

JUnit

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Lecture 9

Testing

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- Testing helps increase our confidence in our code
 - “If it isn’t tested, assume it doesn’t work”
- Testing is a comparison:
 - Expected behavior of the component
 - See Javadoc description
 - Actual behavior of the component
 - Run the code
- Three parts:
 - Implementation, specification, test cases
- Some believe in test-driven development
 - Write tests first!
 - Then write code so that all tests compile
 - Then refine code so that all tests pass
 - Repeat: write more tests, refine code so they pass

Writing Good Tests

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- ❑ Goal: to expose problems!
 - Assume role of an adversary
 - Failure == success
- ❑ Test boundary conditions
 - eg 0, Integer.MAX_VALUE, empty array
- ❑ Test different categories of input
 - eg positive, negative, and zero
- ❑ Test different categories of behavior
 - eg each menu option, each error message
- ❑ Test “unexpected” input
 - eg null pointer, last name includes a space
- ❑ Test representative “normal” input
 - eg random, reasonable values

Primitive Testing: println

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- ❑ Console IO to observe actual behavior
- ❑ Compare IO with expected output
- ❑ See TestRandom
- ❑ Advantages:
 - Testing code is simple, easy, intuitive
- ❑ Problems:
 - Exhaustive testing means lots of output
 - Comparison is tiresome and error-prone
 - Difficult to automate

Serious Testing: JUnit

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- A “framework” for testing Java code
 - Frameworks are libraries with gaps
 - Programmer writes classes following particular conventions to fill in gaps
 - Result is the complete product
- Current version of JUnit: 4 (4.8)
 - JUnit 4.8 is bundled with Eclipse 3.7
 - Big changes from JUnit 3.8
 - Beware: most information available online is about 3.8

Example: RandomWithParityTest

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```
import static org.junit.Assert.*;
import org.junit.Test;

public class RandomWithParityTest {
    private RandomWithParity p; //coding to the interface

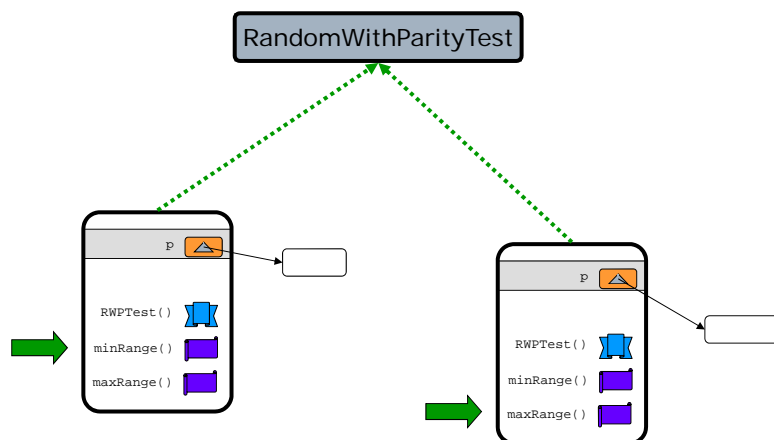
    @Test public void minRange() {
        p = new UnfilteredRandom();
        int actual = p.generateNumber(1);
        assertEquals ("Smallest range", 0, actual % 2);
    }

    @Test public void maxRange() {
        p = new UnfilteredRandom();
        int actual = p.generateNumber(Integer.MAX_VALUE);
        assertEquals ("Largest range", 0, actual % 2);
    }
}
```

Vocabulary

- Test case
 - Exercises a single unit of code / behavior / functionality
 - Test cases should be *small* (ie test one thing)
 - Test cases should be *independent*
 - In JUnit: A public method marked with @Test
- Test fixture
 - Exercises a single class
 - A collection of *test cases*
 - In JUnit: A class containing @Test methods
- Test suite
 - Exercises all the classes in a program
 - A collection of *test fixtures*
 - In JUnit: A class marked with @Suite

Execution Model: Multiple Instances



Execution Model: Implications

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- Separate instances of test class created
 - One instance / test method
- Do not use test cases with side effects
 - Passing or failing one test case should not affect the others
- Do not rely on order of tests
 - Method listed first not guaranteed to be executed first
- Fixture: common set-up to all test cases
 - Field for instance of class being tested
 - Factor initialization code into its own method
 - Mark this method(s) with @Before

Good Practice: @Before

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- Initialize a fixture with a setup method (ie marked with @Before) rather than the constructor
- Reasons:
 - If the code being tested throws an exception *during the setup*, the output is much more meaningful
 - Symmetry with @After method for cleaning up after a test case

Example: RandomWithParityTest

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```
import static org.junit.Assert.*;
import org.junit.Test;
import org.junit.Before;

public class RandomWithParityTest {
    private RandomWithParity p;

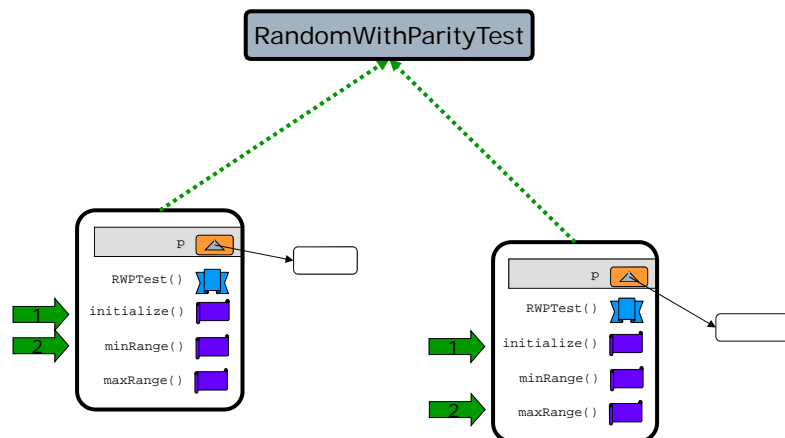
    @Before public void initialize() {
        p = new UnfilteredRandom();
    }

    @Test public void minRange() {
        int actual = p.generateNumber(1);
        assertEquals ("Smallest range", 0, actual % 2);
    }

    @Test public void maxRange() {
        int actual = p.generateNumber(Integer.MAX_VALUE);
        assertEquals ("Largest range", 0, actual % 2);
    }
}
```

