CS 635 Advanced Object-Oriented Design & Programming
Spring Semester, 2001
Doc 14 Patterns, Refactoring & Testing
Contents

References

JUnit Cookbook Local copy at: http://www.eli.sdsu.edu/java-SDSU/junit/cookbook/cookbook.htm

JUnit Test Infected: Programmers Love Writing Tests Local copy at: http://www.eli.sdsu.edu/java-SDSU/junit/testinfected/testing.htm

JUnit on-line documentation Local copy at: http://www.eli.sdsu.edu/java-SDSU/docs/

Originals of the above can be found at: http://www.junit.org/

Refactoring: Improving the Design of Existing Code, Fowler, 1999,

Testing for Programmers: A tutorial for OOPSLA 2000, Brian Marick, http://www.testing.com/writings/half-day-programmer.pdf

Used here with permission from Brian Marick

A Short Catalog of Test Ideas, Brian Marick, http://www.testing.com/writings/short-catalog.pdf

Used here with permission from Brian Marick

Patterns and Coding

Ralph Johnson recommends using patterns with you know you really need it

You have a program in development

You discover that using a pattern would improve the existing code

But adding the pattern requires modifying existing code!

Refactoring

Refactoring is the modifying existing code without adding functionality

Changing existing code is dangerous

- Changes can break existing code

To avoid breaking code while refactoring:

- Need tests for the code

  Tests need to be automated

- Proceed in small steps

Testing

Johnson's Law

If it is not tested it does not work

Types of tests

- Unit Tests

  Tests individual code segments

- Functional Tests

  Test functionality of an application

- Regression Tests

  Determine if new code produces results as old code

- White box testing

  Testing with knowledge of the code

- Black box testing

  Testing with no knowledge of the code

Why Unit Testing

If it is not tested it does not work

The more time between coding and testing

- More effort is needed to write tests
- More effort is needed to find bugs
- Fewer bugs are found
- Time is wasted working with buggy code
- Development time increases
- Quality decreases

Without unit tests

- Code integration is a nightmare
- Changing code is a nightmare

Who Writes Unit Tests?

Programmers

Waiting for QA or testing wastes time

- Long delay for feedback on code
- Programmers forget code in this delay
- Programmers use untested code in new code

Testing First

First write the tests

Then write the code to be tested

Writing tests first:

- Removes temptation to skip tests

- Makes you define of the interface & functionality of the code before

Why Automated Tests

Why bother with automated test?

Just print results to standard out

Automated tests

- Allow you to run many tests at once
- Allow others to run the tests
- Allows you to keep the tests for later

JUnit

Framework for unit testing Java code

Available at: http://www.junit.org/

Already installed in JDK 1.2 & 1.3 on rohan and moria

Ports of JUnit are available in

C++
Delphi
Eiffel
Forte 4GL
Objective-C
Perl
PowerBuilder
Python
Ruby
Smalltalk
Visual Basic
.net

See http://www.xprogramming.com/software.htm to download ports of JUnit

Using JUnit
Example

Goal: Implement a Stack containing integers.

Tests:

Subclass junit.framework.TestCase

Methods starting with 'test" are run by TestRunner

First tests for the constructors:

```
package example;

Import junit.framework.TestCase;

public class  StackTest extends TestCase {

   //required constructor
   public StackTest(String name) {
      super(name);
   }

   public void testDefaultConstructor() {
      Stack test = new Stack();
      assert( test.isEmpty() );
   }

   public void testSizeConstructor() {
      Stack test = new Stack(5);
      assert( test.isEmpty() );
   }
}
```

First part of the Stack

```
package example;

public class Stack  {
   int[] elements;
   int topElement = -1;

   public Stack() {
    this(10);
   }

   public Stack(int size) {
      elements = new int[size];
   }

   public boolean isEmpty() {
      return topElement == -1;
   }
}
```

Running JUnit

JUnit has three interfaces

- Text (junit.textui.*)
- AWT (junit.ui.*)
- Swing (junit.swingui.*)

  Shows list of previously run test classes

JUnit has two class loaders

- Normal java class loader (TestRunner)
- junit.util.TestCaseClassLoader (LoadingTestRunner)

