CS 635 Advanced Object-Oriented Design & Programming
Fall Semester, 2019

Doc 3 Code Smells, Refactoring, Unit Tests
Sep 3, 2019

Review

Object-Oriented Programming is good as it promotes

- Code reuse
- More readable code
- More maintainable code
- Better designs

Basic OO Heuristics

Keep related data and behavior in one place

A class should capture one and only one key abstraction

Beware of classes that have many accessor methods defined in their public interface

So Why is Software Still so Bad?

Example - Billing For Plays

```
function statement (invoice, plays) {
  let totalAmount = 0;
  let volumeCredits = 0;
  let result = `Statement for ${invoice.customer}\n`;
  const format = new Intl.NumberFormat("en-US",{ style: "currency", currency: "USD",
                          minimumFractionDigits: 2 }).format;
  for (let perf of invoice.performances) {
    const play = plays[perf.playID];
    let thisAmount = 0;
    switch (play.type) {
    case "tragedy":
      thisAmount = 40000;
      if (perf.audience > 30) { thisAmount += 1000 * (perf.audience - 30);}
      break;
    case "comedy":
      thisAmount = 30000;
      if (perf.audience > 20) {  thisAmount += 10000 + 500 * (perf.audience - 20); }
      thisAmount += 300 * perf.audience;
      break;
    default:  throw new Error(`unknown type: ${play.type}`);
```

Part 2

```
// add volume credits
volumeCredits += Math.max(perf.audience - 30, 0);
// add extra credit for every ten comedy attendees
if ("comedy" === play.type) volumeCredits += Math.floor(perf.audience / 5);

// print line for this order
result += `  ${play.name}: ${format(thisAmount/100)} (${perf.audience} seats)\n`;
    totalAmount += thisAmount;
  }
  result += `Amount owed is ${format(totalAmount/100)}\n`;
  result += `You earned ${volumeCredits} credits\n`;
  return result;
}
```

```
function statement (invoice, plays) {
  let totalAmount = 0;
  let volumeCredits = 0;
  let result = `Statement for ${invoice.customer}\n`;
  const format = new Intl.NumberFormat("en-US",
                        { style: "currency", currency: "USD", minimumFractionDigits: 2 }).format;
  for (let perf of invoice.performances) {
    const play = plays[perf.playID];
    let thisAmount = amountFor(perf, play);

    // add volume credits
    volumeCredits += Math.max(perf.audience - 30, 0);
    // add extra credit for every ten comedy attendees
    if ("comedy" === play.type) volumeCredits += Math.floor(perf.audience / 5);

    // print line for this order
    result += `  ${play.name}: ${format(thisAmount/100)} (${perf.audience} seats)\n`;
    totalAmount += thisAmount;
  }
  result += `Amount owed is ${format(totalAmount/100)}\n`;
  result += `You earned ${volumeCredits} credits\n`;
  return result;
```

```
function amountFor(perf, play) {
  let thisAmount = 0;
  switch (play.type) {
  case "tragedy":
    thisAmount = 40000;
    if (perf.audience > 30) {
      thisAmount += 1000 * (perf.audience - 30);
    }
    break;
  case "comedy":
    thisAmount = 30000;
    if (perf.audience > 20) {
      thisAmount += 10000 + 500 * (perf.audience - 20);
    }
    thisAmount += 300 * perf.audience;
    break;
  default:
     throw new Error(`unknown type: ${play.type}`);
  }
  return thisAmount;
}
```

Ready to Add Features

```
function statement (invoice, plays) {
  let result = `Statement for ${invoice.customer}\n`;
  for (let perf of invoice.performances) {
    result += `  ${playFor(perf).name}: ${usd(amountFor(perf))} (${perf.audience} seats)\n`;
  }
  result += `Amount owed is ${usd(totalAmount())}\n`;
  result += `You earned ${totalVolumeCredits()} credits\n`;
  return result;

function totalAmount() {
  let result = 0;
  for (let perf of invoice.performances) {
    result += amountFor(perf);
  }
  return result;
}

function totalVolumeCredits() {
  let result = 0;
  for (let perf of invoice.performances) {
    result += volumeCreditsFor(perf);
```

```
function totalVolumeCredits() {
  let result = 0;
  for (let perf of invoice.performances) {
    result += volumeCreditsFor(perf);
  }
  return result;
}

function usd(aNumber) {
  return new Intl.NumberFormat("en-US",
                  { style: "currency", currency: "USD",
                    minimumFractionDigits: 2 }).format(aNumber/100);
}

function volumeCreditsFor(aPerformance) {
  let result = 0;
  result += Math.max(aPerformance.audience - 30, 0);
  if ("comedy" === playFor(aPerformance).type) result += Math.floor(aPerformance.audience / 5);
  return result;
}

function playFor(aPerformance) {
  return plays[aPerformance.playID];
}
```

```
function amountFor(aPerformance) {
  let result = 0;
  switch (playFor(aPerformance).type) {
  case "tragedy":
    result = 40000;
    if (aPerformance.audience > 30) {
      result += 1000 * (aPerformance.audience - 30);
    }
    break;
  case "comedy":
    result = 30000;
    if (aPerformance.audience > 20) {
      result += 10000 + 500 * (aPerformance.audience - 20);
    }
    result += 300 * aPerformance.audience;
    break;
  default:
    throw new Error(`unknown type: ${playFor(aPerformance).type}`);
  }
  return result;
 }
}
```

The true test of good code is how easy it is to change it.

