

Tools for Unit Test - JUnit

Conrad Hughes
School of Informatics

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JUnit

- JUnit is a framework for writing tests
 - Written by Erich Gamma (Design Patterns) and Kent Beck (eXtreme Programming)
 - JUnit uses Java's reflection capabilities (Java programs can examine their own code)
 - JUnit allows us to:
 - define and execute tests and test suites
 - Use test as an effective means of specification
 - write code and use the tests to support refactoring
 - integrate revised code into a build
 - JUnit is available on several IDEs, e.g. BlueJ, JBuilder, and Eclipse have JUnit integration to some extent.

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JUnit's Terminology

- A **test runner** is software that runs tests and reports results.
 - Many implementations: standalone GUI, command line, integrated into IDE
- A **test suite** is a collection of test cases.
- A **test case** tests the response of a single method to a particular set of inputs.
- A **unit test** is a test of the smallest element of code you can sensibly test, usually a single class
- A **test fixture** is the environment in which a test is run. A new fixture is set up before each test case is executed, and torn down afterwards.
 - Example: if you are testing a database client, the fixture might place the database **server** in a standard initial state, ready for the client to connect.
- An **integration test** is a test of how well classes work together.
 - JUnit provides some limited support for integration tests.
- Proper unit testing would involve mock objects** - fake versions of the other classes with which the class under test interacts. JUnit doesn't help with this. It's worth knowing about, but not always necessary.

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Structure of a JUnit test class

- We want to test a class named **Triangle**
- `public class TriangleTest`
 - extends `junit.framework.TestCase` {
 - This is the unit test for the **Triangle** class; it defines objects used by one or more tests.
 - `public TriangleTest() { }`
 - This is the default constructor.
 - `protected void setUp()`
 - Creates a test fixture by creating and initializing objects and values.
 - `protected void tearDown()`
 - Releases any system resources used by the test fixture. Java usually does this for free, but files, network connections etc. might not get tidied up automatically.
 - `public void testTriangle(), public void testIsScalene(), etc.`
 - These methods contain tests for the **Triangle** constructor and its `isScalene()` method.

JUnit 3!

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Making Tests: Assert

- Within a test,
 - Call the method being tested and get the actual result.
 - assert a property that should hold of the test result.
 - Each **assert** is a challenge on the test result.
- If the property fails to hold then **assert** fails, and throws an `AssertionFailedError`:
 - JUnit catches these Errors, records the results of the test and displays them.
- `static void assertTrue(boolean test)`
`static void assertTrue(String message, boolean test)`
 - Throws an `AssertionFailedError` if the test fails.
 - The optional `message` is included in the Error.
- `static void assertFalse(boolean test)`
`static void assertFalse(String message, boolean test)`
 - Throws an `AssertionFailedError` if the test succeeds.

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Aside: Throwable

- `java.lang.Error`: a problem that an application wouldn't normally try to handle. Don't need to be declared in `throws` clause.
 - e.g. command line application given bad parameters by user.
- `java.lang.Exception`: a problem that the application might reasonably cope with. Need to be declared in `throws` clause.
 - e.g. network connection timed out during connect attempt.
- `java.lang.RuntimeException`: application might cope with it, but rarely. Don't need to be declared in `throws` clause.
 - e.g. I/O buffer overflow.

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Example: Triangle class

For the sake of example, we will create and test a trivial "Triangle" class:

- The constructor creates a Triangle object, where only the lengths of the sides are recorded and the private variable `p` is the longest side.
- The `isScalene` method returns `true` if the triangle is scalene.
- The `isEquilateral` method returns `true` if the triangle is equilateral.
- We can write the test methods before the code.
- This has advantages in separating coding from testing.
- But Eclipse helps more if you create the class under test first:
 - Creates test stubs (methods with empty bodies) for all methods and constructors.

