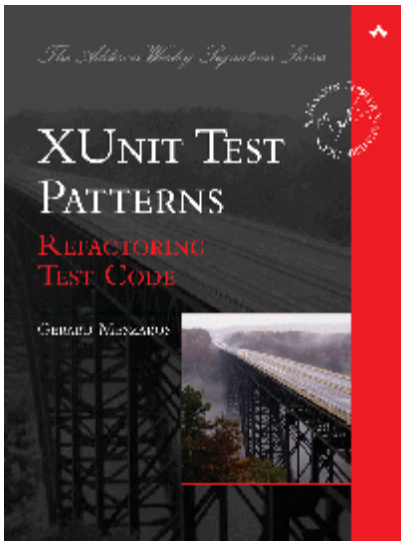
xUnit Test Patterns and Smells

Refactoring Test Code to Improve ROI

or:

Clean Code 99 – Test Code



Gerard Meszaros
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http://www.xunitpatterns.com

My Background

- Software developer
- Development manager
- Project Manager
- Software architect
- OOA/OOD Mentor

Embedded Telecom

- XP/TDD Mentor
- Agile PM Mentor

I.T.

- Test Automation Consultant
- Lean/Agile Coach/Consultant

Gerard Meszaros
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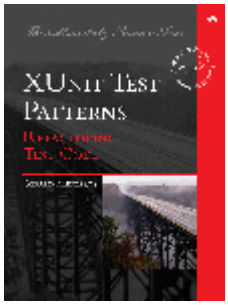
Original Motivation

- **Started writing automated unit tests in 1996**
  - Smalltalk plus homebuilt unit test framework
- **Started doing formal XP in 2000 right after 1st XP book came out**
- **Ran into cost of change problem with our tests**
  - Up to 90% of effort was in changing tests
- **Many teams I've visited have exhibited similar problems**
  - Poorly written tests made automated unit testing scale poorly.

Material Background

- **Started with 2 days onsite training**
  - Java & JUnit
- **Captured as draft of book**
  - http://xunitPatterns.com
- **Fine-tuned through**
  - many years of practice
  - and delivery as half-day tutorial
- **Published as book in 2007**
- **Continues to evolve**
  - Understanding increases
  - Onsite training 2 -> 3 days, C#, C++
  - Tutorial ½ -> ¼ day



Objectives of this Talk

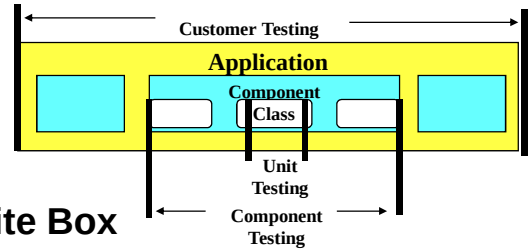
- Understand why maintainability of test code is important
- Be aware of Test Smells as symptoms of issues in your test code.
- Be aware of test design patterns that can address or prevent these issues

Agenda

- Introduction
- Economics of Maintainability
- Intro to Test Smells & Patterns
- Refactoring Smelly Test Code
- Writing New Tests Quickly
- Wrap Up

Terminology

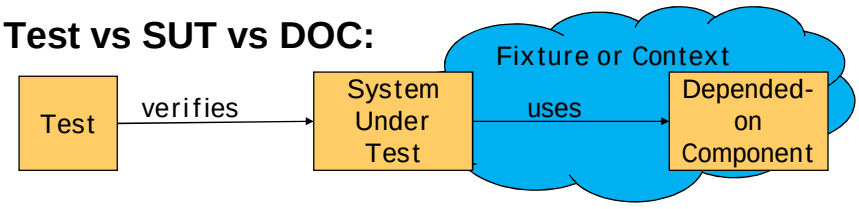
- **Unit vs Component vs Customer Testing**



- **Black Box vs White Box**
  - Black box: know what it should do
  - White box: know how it is built inside
- **Even Unit Tests should be black box.**

Terminology

- **Test vs SUT vs DOC:**



- **Test vs. Spec. vs. Example**
  - Doesn't matter what you call them,
  - same smells and patterns apply!

What Does it Take To be Successful?

Programming Experience

+ xUnit Experience

+ Testing experience

Robust Automated Tests

Why We Automate Unit Tests

- **Self-Testing Code helps us:**
  - Produce better quality software
  - Produce the right software
  - Work faster
  - Respond to change (agility)
- **It does this by:**
  - Providing focus
  - Providing rapid feedback
  - Reducing stress levels (anxiety) by making changes safer

Requires writing tests *before* code (TDD)

A Sobering Thought

Expect to have just as much test code as production code!

The Challenge: How To Prevent Doubling Cost of Software Maintenance?