  Reloads classes without having to restart program

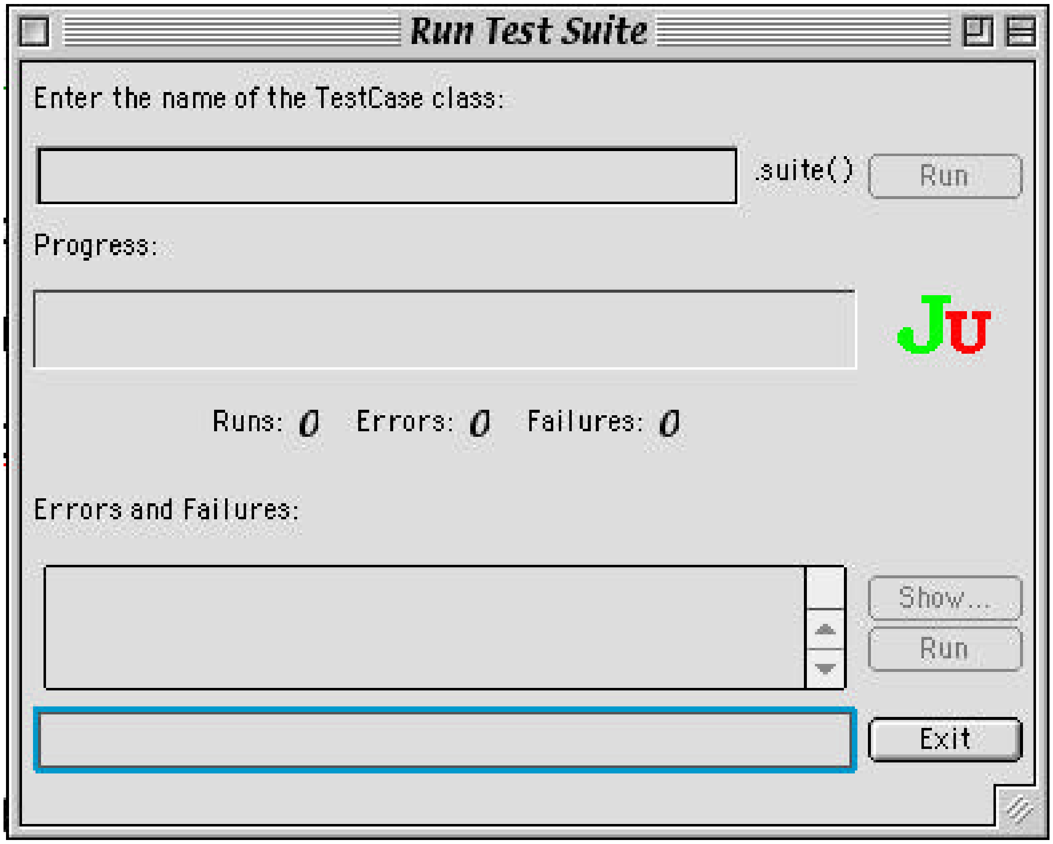
Starting TestRunner

Make sure your classpath includes the code to tested

On Rohan use:

