Tools for Unit Test — JUnit

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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) 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.
JUnit’s Terminology

• 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 does not help with this.* It is worth knowing about, but not always necessary.
Structure of a JUnit (4) test class

We want to test a class named Triangle

• This is the unit test for the Triangle class; it defines objects used by one or more tests.

      public class TriangleTest{
        }

• This is the default constructor.

      public TriangleTest(){ }

Structure of a JUnit (4) test class

- **@Before** public void init()
  
  Creates a test fixture by creating and initialising 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.
Making Tests: Assert

- static void assertTrue(boolean test)
  static void assertTrue(String message, boolean test)
  Throws an AssertionError 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 AssertionError if the test succeeds.
Aside: Throwable

- `java.lang.Error`: a problem that an application would not normally try to handle — does not 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 — needs 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 — does not need to be declared in `throws` clause.
  
e.g. I/O buffer overflow.
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

- **Size**: Often the amount of (very routine) test code will exceed the size of the code for small systems.

- **Complexity**: Testing complex code can be a complex business and the tests can get quite complex.

- **Effort**: 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).

- **Behaviour**: Creating a test often helps clarify our ideas on how a method should behave (particularly in exceptional circumstances).
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 3 test for Triangle
A JUnit 4 test for Triangle

```java
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());
    }

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

    @Test public void scaleneOk() {
        assertTrue(t.isScalene());
    }
}
```
The Triangle class itself

- 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: `expected` and `actual` 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 are not 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.
The assert statement in Java

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

1. Decide what stubs you want to create
2. Identify the class under test

Package
Test class

Source folder: triangle\tests
Package: st

Name: \Triangle\Tests\TestCase
Superclass: junit.framework.TestCase

Which method stubs would you like to
- setUp()
- tearDown()

Do you want to add comments? (Configure templates and default value here)
- Generate comments

Class under test: st.Triangle
Creating a Test

Decide what you want to test.
Template for New Test

```java
import junit.framework.TestCase;

public class TriangleTest2 extends TestCase {
    protected void setUp() throws Exception {
        super.setUp();
    }

    protected void tearDown() throws Exception {
        super.tearDown();
    }

    /\ Test method for 'Triangle.Scalene' \/
    public void testScalene() {
    }

    /\ Test method for 'Triangle.Equilateral' \/
    public void testEquilateral() {
    }

    // Tears down the fixture, for example, close a network connection. This method is called after a test is executed.
    public void tearDown() {
    }
}
```
Running JUnit
Results

Results are here.
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).
Issues with JUnit

- 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.
Another Framework for Testing

- Framework for Integrated Test (FIT), 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 practitioners seem to think it is revolutionary.
Readings

Required Readings

- JUnit Test Infected: Programmers Love Writing Tests
  an introduction to JUnit.
- Using JUnit With Eclipse IDE
  an O'Reilly article
- Unit Testing in Jazz Using JUnit
  an NCSU Open Lab article on using JUnit with Eclipse

Suggested Readings

Resources

Getting started with Eclipse and JUnit

Activity: to start using JUnit within Eclipse review and try the example of defining tests for a Triangle class.

[link to Activity]

Video: this video tutorial shows how to create a new Eclipse project and start writing JUnit tests first.

[link to Video]
Get testing!

Start up Eclipse and:

1. Create a new Java project
2. Add a new package, ‘‘st’’
3. Create st.Triangle; grab the source from the Junit lecture’s Activity in the resources
4. Create a new source folder called ‘‘tests’’ if you like (with a new ‘‘st’’ package)
5. Create a new JUnit test for st.Triangle
6. And get testing!