Code Smell

Hint that something has gone wrong somewhere in your code

http://c2.com/cgi/wiki?CodeSmell

Lists of Code Smells

Coding Horror: Code Smells

http://www.codinghorror.com/blog/2006/05/code-smells.html

Cunningham wiki c2

http://c2.com/cgi/wiki?CodeSmell

Comments

There's a fine line between comments that illuminate and comments that obscure.

Are the comments necessary?

Do they explain "why" and not "what"?

Can you refactor the code so the comments aren't required?

And remember, you're writing comments for people, not machines.

http://blog.codinghorror.com/code-smells/

Uncommunicative Name, Vague Identifier

meetsCriteria
flag

Does the name of the method succinctly describe what that method does?

Could you read the method's name to another developer and have them explain to you what it does?

If not, rename it or rewrite it.

Inconsistent Names

Pick a set of standard terminology and stick to it throughout your methods.

If you have Open(), you should probably have Close().

Type Embedded in Name

Avoid placing types in method names;

it's not only redundant, but it forces you to change the name if the type changes.

Conditional Complexity

Watch out for large conditional logic blocks

Particularly blocks that tend to grow larger or change significantly over time.

Consider alternative object-oriented approaches such as
- decorator,
- strategy, or
- state.

Dead Code

Ruthlessly delete code that isn't being used.

That's why we have source control systems!

Code Smell - Utility Method

Utility methods are a sign that related data and operations are not together

Java & OO

In many situations we can not OO in Java

Can not keep data and operations together in many of Java's existing classes

Ruby, Objective-C & Smalltalk allow you to add to existing classes

Result

Can't practice OO in small cases

Develop poor habits

Lose benefits of OO but don't noticce

One Responsibility Rule

"A class has a single responsibility: it does it all, does it well, and does it only"

Bertrand Meyer

Try to describe a class in 25 words or less, and not to use "and" or "or"

If can not do this you may have more than one class

Duplicate Code

Duplicate Code

Duplicate Code

Duplicate Code

Duplicate Code

Duplicate Code

Duplicate Code

Duplicate Code

Long Method - Large Class

The average method size should be less than 8 lines of code (LOC) for Smalltalk and 24 LOC for C++

The average number of methods per class should be less than 20

The average number of fields per class should be less than 6.

The class hierarchy nesting level should be less than 6

The average number of comment lines per method should be greater than 1

Long Parameter List

```
a.foo(12, 2, "cat", "<tr>", 19.6, x, y, classList, cutOffPoint)
```

Divergent Change

If, over time, you make changes to a class that touch completely different parts of the class, it may contain too much unrelated functionality.

Consider isolating the parts that changed in another class.

ShotGun Surgery

If a change in one class requires cascading changes in several related classes,

consider refactoring so that the changes are limited to a single class.

Middle Man

If a class is delegating all its work, why does it exist?

Cut out the middleman.

Beware classes that are merely wrappers over other classes or existing functionality in the framework.

Feature Envy

A method seems more interested in a class other than the one it is in.

Data Clumps

Same three or four data items together in lots of places

Primitive Obsession

Don't use a gaggle of primitive data type variables as a poor man's substitute for a class.

If your data type is sufficiently complex, write a class to represent it.

Money
Date
Name
Address
Phone Number

Repeated Switch Statements

How do you program without them?

Replace Conditional with Polymorphism

```
switch account {
    case BankAccount: account.foo();
    case SavingsAccount: account.bar();
    case nil: account = new CheckingAccount()
}
```

account.foobar()

foo verses bar?

nil?

Repeated Switch Statements

How do you program without them?

Replace Conditional with Polymorphism

```
switch size {
    case 1..9: small();
    case 10: middle();
    default: large();
}
```

Lazy Class

Classes should pull their weight.

Every additional class increases the complexity of a project.

If you have a class that isn't doing enough to pay for itself,
can it be collapsed or combined into another class?

Data Class

Class with just fields and setter/getter methods

Data classes are like children.

They are okay as a starting point, but to participate as a grownup object, they need to take some responsibility

Inappropriate Intimacy

Watch out for classes that spend too much time together,
or classes that interface in inappropriate ways.

Classes should know as little as possible about each other.

Message Chains

```
location = rat.getRoom().getMaze().getLocation()
```

Negative Slope

```
if (foo) {
   if (bar) {
      if (cat = dog) {
         if (rat < 10) {
            ...
```

Temporary Field

Field is only used in certain circumstances

Common case

- field is only used by an algorithm
- Don't want to pass around long parameter list
- Make parameter a field

Refused Bequest

Subclass does not want to support all the methods of parent class

Subclass should support the interface of the parent class

Solution Sprawl

If it takes five classes to do anything useful, you might have solution sprawl.

Consider simplifying and consolidating your design.

Loops

Replace Loop with Pipeline

- Map
- Reduce
- Filter

Easier to see what is being processed

```
for (int k = 0; k++; k <= items.size() ) {
    sum = 0;
    if (items[k] > 10) {
        sum = sum + 2*items[k] -3;
    }
}
```

```
items.
    filter( item -> item > 10).
    map( item -> 2 * item -2).
    sum()
```

Mutable Data

Changes to data can often lead to unexpected consequences and tricky bugs

Swift

```
var a = [1, 2, 3]    // mutable
let b = [1, 2, 3]    // immutable
```

Kotlin

```
var a = [1, 2, 3]    // mutable
val b = [1, 2, 3]    // immutable
```

Mutable Data

Encapsulate Variable

All updates occur through narrow functions

Extract Function

Separate the side-effect-free code from anything that performs the update

Separate Query from Modifier

Ensure callers don’t need to call code with side effects unless they really need to.