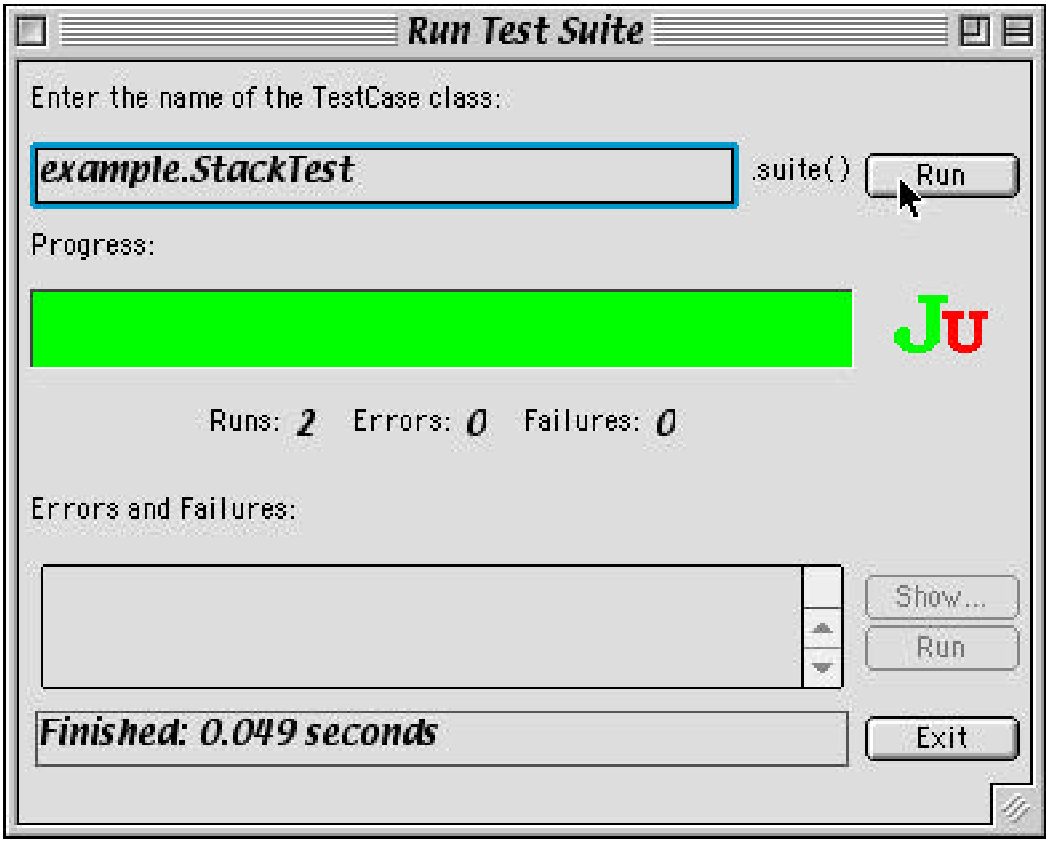
java junit.ui.LoadingTestRunner

You get a window like:



Enter the full name of the test class

Click on the Run button



Enter the name of the TestCase class: example.StackTest

Runs: 2 Errors: 0 Failures: 0

Finished: 0.049 seconds

If there are errors/failures select one and click on Show

You will see a stack trace of the error

With LoadingTestRunner you can recompile the Stack & StackTest classes without exiting LoadingTestRunner

Testing the Tests

If can be useful to modify the code to break the tests

```
package example;

public class Stack  {
   int[] elements;
   int topElement = -1;

   etc.

   public boolean isEmpty() {
      return topElement == 1;
   }
}
```

One company had an automatic build and test cycle that ran at night. The daily build was created and all the tests were run at night. The test results were available first thing in the morning. One night the build process crashed, so the daily build was not made. Hence there was no code to test. Still 70% of the tests passed. If they had tested their tests, they would have discovered immediately that their tests were broken.

Test Fixtures

Before each test setUp() is run

After each test tearDown() is run

```
package example;

import junit.framework.TestCase;

public class  StackTest extends TestCase {
   Stack test;

   public StackTest(String name) {
      super(name);
   }

   public void setUp() {
      test = new Stack(5);
      for (int k = 1; k <=5;k++)
         test.push( k);
   }

   public void testPushPop() {
      for (int k = 5; k >= 1; k--)
         assert( "Popping element " + k,  test.pop() == k);
   }
}
```

Suites – Multiple Test Classes

Multiple test classes can be run at the same time

Running AllTests in TestRunner runs the test in

StackTest

QueueTest

```
package example;
import junit.framework.TestSuite;

public class AllTests
{
   static public TestSuite suite()
      {
         TestSuite suite= new TestSuite();
      try
         {
         suite.addTest(new TestSuite(StackTest.class));
         suite.addTest(new TestSuite(QueueTest.class));
         }
      catch (Exception e)
         {
         }
         return suite;
      }
}
```

Using Main

We can use main to run the test via textui.TestRunner

The command:

```
   java example.AllTests
```

will run all the tests in StackTest & QueueTest

```
package example;

import junit.framework.TestSuite;
import junit.textui.TestRunner;

public class AllTests
   {
   static public void main(String[] args)
      {
      TestRunner.main(args);
      }

   static public TestSuite suite()
      {
      same as last page
      }
   }
```

What to Test

Fowler on Testing[1]

"It is better to write and run incomplete tests than not to run complete tests"

"Don't let the fear that testing can't catch all bugs stop you from writing the tests that will catch most bugs"

"Trying to write too many tests usually leads to not writing enough"

"Run your tests frequently"

"When you get a bug report, start by writing a unit test that exposes the bug"

Think of the boundary conditions and concentrate your tests there

[1] Fowler Chapter 4, pp. 89-102

Programming Errors

Programmers tend to make the same errors many times

Keep a list or catalog of your errors

A Short Catalog of Test Ideas

Tests develop catalogs of commonly found errors in programs

Since errors are often repeated, this helps testers find common errors

As programmers such a catalog:

- Suggests tests to uncover errors
- Help avoid errors when writing code

  If we know these are common errors, we can keep them in mind while coding

The following catalog is from Brian Marick

http://www.testing.com/writings/short-catalog.pdf

The catalog is used here with permission

Any Object

Test nil(null) references and pointers to objects

In Java/Smalltalk

Does the code handle correctly variables & parameters that are null(nil)

Java

```
String firstName = null
```

Smalltalk

```
| firstName  |
firstName := nil.
```

Strings

Test the empty string

Does the code to the correct thing when string variables/parameters are the empty string

