Advanced Programming

Lecture 3: Programming by contract

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Data hiding

```
public class DataSet {

  private ArrayList<double[]> data;

  public DataSet(String fname) throws IOException,
  FileNotFoundException { ... }

  public int getNrColumns() { ... }

  public double[] getColumn(int index) { ... }

}
```

Private / public visibility

- `public` are visible to everyone
- `private` visible only within the **class**: also other objects of the same class can access them (motivation: if you modify the variable type, you can also modify the uses)

```
public class Matrix {
  private double[] data;
  private int nrows;

  public Matrix(Matrix other) {
    this.nrows = other.nrows;
    copyData(other.data);
  }
  ...
}
```

Private methods

- Maximize use of private methods for code clarity and to avoid redundance
- Every method should fit in one screen of code

```
public DataSet(String fname) throws IOException {
    this.fname = fname;
    FileReader fr = new FileReader(fname);
    BufferedReader rdr = new BufferedReader(fr);
    loadData(rdr);
}

private void loadData(Reader rdr)
    throws IOException {
        ...
}
```

Reminder: side-effects

- Java passes primitives by value, objects by reference
- Side effects can occur when mutable objects are passed as parameters (or: object the method is called on can be modified)

Contract documentation

```
/**
 * Sorts the array in ascending order from
 * from sIndex. I.e. guarantees the post-condition:
 * array[sIndex] <= ... <= array[array.length-1]
 *
 * @param array the array to sort.
 * @param sIndex the starting index.
 *   PRECOND: 0 <= sIndex < array.length
 */
void sortFromIndex(double[] array, int sIndex)
```

Violating pre-conditions

- Crash the program execution by throwing an unchecked exception (e.g. `IllegalArgumentException`)
- By convention, `null` references should never be passed in Java (or `NullPointerException` is thrown)

```
public void sortFromIndex(int[] array, int index) {
  if(index < 0 || index >= array.length) {
    throw new IllegalArgumentException("outofb");
  }
  // ... do the actual sorting
}
```

Assertions in Java

- In addition to unchecked exceptions (e.g. `IllegalArgumentException`), java has `assert` keyword that checks for a condition
- Assertions are only enabled during development as they can do computationally expensive checks (similar convention in C, but not in Matlab!)
- Need to be enabled in Eclipse (run as / run configurations / arguments / VM arguments: add "-ea")
- Failed assertions throw `AssertionException`
- Do not use assertions to check pre-conditions of public methods!

How do you know your method works?

Unit testing

- Unit testing refers to automated testing of code functionality a "unit" at a time (e.g. method)
- We test only public methods (=the interface)
- Not tested = doesn't work
- A single unit test tests one functionality, and tests can be grouped to test suites (usually 1 test suite with all tests)
- In Eclipse the JUnit library needs to be added to build path

```
public void sortFromIndex (int[] array, int index)
```

```
public class SorterTest {

  @Test
  public void testSort() {
    Sorter s = new Sorter();

    int[] arr = new int[]{3.0, 2.0, 1.0};
    s.sortFromIndex(arr, 1);

    assertEquals(3.0, arr[0], 0.00001);
    assertEquals(1.0, arr[1], 0.00001);
    assertTrue(arr[2] == 2.0);

    s.sortFromIndex(arr, 0);
    assertArrayEquals(new double[]{1.0, 2.0, 3.0},
    arr, 0.00001);
  }
}
```

