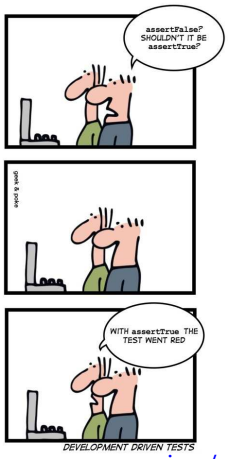


Unit Testing and TDD

www.cs.uoi.gr/~zarras/http://www.cs.uoi.gr/~zarras/se.htm

Slides material sources:

SWEBOK v3: IEEE Software Engineering Body of Knowledge

Working Effectively with Legacy Code, M. Feathers

Software Testing – A Craftsman's Approach, P Jorgensen

What is software testing?

Software testing

Testing is the act of exercising software with **test cases**.

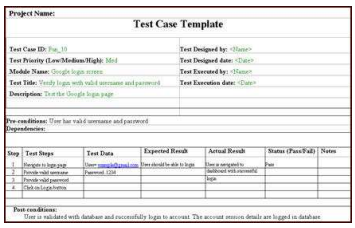
A test has two distinct goals:

To find failures (**verification** aspect).

To demonstrate correct execution (**validation** aspect).

What is a test case?

Test cases



Project Name:

Test Case Template

Test Case ID: Test_10	Test Designed by: <Name>
Test Priority (Low/Medium/High): Med	Test Designed date: <Date>
Module Name: Google login screen	Test Executed by: <Name>
Test Title: Verify login with valid username and password	Test Execution date: <Date>
Description: Test the Google login page	

Pre-conditions: User has valid username and password

Dependencies:

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1	Navigate to login page	User:	User should be able to login	User is navigated to	Pass	
2	Provide valid username	Password: 1234		dashboard with successful		
3	Provide valid password			login		
4	Click on Login button					

Post-conditions:
User is validated with database and successfully login to account. The account session details are logged in database

The essence of software testing is to determine a set of test cases for the item to be tested.

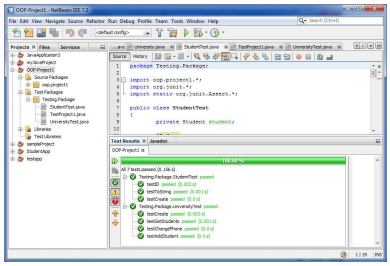
A **test case** is (or should be) a recognized work product.

A **complete test case** will contain a test case identifier, a brief statement of purpose, a description of preconditions, the actual test case inputs, the expected outputs, a description of expected post-conditions, and an execution history.

The execution **history** is primarily for test management use—it may contain the date when the test was run, the person who ran it, the version on which it was run, and the pass/fail result.

What is unit testing?

Unit testing



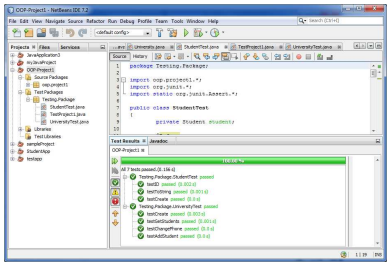
Common to most conceptions of unit tests is the idea that they are **tests in isolation** of individual components of software.

What are components?

- In unit testing, we are usually concerned with the most atomic behavioral units of a system.
- In procedural code, the units are often functions.
- In object oriented code, the units are classes.

Test harness *is a generic term for the testing code that we* write to exercise some piece of software and the code that is needed to run it.

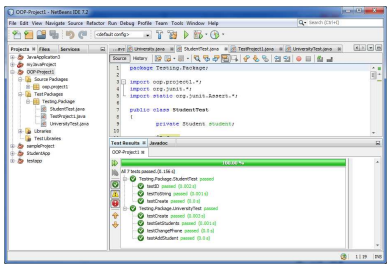
Unit testing



Testing in isolation is an important part of the definition of a unit test, but **why is it important**?

- **Error localization**
  - As tests get further from what they test, it is harder to determine what a test failure means.
  - Often it takes considerable work to pinpoint the source of a test failure.
- **Execution time**
  - Larger tests tend to take longer to execute.
  - This tends to make test runs rather frustrating.
  - Tests that take too long to run end up not being run.

Unit testing



Here are qualities of **good unit tests**:

- They run fast.
  - If they don't run fast, they aren't unit tests.
- They help us localize problems.

A test is **not a unit test** if during execution the tested software:

- talks to a database.
- communicates across a network.
- You have to do special things to your environment (such as editing configuration files) to run it.**....**

A unit test that takes 1/10th of a second to run is a slow unit test !!!

Unit testing

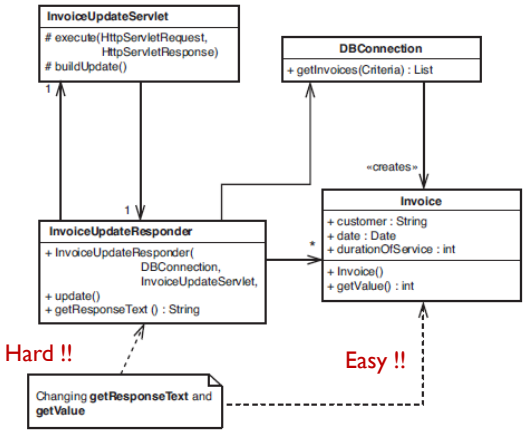
To **put unit tests in place**, we often have to **change code** !!

