Tools for Unit Test - JUnit

Conrad Hughes
School of Informatics

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informatics

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) and (as of version 4) annotations
  - 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.

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.

Structure of a JUnit (4) test class

- We want to test a class named Triangle
- public class TriangleTestJ4 {
  - 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.
- @Before public void init()
  - Creates a test fixture by creating and initializing objects and values.
- @After public void cleanUp()
  - 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.
- @Test public void noBadTriangles(), @Test public void scaleneOk(), etc.
  - These methods contain tests for the Triangle constructor and its isScalene() method.

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.

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.

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.

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).

A JUnit 3 test for Triangle

```
import junit.framework.TestCase;

public class TriangleTest extends TestCase {

  private Triangle t;

  // Any method named setUp will be executed before each test.
  protected void setUp() {
    t = new Triangle(5,4,3);
  }

  protected void tearDown() {} // tearDown will be executed afterwards

  public void testIsScalene() { // All tests are named "test[Something]"
    assertTrue(t.isScalene());
  }

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

}
```


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

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 ((r>0) && (q>0) && (p>0) &&
                (p<(q+r))&& ((q>r) || (r>q)));
}

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

- Is JUnit too much for small programs?
- Not if you think it will reduce errors.
- Tests on this scale of program often turn up errors or omissions – construct the tests working from the specification
- Sometimes you can omit tests for some particularly straightforward parts of the system

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

Assert methods III

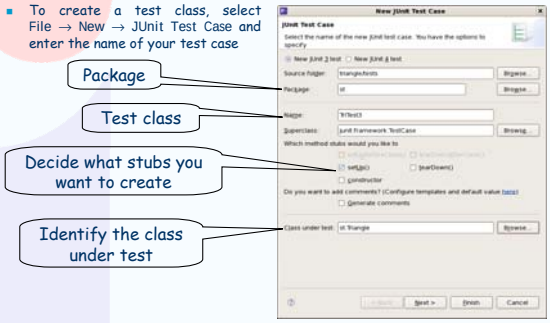
- assertNull(Object ***object***)
  assertNull(String ***message***, Object ***object***)
  - Asserts that the object is null
- assertNotNull(Object ***object***)
  assertNotNull(String ***message***, Object ***object***)
  - Asserts that the object is null
- fail()
  fail(String ***message***)
  - Causes 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

The assert statement in Java

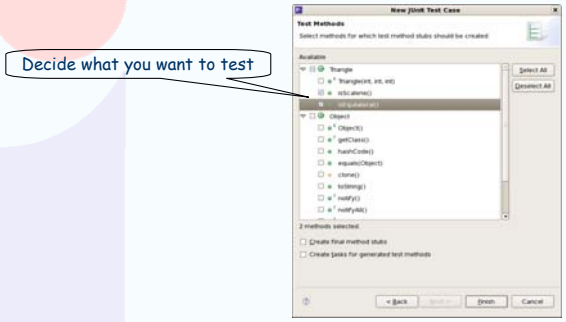
- Earlier versions of JUnit had an assert method instead of an assertTrue method
  - The name had to be changed when Java 1.4 introduced the assert statement
- There are two forms of the assert statement:
  - assert ***boolean_condition***;
  - assert ***boolean_condition***: ***error_message***;
  - 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.

JUnit in Eclipse

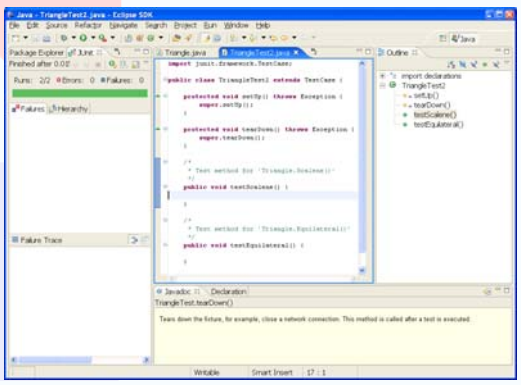
- To create a test class, select File → New → JUnit Test Case and enter the name of your test case



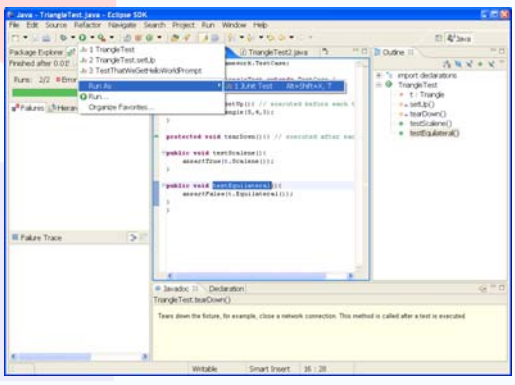
Creating a Test



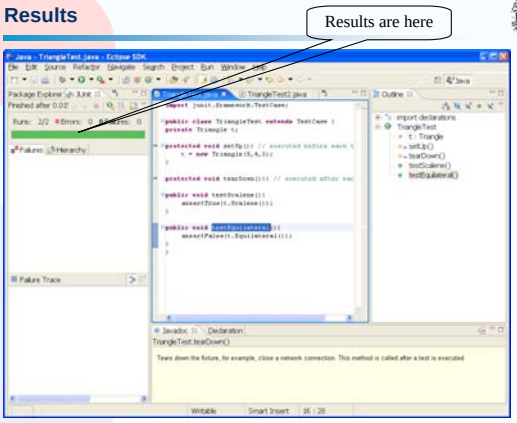
Template for New Test



Running JUnit



Results



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/

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?)

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.g. 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.

Get testing!

- Start up Eclipse and:
  - Create a new Java project
  - Add a new package, "st"
  - Create st.Triangle; grab the source from `http://www.inf.ed.ac.uk/teaching/courses/st/2009-2010/tutorials/tutorial1.html`
  - 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!
  - Follow the video from the Tutorial 1 web page for more details.