Software Engineering
Testing and Debugging — Testing

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Recap

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- Making testing a part of the development makes claims about the software more credible

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  - How to write a test case
  - How to come up with a good test suite (collection of test cases)

Specifications

- Program specifications tell what a piece of code should do
- But also what it requires to be able to do its job
- A specification can be seen as contract between the implementor and the user of the implemented code.
- A specification consists of two parts:
  - Requires (precondition) – what the user should fulfill before calling the code
  - Ensures (postcondition) – what the implementor promises about the result of the execution (provided requires were fulfilled)

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Specification Example

```
public static int find_min(int[] a) {
 int x, i;
 x = a[0];
 for (i = 1; i < a.length;i ++) {
  if (a[i] < x) x = a[i];
 }
 return x;
}
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Specification

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Specification

Requires: a *is non-null and contains at least one element*

Ensures: *Result is less than or equal to all elements in* a *and equal to at least one element in* a, *and result is greater than 0*

What can go wrong when writing specifications?

Are all these cases of "bad" specifications?

- It's clear that we don't invalid or incorrect specifications.
- Vague specifications is a matter of whether they can be misunderstood.
- But imprecise specifications is not such a bad thing

Example: Strong or Weak Precondition

Example

What does this method do?

```
public static int[] insert(int[] x, int n)
{
  int[] y = new int[x.length + 1];
  int i;
  for (i = 0; i < x.length; i++) {
    if (n >= x[i]) break;
    y[i] = x[i];
  }
  y[i] = n;
  for (; i < x.length; i++) {
    y[i+1] = x[i];
  }
  return y;
}
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Specification of a Class

Class invariant

- A class invariant is a condition about the state of each class instance that should be maintain throughout its existence
- We will focus on weak invariants
  - It should hold between calls to methods of the class,
  - but not during the execution of such methods

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Class specification consists of

- Class invariant
- Requires and ensures of the methods

Example, class invariant

```
public class HashSet {
  private Object[] arr;
  int nobj;

  public void insert(Object o) { ... }
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- for each index i in range of `arr` suc that `arr`$[i]$ is non-null, all elements between indices `arr`$[i]$`.hash()` and i are non-null, and

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- for each index i in range of `arr` suc that `arr`[i] is non-null, all elements between indices `arr`[i].`hash`() and i are non-null, and
- there are no two non-null elements of `arr` that are equal

Testing

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- Repeatable – be able to run tests over and over again

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What we don't look at here

- Running a program to see if anything goes wrong
- Letting a lot of people run the program to see if anything goes wrong (Beta-testing)

Testing on Different Levels

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The code that is being tested is called the IUT (implementation under test).

Testing Non-Functional Requirements

Not considered further

- Performance testing or load testing
- Stability testing
- Usability testing
- Security testing

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But writing specifications for the units of a system is already needed for a large project when programming by contract.

Tested units may be replaced later on, making the tests useless.

On the other hand, writing and running tests often gives a deep understanding of the program. The need to replace the unit may have been realized during the testing activities.

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- Organize collections of related test cases in test suites
- Use precise methods to make sure that a test suite has a good coverage of the different cases of usage

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JUnit is a small tool for writing and running test cases. It provides:

- Some functionality that is repeatedly needed when writing test cases
- A way to annotate methods as being test cases
- A way to run test cases automatically in a batch

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- When writing specifications and test cases for units, the responsibilities of the different parts become clearer, which promotes good OO programming style (low coupling)
- In order to be able to test programs automatically, separating the IO and functionality becomes important

What does a test case consists of?

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- Call to the method of the IUT
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- The test oracle is vital to run tests automatically

Demo

Small demo showing basics of how to use JUnit

Summary, and what's next?

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- Specifications (motivation, contracts, pre- and postconditions, what to think about)
- Testing (motivation, different kinds of testing, role in software development, junit)

What's next?

- More examples of test cases, presenting aspects of writing test cases and features of JUnit
- How to write a good test case?
- How to construct a good collection of test cases (test suite)?