Combine Functions into Class

Combine Functions into Transform

Limit how much code needs to update a variable

Change Reference to Value

Replace the entire structure rather than modify it

Refactoring

Refactoring

Changing the internal structure of software that changes its observable behavior

Done to make the software easier to understand and easier to modify

Brief History of Refactoring

UIUC

Opdyke, Refactoring Object-Oriented Frameworks, Ph.D. 1992

Brant & Roberts, Refactoring Browser, mid- to late 1990s

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

Refactoring: Improving the Design of Existing Code 2nd,

Martin Fowler, Nov 2, 2018

When to Refactor

Rule of three

Three strikes and you refactor

When to Refactor

When you add a new function
When you need to fix a bug
When you do a code review

When Refactoring is Hard

Databases

Changing published interfaces

Major design issues

When you add a feature to a program

If needed Refactor the program to make it easy to add the feature

Then add the feature

Before you start refactoring

Make sure that you have a solid suite of tests

Test should be self-checking

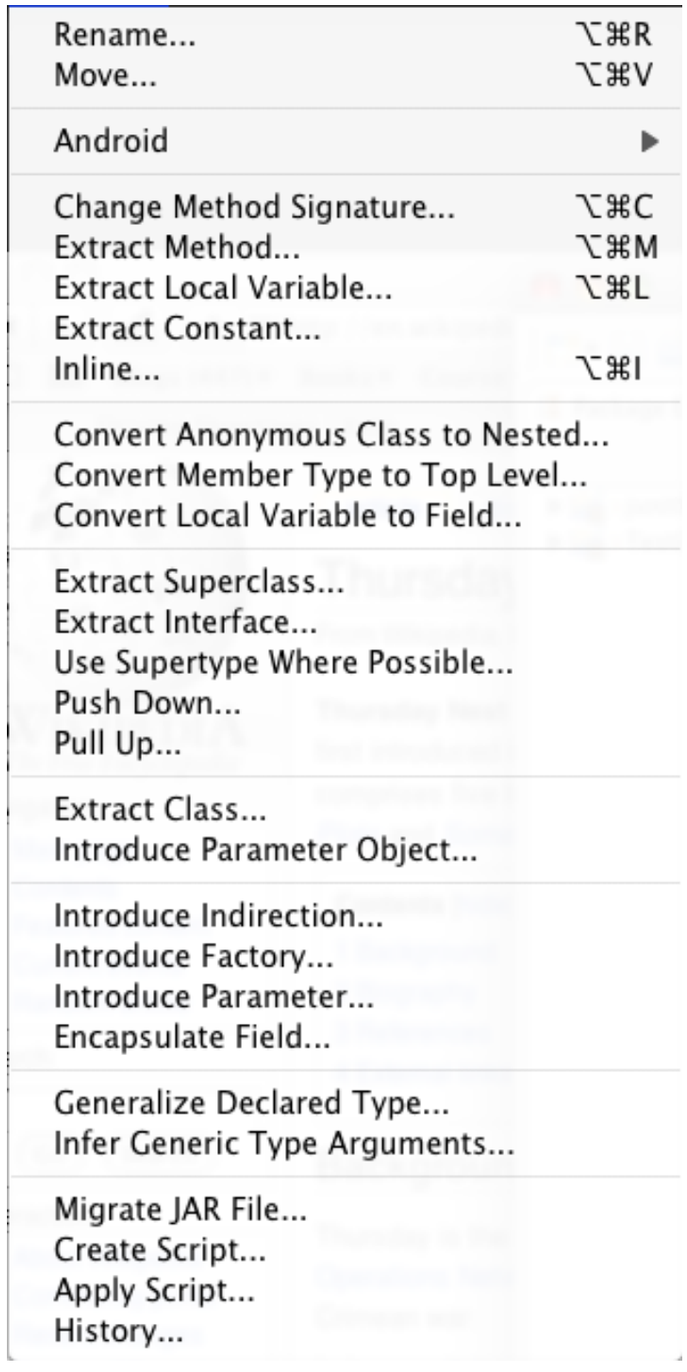
Do I need tests when I use my IDEs refactoring tools?

Are your IDE refactoring tools bug free?