Why ??

Dependency is one of the most critical problems in software development.

Often, classes depend directly on things that are hard to use in a test, they are hard to modify and hard to access.

Unit testing

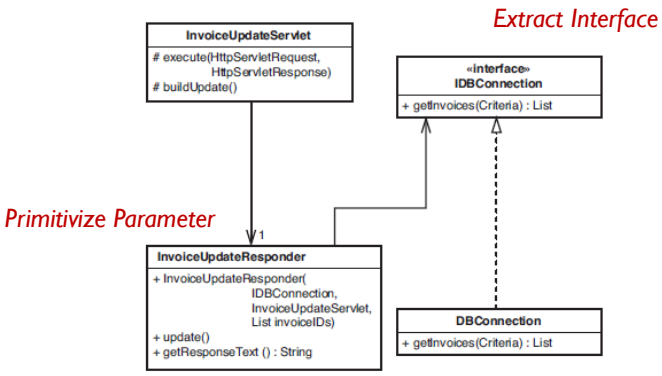


Reasons for breaking dependencies

When we want to get tests in place, there are two reasons to break dependencies:

- **Separation -** We break dependencies to *separate from* ***"other code"*** *when we can't get* this other code into a test harness to run.
- **Sensing -** We break dependencies to some ***"other code"*** *when* that code is the only place we can sense the effects of our actions but *we can't easily access the state of the other code.*

Unit testing



Faking collaborators

Breaking dependencies on **other code** is hardly ever that simple.

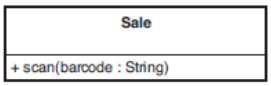
A useful technique is to substitute the *"other code"* upon which we depend with some "fake" code that is easy to instantiate and access .

A fake object is an object that impersonates some collaborator of a class when it is being tested.

- In object orientation, these other pieces of code are often called **fake objects**.
  - ***Stub*** *is another way to call these elements*

Faking collaborators

In a point-of-sale system, we have a class called Sale. Whenever scan() is called, the Sale object needs to display the name of the item that was scanned, along with its price on a cash register display.



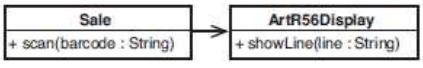
How can we test this to see if the right text shows up on the display?

If the calls to the cash register's **display API are buried** deep in the Sale class, it's going to be hard.

Faking collaborators

We can move all of the display code form Sale over to ArtR56Display and have a system that does exactly the same thing that it did before.

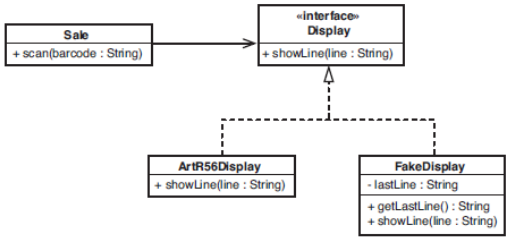
Does that get us anything?



Faking collaborators

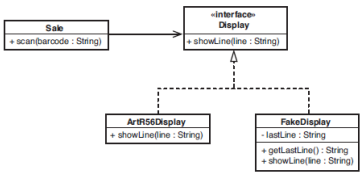
The Sale class can now hold on to either an ArtR56Display or something else, a FakeDisplay.

The nice thing **about having a fake display** is that we can write tests against it **to find out what the Sale does.**



Faking collaborators

Class being tested




```
public interface Display
{
    void showLine(String line);
}
```

```
public class Sale
{
    private Display display;

    public Sale(Display display) {
        this.display = display;
    }

    public void scan(String barcode) {
        ...
        String itemLine = item.name()
                + " " + item.price().asDisplayText();
        display.showLine(itemLine);
        ...
    }
}
```

```
public class FakeDisplay implements Display
{
    private String lastLine = "";

    public void showLine(String line) {
        lastLine = line;
    }

    public String getLastLine() {
        return lastLine;
    }
}
```

Test stub / fake class

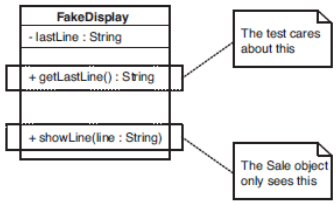
```
import junit.framework.*;

public class SaleTest extends TestCase
{
    public void testDisplayAnItem() {
        FakeDisplay display = new FakeDisplay();
        Sale sale = new Sale(display);

        sale.scan("1");
        assertEquals("Milk $3.99", display.getLastLine());
    }
}
```

Test driver

Faking collaborators



Fake objects can be confusing in a way...

One of the oddest things about them is that they have **two sides.**

Faking collaborators

```
public class SaleTest extends TestCase
{
    public void testDisplayAnItem() {
        MockDisplay display = new MockDisplay();
        display.setExpectation("showLine", "Milk $3.99");
        Sale sale = new Sale(display);
        sale.scan("1");
        display.verify();
    }
}
```

A more advanced type of fake is called a ***mock object***.