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Notes on creating tests

- Often the amount of (very routine) test code will exceed the size of the code for small systems.
- Testing complex code can be a complex business and the tests can get quite complex.
- The effort taken in creating test code is repaid in reduced development time, most particularly when we go on to use the test subject in anger (i.e. real code).
- Creating a test often helps clarify our ideas on how a method should behave (particularly in exceptional circumstances).

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A JUnit 3 test for Triangle

```
import junit.framework.TestCase;

public class TriangleTest extends TestCase {
    private Triangle t;

    protected void setUp() { // executed before each test
        t = new Triangle(5,4,3);
    }

    protected void tearDown() {} // executed after each test

    public void testIsScalene() {
        assertTrue(t.isScalene());
    }

    public void testIsEquilateral() {
        assertFalse(t.isEquilateral());
    }
}
```

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A JUnit 4 test for Triangle

```
package st;

import static org.junit.Assert.*;

import org.junit.Before;
import org.junit.Test;

public class TestTriangle {
    private Triangle t;

    @Before public void setUp() throws Exception {
        t = new Triangle(3, 4, 5);
    }

    @Test public void scaleneOk() {
        assertTrue(t.isScalene());
    }
}
```

More imports

No need to inherit from TestCase

Use annotations ...

... rather than special names

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The Triangle class itself

```
public class Triangle {
    private int p; // Longest edge
    private int q;
    private int r;

    public Triangle(int s1, int s2, int s3) {
        if (s1>s2) {
            p = s1; q = s2;
        } else {
            p = s2; q = s1;
        }
        if (s3>p) {
            r = p; p = s3;
        } else {
            r = s3;
        }
    }

    public boolean isScalene() {
        return p>0 && q>0 && r>0 && p<(q+r) &&
            q != r && r != p && p != q;
    }

    public boolean isEquilateral() {
        return p == q && q == r;
    }
}
```

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Assert methods II

- `assertEquals(expected, actual)`
`assertEquals(String message, expected, actual)`
 - This method is heavily overloaded: `arg1` and `arg2` must be both objects or both of the same primitive type
 - For objects, uses your `equals` method, if you have defined it properly, as `public boolean equals(Object o)`—otherwise it uses `==`
- `assertSame(Object expected, Object actual)`
`assertSame(String message, Object expected, Object actual)`
 - Asserts that two objects refer to the same object (using `==`)
- `assertNotSame(Object expected, Object actual)`
`assertNotSame(String message, Object expected, Object actual)`
 - Asserts that two objects do not refer to the same object

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Assert methods III

- assertNull(Object object)**
assertNull(String message, Object object)
 - Asserts that the object is null
- assertNotNull(Object object)**
assertNotNull(String message, Object object)
 - Asserts that the object is not null
- fail()**
fail(String message)
 - Causes the test to fail and throw an `AssertionFailedError`
 - Useful as a result of a complex test, when the other assert methods aren't quite what you want

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The assert statement in Java

- Earlier versions of JUnit had an `assert` method instead of an `assertTrue` method
 - The name had to be changed when Java 1.4 introduced the `assert` statement
- There are two forms of the `assert` statement:
 - `assert boolean_condition;`
 - `assert boolean_condition, error_message;`
 - Both forms throw an `AssertionFailedError` if the `boolean_condition` is false
 - The second form, with an explicit error message, is seldom necessary
- When to use an `assert` statement:
 - Use it to document a condition that you "know" to be true
 - Use `assert false;` in code that you "know" cannot be reached (such as a default case in a switch statement)
 - Do not use `assert` to check whether parameters have legal values, or other places where throwing an `Exception` is more appropriate
 - Can be dangerous: customers are not impressed by a library bombing out with an assertion failure.