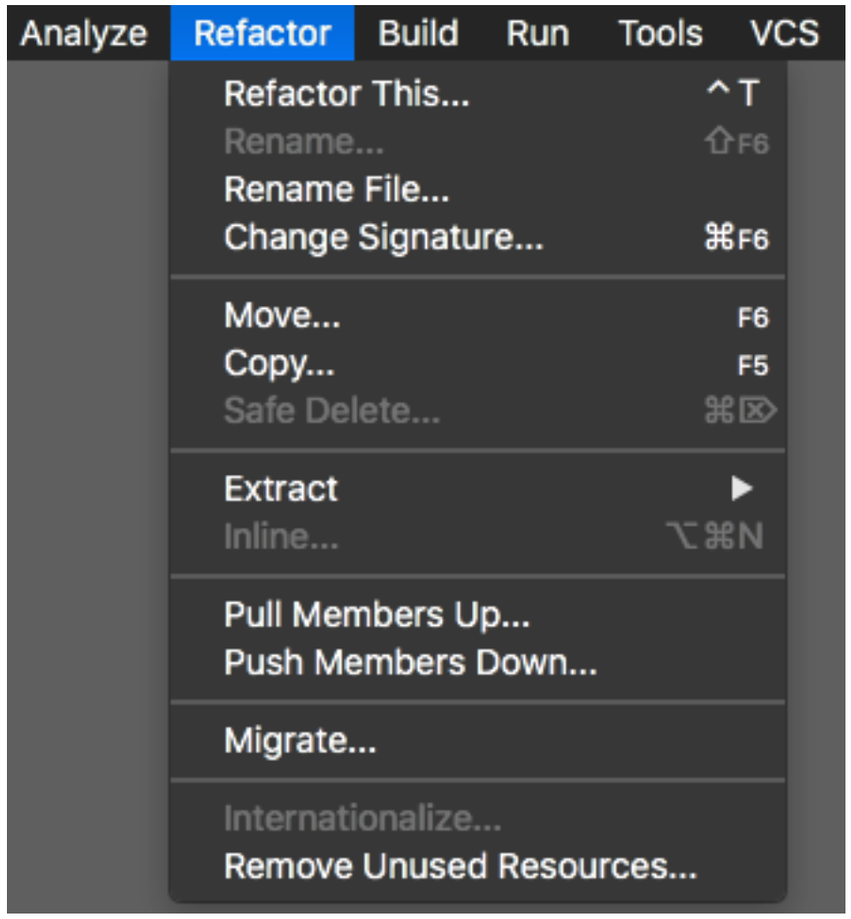
Refactoring in IDE

Refactoring Menu

Eclipse



Intellij



Rename Class

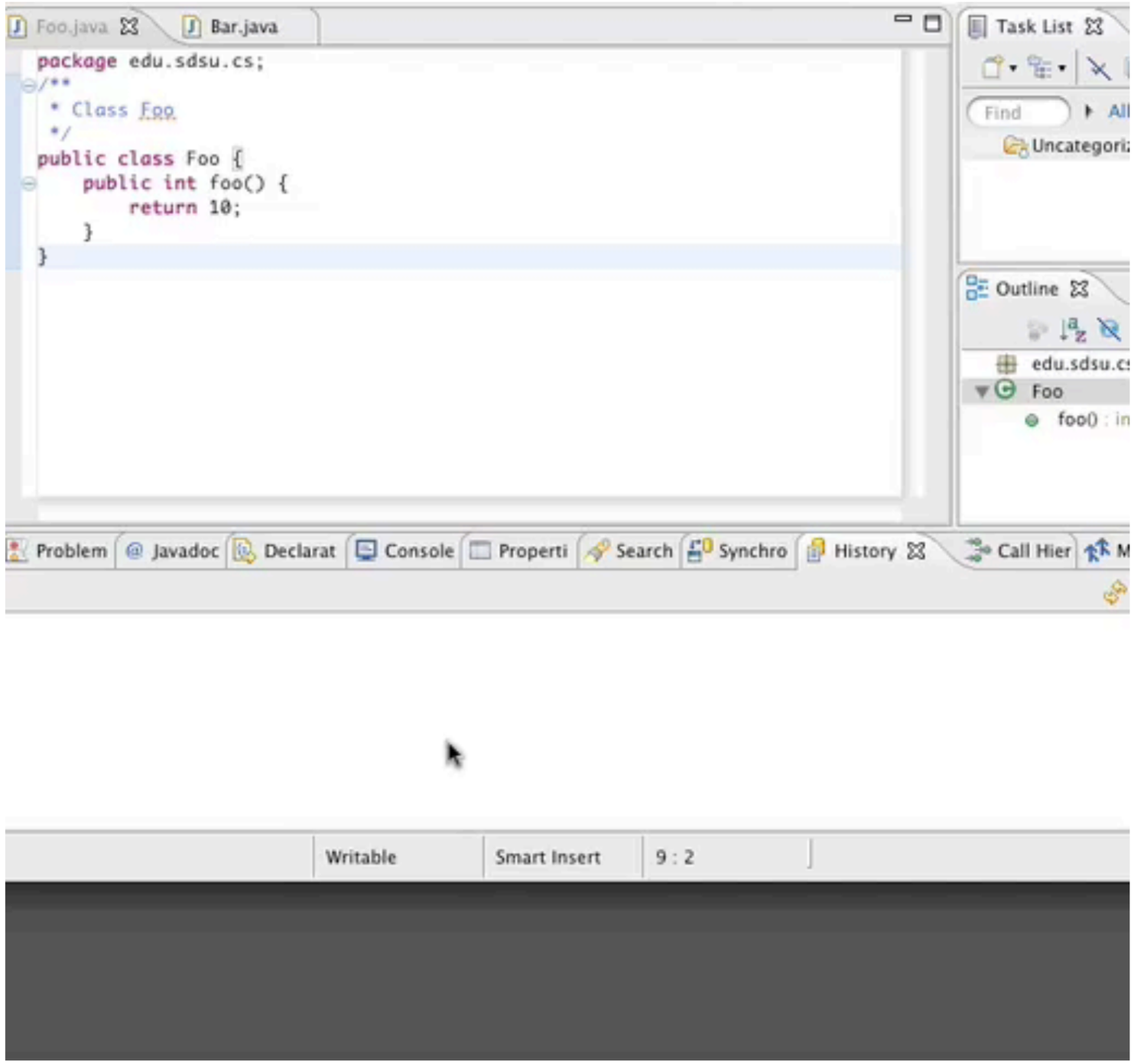
```
public class Foo {
        public int foo() {
            return 10;
    }
}
```

```
public class NewFoo {
        public int foo() {
            return 10;
    }
}
```

```
public class Bar {
    public int bar() {
        Foo test = new Foo();
        return test.foo() + 99;
    }
}
```

```
public class Bar {
    public int bar() {
        NewFoo test = new NewFoo();
        return test.foo() + 99;
    }
}
```