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Why is Test Maintainablity so Crucial?

- **Tests need to be maintained along with rest of the software.**
- **Testware must be much easier to maintain than production software, otherwise:**
  - It will slow you down
  - It will get left behind
  - Value drops to zero
  - You'll go back to manual testing

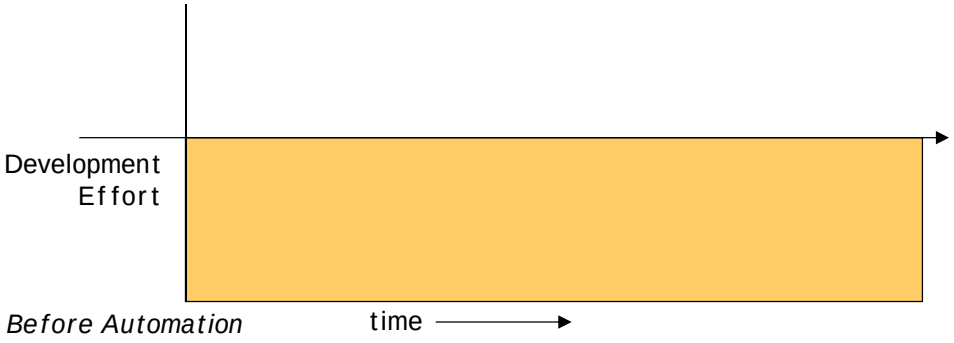
Critical Success Factor:

Writing tests in a maintainable style

Economics of Maintainability

Test Automation is a lot easier to sell on

- **Cost reduction than**
- **Software Quality Improvement or**
- **Quality of Life Improvement**



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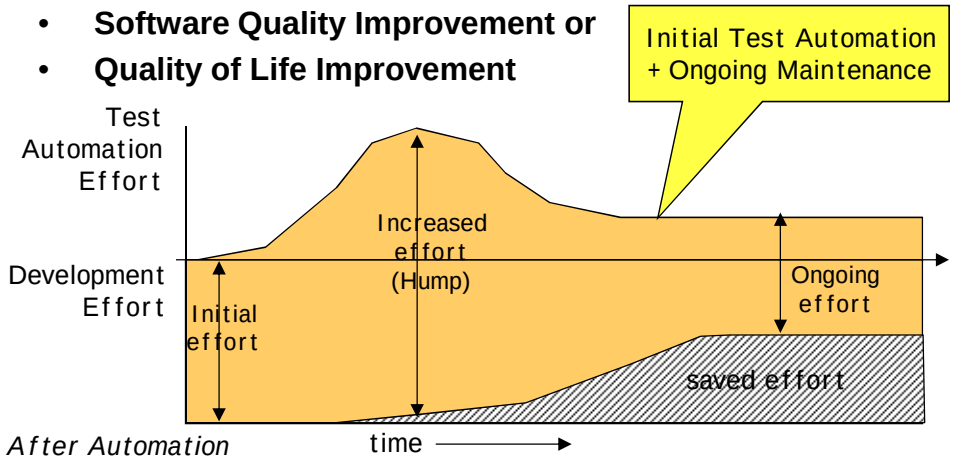

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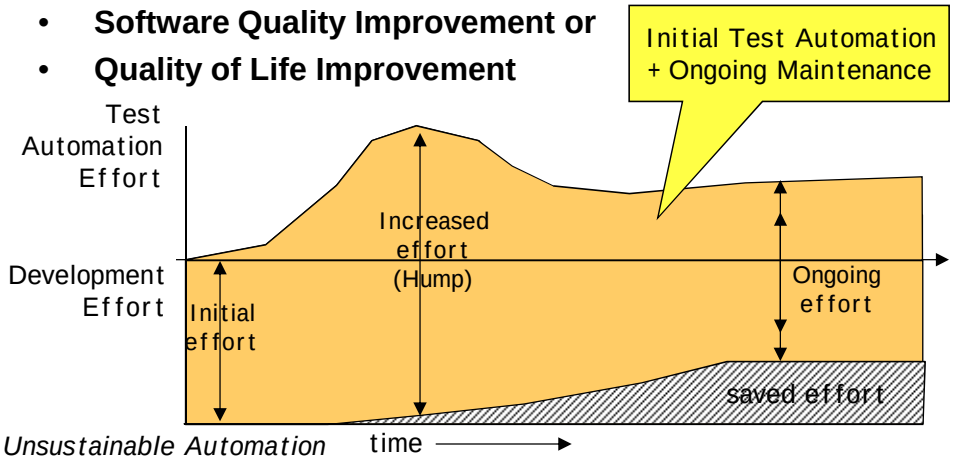

Goals of Automated Developer Tests

- **Before code is written**
  - Tests as Specification
- **After code is written**
  - Tests as Documentation
  - Tests as Safety Net (Bug Repellent)
  - Defect Triangulation (Minimize Debugging)
- **Minimize Cost of Running Tests**
  - Fully Automated Tests
  - Repeatable Tests
  - Robust Tests

Requires writing tests *before* code (TDD)

Agenda

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- **Economics of Maintainability**
- **Intro to Test Smells & Patterns**
- **Refactoring Smelly Test Code**
- **Writing New Tests Quickly**
- **Wrap Up**

What's a "Smell"?