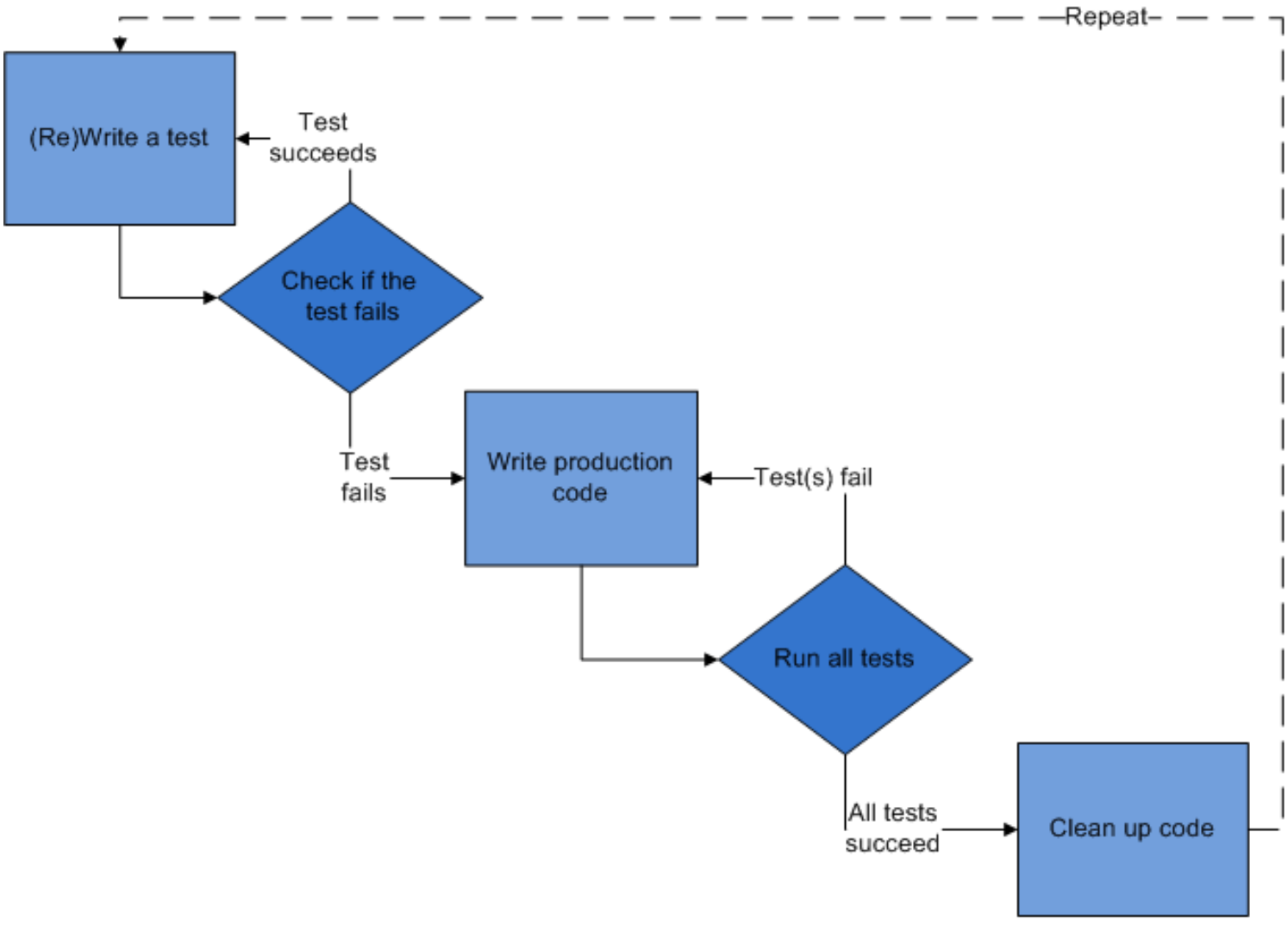
- Example: fi.smaa.jsmaa.model.ScaleCriterion tests

```
public class StudentTest {
  private Student s;
  @Before
  public void setUp() {
    s = new Student("tommi", 1212);
  }
  @Test
  public void testConstructor() {
    assertEquals("tommi", s.getName());
    assertEquals(1212, s.getNumber());
  }
  @Test
  public void testSetGetName() {
    assertEquals("tommi", s.getName());
    s.setName("x");
    assertEquals("x", s.getName());
  }
  @Test
  public void testSetGetNumber() { ...
```

Why test?

- Unit tests document functionality
- Unit tests provide a safety net ("let me change this ... does it break something?")
- More tests = more trust in your code
- Bug = **lack of a test**
- Test-driven development

Test-driven development



Class invariants

- Classes can have **invariants** that hold after the constructor has finished, and before and after each public method call
- Throw `IllegalStateException` if the class invariant does not hold (often a sanity check)

```
public class CircularLinkedList {
  // invariant: !isEmpty() -> list is circular
  ...
}
```

```
public class Date {
  private int day; // invariant: 1 <= day <= 31
  private int month; // invariant: 1 <= month <= 12

  /**
   * Sets the day.
   *
   * @param day New day, PRECOND: 1 <= day <= 31
   */
  public void setDay(int day) {
    if (day < 1 || day > 31) {
      throw new IllegalArgumentException("precond"
      + " violation: day not valid");
    }
    this.day = day;
  }
  ...
}
```

Refactoring

- Re-structure code without altering functionality
- Unit tests crucial
- Rename field/method, extract class, extract variable, convert local variable to field, inline variable, change method signature, move method, move field
- Pull up/push down methods in class hierarchy, extract interface
- Superb support in Eclipse

Method overloading

- Single method can have different implementations with different parameters. e.g.

```
public String() // constructs an empty string
public String(char[] value)
 // constructs a string with contents
```

- The constructor is **overloaded** (note: constructor name is fixed, otherwise only 1 way to construct an object)
- Overloading is defined by the method name and parameters (not including exceptions or the return value!)

Final variables

- `final` keyword declares that the value of the variable cannot be re-set

```
final int x = 2;
x = 3; // error

final Student s = new Student("tommi");
s.setName("tommi2"); // ok
s = new Student("tommi3"); // error
```

Static variables and methods

- In OOP, most method calls are bound to an object
- `static` allows to create variables and methods that exist statically, i.e. can be called without an object

```
public class Math {
    ...
    public static final double PI = 3.141592654;
    ...
    public static double abs(double x) { ... }
    ...
}
```