In Java/Smalltalk an empty string is not the same as a null(nil) reference to a string

Java

```
String firstName = "";
String secondName = new String();
```

Smalltalk

```
| firstName secondName |
firstName := ".
secondName := String new
```

Numbers

Test the code using:

- 0
- The smallest number

  Often numbers are used in a context with a valid range

  The smallest number refers to the smallest valid number in the range

- Just below the smallest number
- The largest number
- Just above the largest number

Example

```
int planetIndex;//Represents the I'th planet from the Sun
```

Numbers to test

0	Below the smallest
1	Smallest
9	Largest (Pluto is still considered a planet)
10	Above the largest

Collections

Test the code using:

- An empty collection
- A collection with one element
- The largest possible collection

  Not the largest possible collection allowed by the language/hardware

  The largest possible collection the system will encounter

  If this is not possible use a collection with more than one element

- A collection with duplicate elements

Linked Structures (trees, graphs, etc.)

Test the code using:

- An empty structure
- Minimal non-empty structure
- A circular structure
- A structure with depth greater than one

  The test must make the code reach the lowest depth

  If the structure in the context has a maximally deep use that level

Equality Testing of Objects

Objects have two meanings of equality

- Pointer Identical
  Two object references point to the same memory location

- Equal
  The fields of the two objects have the same value

Java

- ==
  Tests if two object references are pointer identical

- equals()
  Tests if two objects are equal

  If this method is not implemented in a class it defaults to ==

Smalltalk

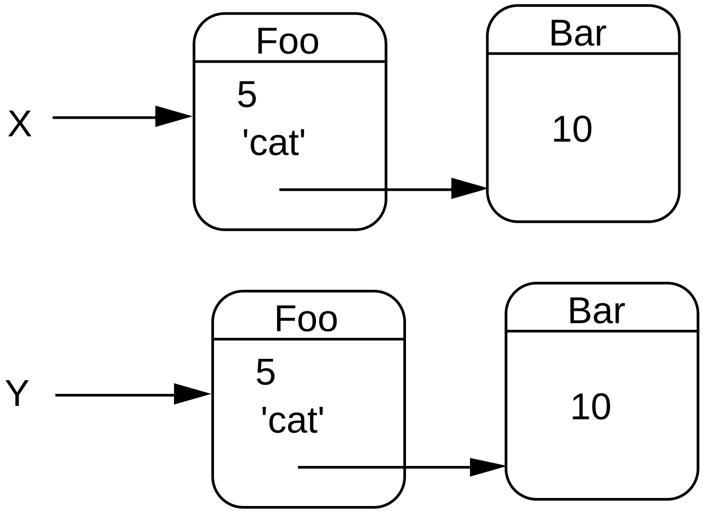
- ==
  Tests if two object references are pointer identical

- =
  Tests if two objects are equal

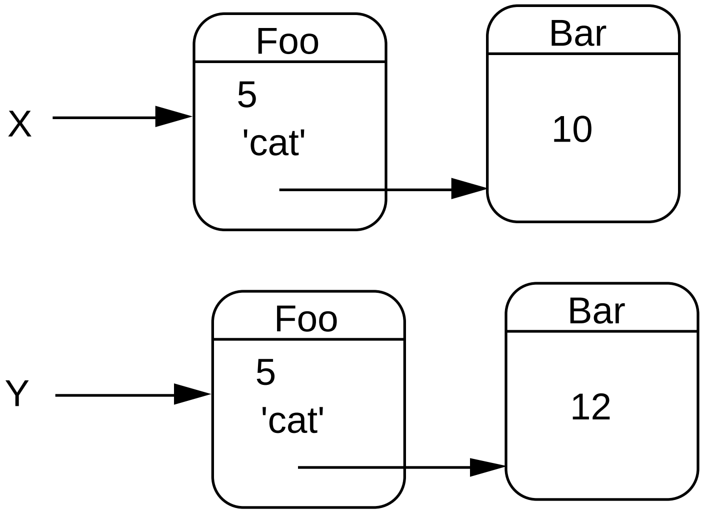
  If this method is not implemented in a class it defaults to ==

Test the code with objects equal but not identical

Lack of pointer identity should extend as far down as is meaningful to the code



Test the code with objects different at the lowest level



Don't Forget

"Trying to write too many tests usually leads to not writing enough … You get many benefits from testing even if you do a little testing …"

Fowler

Back To Refactoring

Refactoring requires:

- Testing
- Knowing when code could be improved
- Knowing how to improve the code
- Knowing the benefits of the improvement

Code Smells

If it stinks, change it

-- Grandma Beck on child-rearing

Some Smells

Duplicate Code	Long Method
Large Class	Long Parameter List
Divergent Change	Shotgun Surgery
Feature Envy	Data Clumps
Primitive Obsession	Switch Statements
Parallel Inheritance Hierarchies	Lazy Class
Speculative Generality	Temporary Field
Message Chains	Middle Man
Inappropriate Intimacy	Alternative Classes with Different Interfaces
Incomplete Library Class	Data Class
Refused Bequest	Comments

Most Common Refactoring: Extract Method[2]

You have a code fragment that can be grouped together.