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JUnit in Eclipse

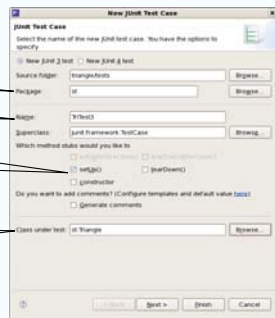
- To create a test class, select `File` → `New` → `JUnit Test Case` and enter the name of your test case

Package

Test class

Decide what stubs you want to create

Identify the class under test



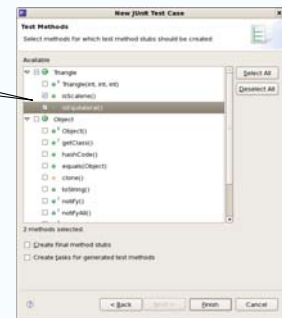
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Creating a Test

Decide what you want to test

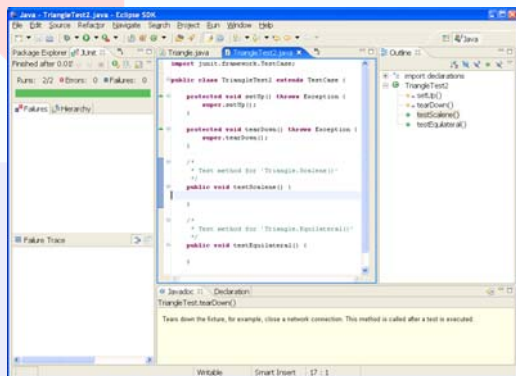


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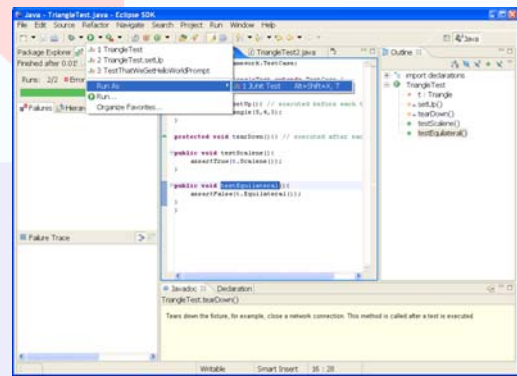
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Template for New Test



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Running JUnit



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Results

Results are here

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Aside: FIT

- Framework for Integrated Tests, by Ward Cunningham (inventor of wiki)
- Allows closed loop between customers and developers:
 - Takes HTML tables of expected behaviour from customers or spec.
 - Turns those tables into test data: inputs, activities and assertions regarding expected results.
 - Runs the tests and produces tabular summaries of the test runs.
- Only a few years old, but lots of people seem to like it; various commercial folk I've introduced it to still seem to think it's revolutionary.
- <http://fit.c2.com/>

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Issues with JUnit

JUnit has a model of calling methods and checking results against the expected result. Issues are:

- State: objects that have significant internal state (e.g. collections with some additional structure) are harder to test because it may take many method calls to get an object into a state you want to test. Solutions:
 - Write long tests that call some methods many times.
 - Add additional methods in the interface to allow observation of state (or make private variables public?)
 - Add additional methods in the interface that allow the internal state to be set to a particular value
 - Heisenbugs can be an issue in these cases (changing the observations changes what is observed).
- Other effects, e.g. output can be hard to capture correctly.
- JUnit tests of GUIs are not particularly helpful (recording gestures might be helpful here?)

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Positives

- Using JUnit encourages a "testable" style, where the result of a calling a method is easy to check against the specification:
 - Controlled use of state
 - Additional observers of the state (testing interface)
 - Additional components in results that ease checking
- It is well integrated into a range of IDEs (e.f. Eclipse)
- Tests are easy to define and apply in these environments.
- JUnit encourages frequent testing during development (e.g. XP (eXtreme Programming) "test as specification")
- JUnit tends to shape code to be easily testable.
- JUnit supports a range of extensions that support structured testing (e.g. coverage analysis) - we will see some of these extensions later.

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Get testing!

- Start up Eclipse and:
 - Create a new Java project
 - Add a nw package, "st"
 - Create st.Triangle; use File->Import (from File System) to copy -chughes1/shared/Triangle.java into Triangle/src/st
 - Create a new source folder called "tests" if you like (with a new "st" package)
 - Create a new JUnit test for st.Triangle
 - And get testing!

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