Eclipse Rename



Move

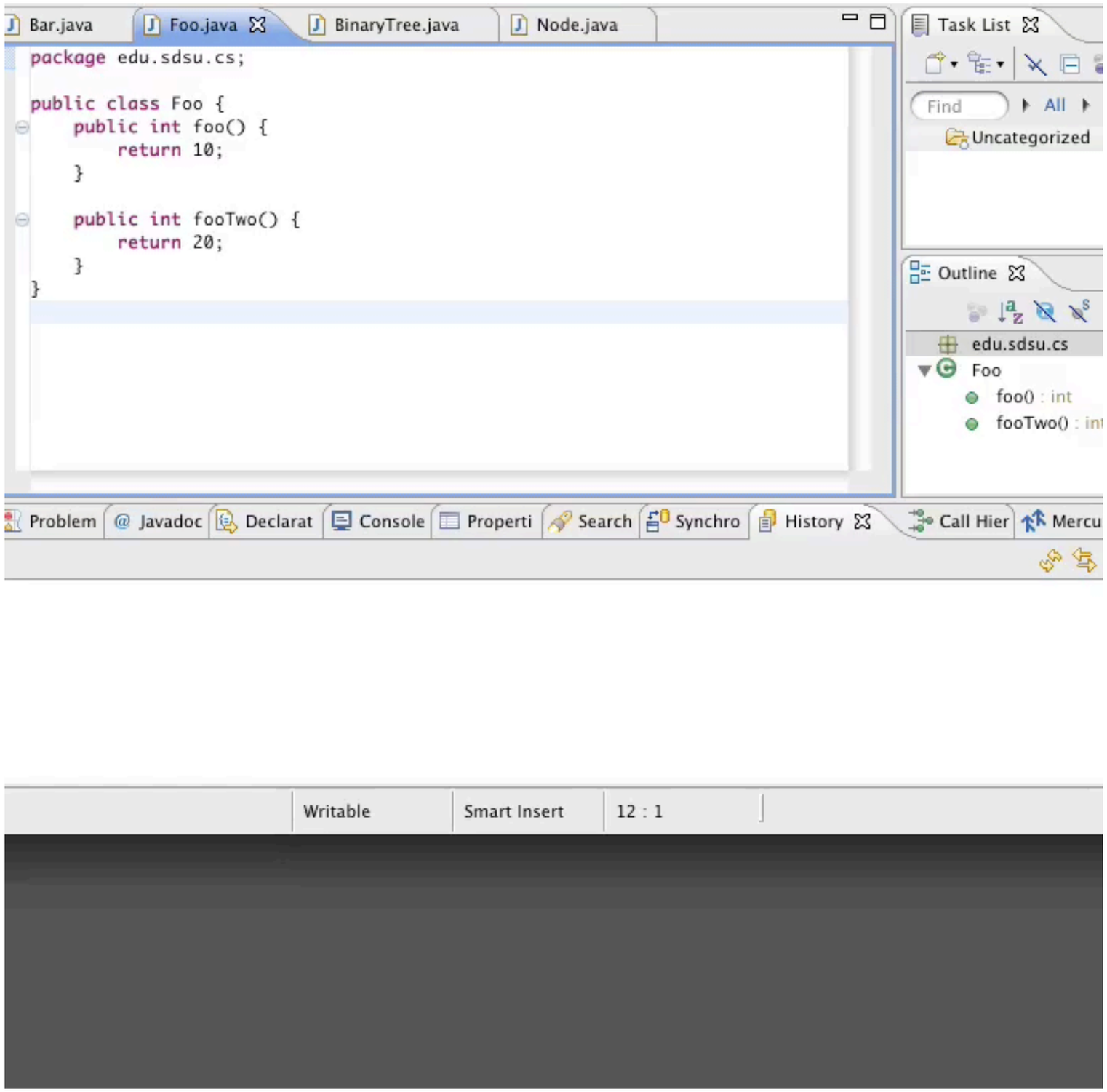
```
public class Bar {
   public int helperMethod(Foo test) {
      return test.foo() + test.fooTwo();
   }

   public int callHelper() {
      Foo data = new Foo();
      return helperMethod(data);
   }
}
```

```
public class Foo {
   public int foo() { return 10;}

   public int fooTwo() { return 20; }
}
```