Mock objects are fakes that perform assertions internally

i.e., we tell them what calls to expect, and then we tell them to check and see if they received those calls.

How do we create test cases?

Ad-hoc testing

Perhaps the most widely practiced technique **is ad hoc testing**:

Tests are derived relying on the software engineer's skill, intuition, and experience with similar programs.

Ad hoc testing can be useful for identifying tests cases that not easily generated by more formalized techniques.

Input domain based techniques

Two widely know categories are:

- Boundary value testing techniques.
- Equivalence class testing techniques.

Code based techniques

Two widely know categories are:

- Control flow testing techniques.
- Data flow testing techniques.

Test-driven development

Test-driven development activities:

1. Write a failing test case.
2. Get it to compile.
3. Make it pass.
4. Remove duplication.
5. Repeat.

Test-driven development

Suppose we're working on a financial application, and we need a class that is going to use some statistic mathematics to verify whether certain commodities should be traded.

The class must have a method that calculates something called the first statistical moment about a point.

We know the math, so we know that the answer should be -0.5 for the data series we code in the test.

Test-driven development

```
public void testFirstMoment() {
    InstrumentCalculator calculator = new InstrumentCalculator();
    calculator.addElement(1.0);
    calculator.addElement(2.0);

    assertEquals(-0.5, calculator.firstMomentAbout(2.0), TOLERANCE);
}
```

Write a Failing Test Case

```
public class InstrumentCalculator
{
    double firstMomentAbout(double point) {
        return Double.NaN;
    }
    ...
}
```

Get It to Compile

```
public double firstMomentAbout(double point) {
    double numerator = 0.0;
    for (Iterator it = elements.iterator(); it.hasNext(); ) {
        double element = ((Double)(it.next())).doubleValue();
        numerator += element - point;
    }
    return numerator / elements.size();
}
```

Make It Pass

Test driven development

A additional feature: firstMomentAbout() must throw an exception when the elements list is empty

```
public void testFirstMoment() {
    try {
        new InstrumentCalculator().firstMomentAbout(0.0);
        fail("expected InvalidBasisException");
    }

    catch (InvalidBasisException e) {
    }
}
```

Write a Failing Test Case

```
public double firstMomentAbout(double point)
            throws InvalidBasisException  {

    if (element.size() == 0)
        throw new InvalidBasisException("no elements");

    double numerator = 0.0;
    for (Iterator it = elements.iterator(); it.hasNext(); ) {
        double element = ((Double)(it.next())).doubleValue();
        numerator += element - point;
    }
    return numerator / elements.size();
}
```

Get It to Compile

Make It Pass

Test-driven development

The class must have another method that calculates something called the second statistical moment about a point.

```
public void testSecondMoment() throws Exception {
    InstrumentCalculator calculator = new InstrumentCalculator();
    calculator.addElement(1.0);
    calculator.addElement(2.0);

    assertEquals(0.5, calculator.secondMomentAbout(2.0), TOLERANCE);
}
```

Write a Failing Test Case

Test-driven development

```
public void testSecondMoment() throws Exception {
    InstrumentCalculator calculator = new InstrumentCalculator();
    calculator.addElement(1.0);
    calculator.addElement(2.0);

    assertEquals(0.5, calculator.secondMomentAbout(2.0), TOLERANCE);
}
```

Write a Failing Test Case

```
public double secondMomentAbout(double point)
        throws InvalidBasisException {

    if (elements.size() == 0)
        throw new InvalidBasisException("no elements");

    double numerator = 0.0;
    for (Iterator it = elements.iterator(); it.hasNext(); ) {
        double element = ((Double)(it.next())).doubleValue();
        numerator += element - point;
    }
    return numerator / elements.size();
}
```

Get It to Compile

To make it compile, we can make a copy of the firstMomentAbout method and rename it so that it is now called secondMomentAbout

Test-driven development

```
public double secondMomentAbout(double point)
        throws InvalidBasisException {

    if (elements.size() == 0)
        throw new InvalidBasisException("no elements");

    double numerator = 0.0;
    for (Iterator it = elements.iterator(); it.hasNext(); ) {
        double element = ((Double)(it.next())).doubleValue();
        numerator += Math.pow(element - point, 2.0);
    }
    return numerator / elements.size();
}
```

Make It Pass

Test-driven development

```
public double firstMomentAbout(double point)
        throws InvalidBasisException {
    return nthMomentAbout(point, 1.0);
}
public double secondMomentAbout(double point)
        throws InvalidBasisException {
    return nthMomentAbout(point, 2.0);
}

private double nthMomentAbout(double point, double n)
        throws InvalidBasisException {

    if (elements.size() == 0)
        throw new InvalidBasisException("no elements");

    double numerator = 0.0;
    for (Iterator it = elements.iterator(); it.hasNext(); ) {
        double element = ((Double)(it.next())).doubleValue();
        numerator += Math.pow(element - point, n);
    }
    return numerator / elements.size();
}
```

Remove Duplication