Execution Model

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Practice: Anachronisms

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- ❑ Common, but out-dated, idioms (to avoid)
- ❑ Test method names start with "test"
 - This used to be a requirement (prior to JUnit 4)
 - Now use `@Test` annotation and name method something appropriate
- ❑ Set up (tear down) method named `setUp` (`tearDown`)
 - This used to be a requirement (prior to JUnit 4)
 - Now use `@Before` (`@After`) annotation and name method something appropriate
- ❑ A static method called `suite()`

```
public static junit.framework.Test suite() {
    return new JUnit4TestAdapter(Thing.class);
}
```

 - Allows JUnit 4 tests to be run by older JUnit frameworks and tools

Assertions

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- ❑ Different kinds of tests
 - Static methods of `org.junit.Assert`

```
assertEquals (message, expected, actual);
assertTrue (message, condition);
assertFalse (message, condition);
assertNull (message, object);
assertNotNull (message, object);
```
- ❑ Timed tests
 - Parameterize `@Test` with `timeout`
 - Long argument is number of ms allowed for

```
@Test(timeout=100) public void maxRange() {
    int actual = p.generateNumber(1);
    assertTrue ("Largest range", actual%2==0);
}
```

Good Practice: assertEquals

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- ❑ Prefer assertEquals to assertTrue
 - assertEquals is overloaded
 - ❑ Expected and actual can be primitives or references
 - Failed test case produces useful output

```
org.junit.ComparisonFailure: Age at birth expected:
<0> but was: <1>
```
 - Compare with assertTrue

```
java.lang.AssertionError: Age at birth
```
- ❑ Use 3-argument version
 - 1st argument: String to display on failure

```
assertEquals(String msg, int expected, int actual)
```
- ❑ For now, avoid using assertEquals to directly compare instances of your own classes
 - assertEquals on Java classes (Integer, String...)? OK
 - assertEquals on your classes (Pencil...)? later

Good Practice: Comparing Floats

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- ❑ Never compare floating point numbers directly for equality

```
assertEquals("Low-density experiment",
1.456, calculated);
```

 - Numeric instabilities make exact equality problematic
- ❑ Better approach: Equality with tolerance

```
assertEquals("Low-density experiment",
1.456, calculated, 0.001);
```

Eclipse Demo

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- New > JUnit Test Case
- First screen of wizard:
 - Checkbox “New JUnit 4 Test”
 - Enter name of test class (eg ThingTest)
 - Enter name of “class under test” (eg Thing)
- Second screen of wizard:
 - Select methods to test
 - Generates one test case / selected method
 - But you will need many more than that
 - If warning “JUnit 4 not on build path” appears, click link to add it to build path
- To run, Run As... > JUnit Test Case

Specification vs Implementation

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- Tests can be written for either
 - Specification tests test only behavior promised in Javadoc of *interface*
 - Implementation tests test all behavior documented in Javadoc of *class*
- Examples:
 - Interface does not guarantee order of elements in a returned array, but implementation always has them in sorted order
 - RandomWithParity guarantees only even/odd values, AlternatingCoin gives 0,1,0,...
- Specification tests work for all (correct) classes implementing the given interface
 - See RandomWithParityTest

Test Suite

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- To run multiple test classes, they can be bundled together into a test suite

```
import org.junit.runner.RunWith;
import org.junit.runners.Suite;

@RunWith(Suite.class)
@Suite.SuiteClasses({
    RandomWithParityTest.class,
    CoinAlternatingTest.class,
    UnfilteredRandomTest.class,
})
public class VegasSuite {
    //the class remains completely empty,
    //used only as holder for above annotations
}
```

- Eclipse also allows running “all JUnit tests in package”
 - Preferred because no extra book-keeping, but Eclipse-specific

Good Practice: Organization

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- Keep test classes in the same project as the code
 - They are part of the build
 - Helps to keep tests current
- Name test classes consistently
 - eg WritingStickTest tests WritingStick
- Group tests in same package, but different source folder as the code
 - Eg project X9, package osu.cse:
 - Code: X9/src/osu/cse/WritingStick.java
 - Tests: X9/test/osu/cse/WritingStickTest.java
 - Tests can see public and package-visible stuff

Supplemental Reading

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- JUnit web site
 - <http://www.junit.org>
 - See “Getting Started”
- JUnit FAQ
 - <http://junit.sourceforge.net/doc/faq/faq.htm>
- JUnit cookbook
 - <http://junit.sourceforge.net/doc/cookbook/cookbook.htm>
- IBM developerWorks
 - “An Early Look at JUnit 4”
 - <http://www-128.ibm.com/developerworks/java/library/j-junit4.html>
 - Assumes JUnit 3.8 background

Summary

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- Nature of testing
 - Specification, implementation, test cases
 - Return only copies of fields (reference types)
- JUnit overview
 - Test case: method marked with `@Test`
 - Test fixture: class collecting common tests
 - Test suite: set of fixtures
 - Assertions
- Execution model
 - Multiple instantiation of test class
 - Independence of test cases
 - No ordering guarantee