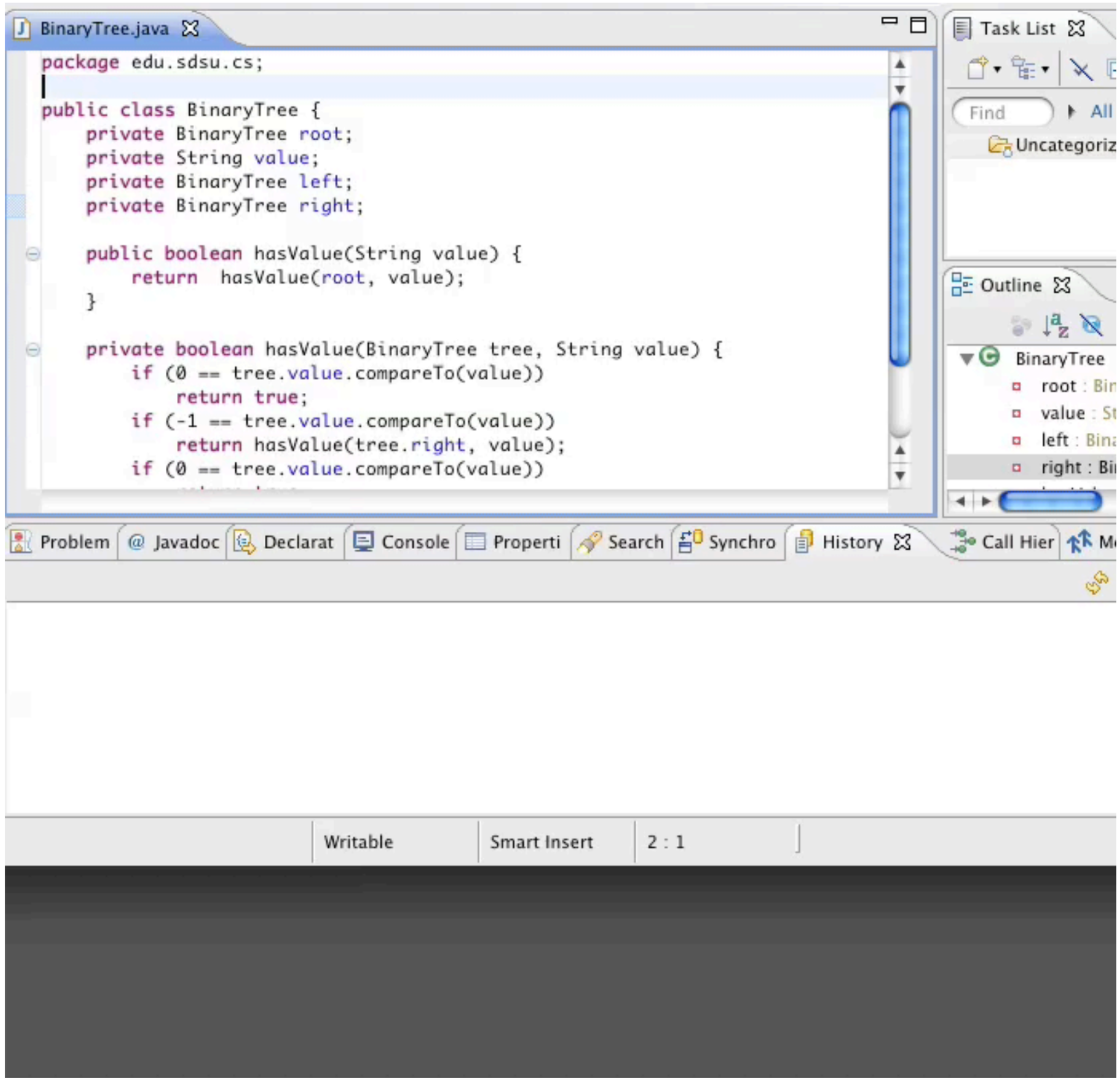
```
public class Bar {
   public int callHelper() {
      Foo data = new Foo();
      return data.sum();
   }
}
```

```
public class Foo {
   public int foo() { return 10;}

   public int fooTwo() {return 20; }

   public int sum() {
      return foo() + fooTwo();
   }
}
```

Eclipse Move



Extract Class



Refactoring Tool Issue

People tend to only use the features they know

Refactoring Tool Issue

Is a tool hard to use because I am unfamiliar with it or is it just hard to use

Refactoring by 41 Professional Programmers

	Number of Programmers used Refactoring	Total Times used
IntroduceFactory	1	1
PushDown	1	1
UseSupertype	1	6
EncapsulateField	2	5
Introduce Parameter	3	25
Convert Local to Field	5	37
Extract Interface	10	26
Inline	11	185
Modify Parameters	11	79
Pull up	11	37
Extract Method	20	344
Move	24	212
Rename	41	2396

Try In You IDE

Rename
Move
Encapsulate Field
Extract Method
Extract Class

Unit Testing

Testing

Johnson's Law

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

Unit Testing

Tests individual code segments

Automated tests

What wrong with:

Using print statements

Writing driver program in main

Writing small sample programs to run code

Running program and testing it be using it

We have a QA Team, so why should I write tests?

When to Write Tests

First write the tests

Then write the code to be tested

Writing tests first saves time

Makes you clear of the interface & functionality of the code

Removes temptation to skip tests

What to Test

Everything that could possibly break

Test values

- Inside valid range
- Outside valid range
- On the boundary between valid/invalid

GUIs are very hard to test

- Keep GUI layer very thin
- Unit test program behind the GUI, not the GUI

Common Things Programs Handle Incorrectly

Adapted with permission from “A Short Catalog of Test Ideas” by Brian Marick,

http://www.testing.com/writings.html

Strings

Empty String

Collections

Empty Collection

Collection with one element

Collection with duplicate elements

Collections with maximum possible size

Numbers

Zero

The smallest number

Just below the smallest number

The largest number

Just above the largest number

XUnit

Free frameworks for Unit testing

SUnit originally written by Kent Beck 1994

JUnit written by Kent Beck & Erich Gamma

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

Ports to many languages at:

