and the temp is getting in the way of other refactorings.* Replace all references to that temp with the expression.
- 6 **Introduce Explaining Variable** - *You have a complicated expression.* Put the result of the expression, or parts of the expression, in a temporary variable with a name that explains the purpose.

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- 7 Remove Assignments to Parameters** - *The code assigns to a parameter. Use a temporary variable instead.*
- 8 Remove Control Flag** - *You have a variable that is acting as a control flag for a series of boolean expressions. Use a break or return instead.*
- 9 Remove Double Negative** - *You have a double negative conditional. Make it a single positive conditional*

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- 10 Replace Nested Conditional with Guard Clauses** - *A method has conditional behavior that does not make clear what the normal path of execution is. Use Guard Clauses for all the special cases.*
- 11 Replace Temp with Query** - *You are using a temporary variable to hold the result of an expression. Extract the expression into a method. Replace all references to the temp with the expression. The new method can then be used in other methods.*

Refactoring classes

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- 12 Encapsulate Field** - *There is a public field.* Make it private and provide accessors.
- 13 Replace Magic Number with Symbolic Constant** - *You have a literal number with a particular meaning.* Create a constant, name it after the meaning, and replace the number with it.
- 14 Extract Method** - *You have a code fragment that can be grouped together.* Turn the fragment into a method whose name explains the purpose of the method.

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- 15 Move Method** - *A method is, or will be, using or used by more features of another class than the class on which it is defined.* Create a new method with a similar body in the class it uses most. Either turn the old method into a simple delegation, or remove it altogether.
- 16 Move Field** - *A field is, or will be, used by another class more than the class on which it is defined.* Create a new field in the target class, and change all its users.