Turn the fragment into a method whose name explains the purpose of the method

Motivation

Short methods:

- Increase possible reuse
- Makes high level methods easier to read
- Makes easier to override methods

[2] Refactoring Text, pp. 110-116

Mechanics

- Create a new method - the target method

  Name the target method after the intention of the method

  With short code only extract if the new method name is better than the code at revealing the code's intention

- Copy the extracted code from the source method into the target method

- Scan extracted code for references to local variables (temporary variables or parameters) of the source method

- If a temporary variable is used only in the extracted code declare it local in the target method

- If a parameter of the source method is used in the extracted code, pass the parameter to the target method

Mechanics - Continued

- See if the extracted code modifies any of the local variables of the source method

  If only one variable is modified, then try to return the modified value

  If more than one variable is modified, then the extracted code must be modified before it can be extracted

  Split Temporary Variables or Replace Temp with Query may help

- Compile when you have dealt with all the local variables

- Replace the extracted code in source code with a call to the target method

- Compile and test

Example[3]
No Local Variables

Note I will use Fowler's convention of starting instance variables with "_" even though one can not do this is Squeak.

```
void printOwing() {

   //print banner
   System.out.println( "*************************");
   System.out.println( "****Customer Owes*********");
   System.out.println( "*************************");

   Iterator orders = _orders.iterator();
   double outstanding = 0.0;

   // Calculate outstanding
   while (orders.hasNext() ) {
      Order each = (Order) orders.next();
      outstanding = outstanding + each.getAmount();
   }

   //Print Details
   System.out.println("name: " + _name);
   System.out.println("amout: " + outstanding);
}
```

[3] Example code is Squeak version of Fowler's Java example

Extracting the banner code we get:

```
void printOwing() {

   printBanner();

   Iterator orders = _orders.iterator();
   double outstanding = 0.0;

   // Calculate outstanding
   while (orders.hasNext() ) {
      Order each = (Order) orders.next();
      outstanding = outstanding + each.getAmount();
   }

   //Print Details
   System.out.println("name: " + _name);
   System.out.println("amout: " + outstanding);
}

void printBanner() {
   System.out.println( "*************************");
   System.out.println( "****Customer Owes*********");
   System.out.println( "*************************");
}
```

Examples: Using Local Variables

We can extract printDetails() to get

```
void printOwing() {

   printBanner();

   Iterator orders = _orders.iterator();
   double outstanding = 0.0;

   // Calculate outstanding
   while (orders.hasNext() ) {
      Order each = (Order) orders.next();
      outstanding = outstanding + each.getAmount();
   }

   printDetails(outstanding);
}

void printDetails( double amountOwed) {
   System.out.println("name: " + _name);
   System.out.println("amout: " + outstanding);
}
```

Then we can extract outstanding to get:

```
void printOwing() {

   printBanner();
   double outstanding = outStanding();
   printDetails(outstanding);
}

double outStanding() {
   Iterator orders = _orders.iterator();
   double outstanding = 0.0;

   while (orders.hasNext() ) {
      Order each = (Order) orders.next();
      outstanding = outstanding + each.getAmount();
   }
   return outstanding;
}
```

Using Replace Parameter with Method[4] we can change this to:

```
void printOwing() {
   printBanner();
   printDetails();
}

void printDetails() {
   System.out.println("name: " + _name);
   System.out.println("amout: " + outstanding());
}
```

[4] Fowler pp. 292-294

Reducing Coupling

The printing is still coupled to System.out

Using Add Parameter we get:

```
void printOwing(PrintString out) {
   printBanner(out);
   printDetails(out);
}
```

where

```
void printDetails(PrintString out) {
   out.println("name: " + _name);
   out.println("amout: " + outstanding());
}

void printBanner(PrintString out) {
   out.println( "*************************");
   out.println( "****Customer Owes*********");
   out.println( "*************************");
}
```

If you really do print to the screen a lot, you might add:

```
void printOwing() {
   printOwing(System.out);
}
```