http://www.xprogramming.com/software.htm

JUnit Versions

3.x
Old version
Works with a versions of Java

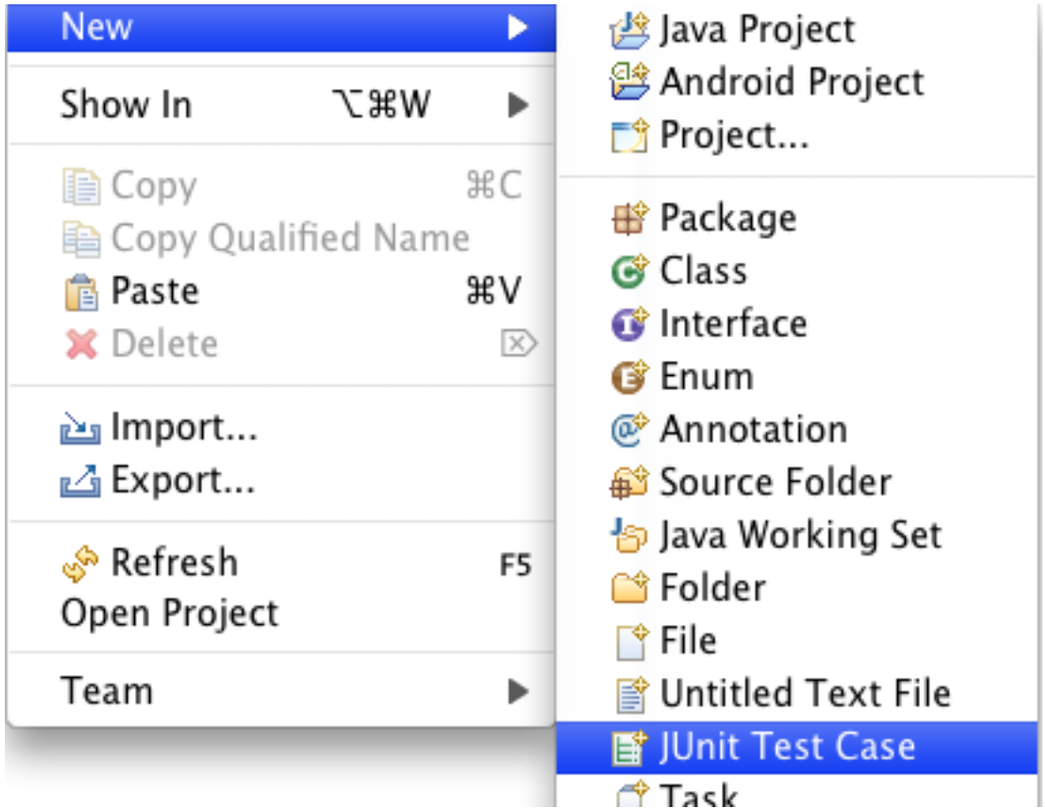
4.x
Uses Annotations
Requires Java 5 or later

5.x
Supports Java 8 and later

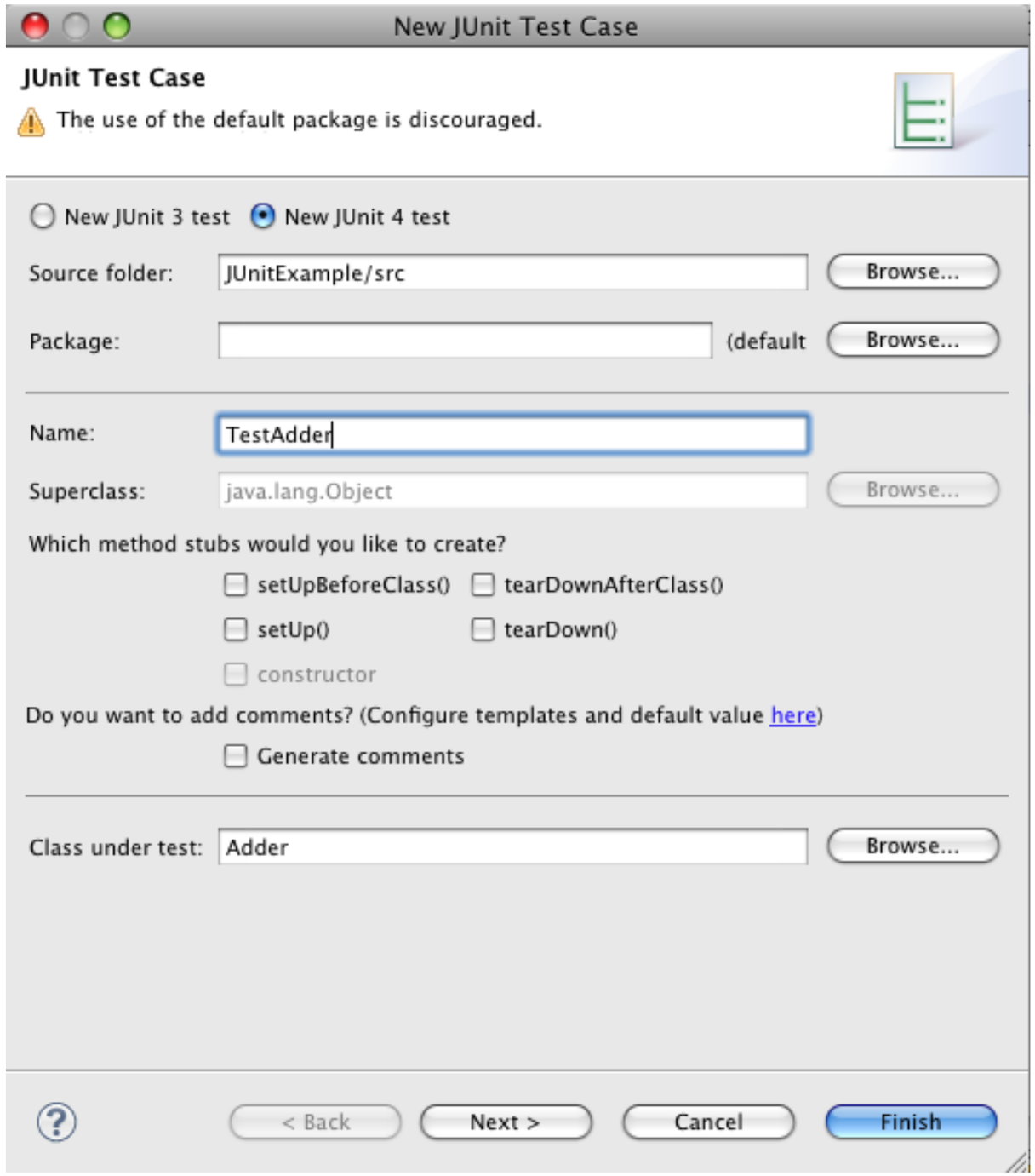
Simple Class to Test

```
public class Adder {
    private int base;
    public Adder(int value) {
        base = value;
    }

    public int add(int amount) {
        return base + amount;
    }
}
```

Creating Test Case in Eclipse



Creating Test Case in Eclipse



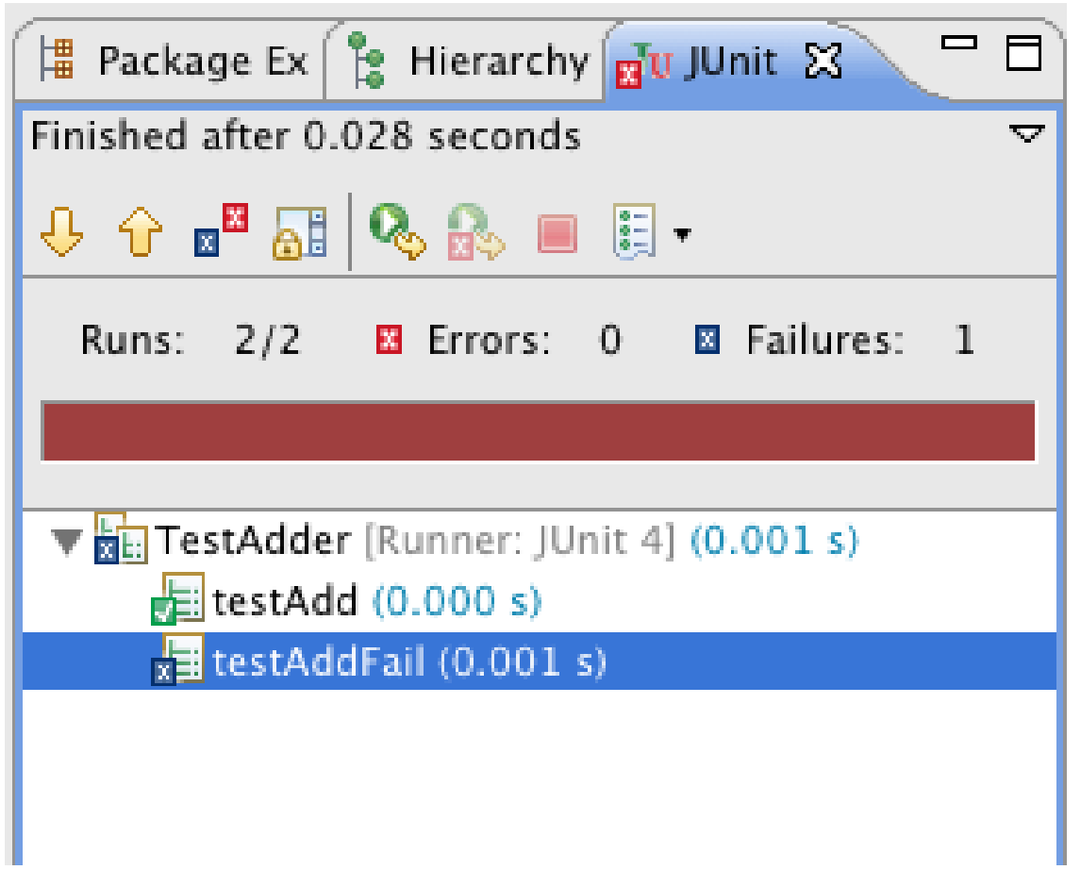
Fill in dialog window & create the test cases

Test Class

```
import static org.junit.Assert.assertEquals;
import static org.junit.Assert.assertTrue;
import org.junit.Test;

public class TestAdder {

    @Test
    public void testAdd() {
        Adder example = new Adder(3);
        assertEquals(4, example.add(1));
    }

    @Test
    public void testAddFail() {
        Adder example = new Adder(3);
        assertTrue(3 == example.add(1));
    }
}
```

Running the Tests

The result


Package Ex
Hierarchy
JUnit
Finished after 0.028 seconds
Runs: 2/2
Errors: 0
Failures: 1
TestAdder [Runner: JUnit 4] (0.001 s)
testAdd (0.000 s)
testAddFail (0.001 s)

Assert Methods

assertArrayEquals()
assertTrue()
assertFalse()
assertEquals()
assertNotEquals()
assertSame()
assertNotSame()
assertNull()
assertNotNull()
fail()

Annotations

After
AfterClass
Before
BeforeClass
Ignore
Rule
Test

Using Before

```
import static org.junit.Assert.assertEquals;
import static org.junit.Assert.assertTrue;

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

public class TestAdder {
   Adder example;
   @Before
   public void setupExample() {
      example = new Adder(3);
   }

   @Test
   public void testAdd() {
      assertEquals(4, example.add(1));
   }
}
```