- **A set of symptoms of an underlying problem in code**
- **Introduced by Martin Fowler in:**
  - Refactoring – Improving the Design of Existing Code
  - Term originally attributed to Kent Beck

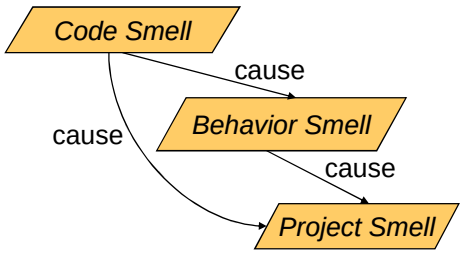
The "Sniff Test":

- **A smell should be obvious**
  - It should "grab you by the nose"
- **Not necessarily the actual cause**
  - There may be many possible causes for the symptom
  - Some root causes may contribute to several different smells

Note: Past literature often labels the cause as a smell.
e.g. "Sensitive Equality" is really a cause of "Fragile Test"

Kinds of Test Smells

- **Three common kinds of Test Smells:**
  - Code Smells – Visible Problems in Test Code
  - Behavior Smells – Tests Behaving Badly
  - Project Smells – Testing-related problems visible to a Project Manager
- **Code Smells may be root cause of Behavior and Project Smells**



What's a "Test Pattern"?

- **A "test pattern" is a recurring solution to a test automation problem**
  - E.g. A "Mock Object" solves the problem of verifying the behavior of an object that should delegate behavior to other objects
- **Invented in parallel by many people**

Test Patterns occur at many levels:

- **Test Automation Strategy Patterns**
  - Recorded Test vs Scripted Test
- **Test Design Patterns**
  - Implicit SetUp vs Delegated SetUp
- **Test Coding Patterns**
  - Assertion Method, Creation Method
- **Language-specific Test Coding Idioms**
  - E.g. Expected Exception Test
    - » **Try/Catch**
    - » **AssertThrows aBlock, expectedEx**
    - » **ExpectedException attribute/annotation**

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What's a Code Smell?

A problem visible when looking at test code:

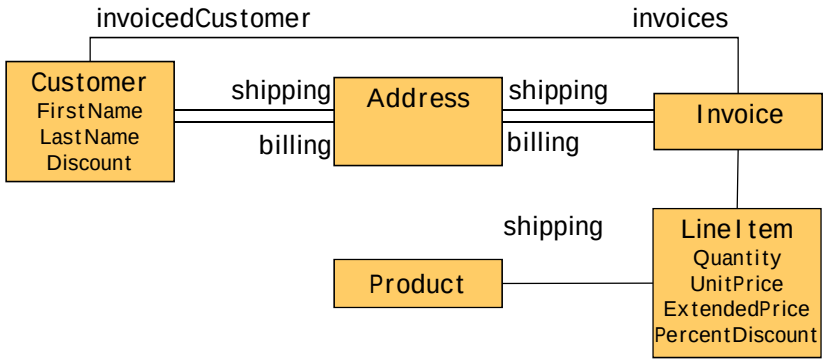
- **Tests are hard to understand**
- **Tests contain coding errors that may result in**
  - Missed bugs
  - Erratic Tests
- **Tests are difficult or impossible to write**
  - No test API on SUT
  - Cannot control initial state of SUT
  - Cannot observe final state of SUT
- **Sniff Test:**
  - Problem must be visible (in their face) to test automater or test reader

Common Code Smells

- **Conditional Test Logic**
- **Hard to Test Code**
- **Obscure Test**
- **Test Code Duplication**
- **Test Logic in Production**

Example

- **Test addItemQuantity and removeLineItem methods of Invoice**



The Whole Test

```
public void testAddItemQuantity_severalQuantity() throws Exception {
  try {
     // Setup Fixture
     final int QUANTITY = 5;
     Address billingAddress = new Address("1222 1st St SW", "Calgary", "Alberta", "T2N
           2V2", "Canada");
     Address shippingAddress = new Address("1333 1st St SW", "Calgary", "Alberta", "T2N
           2V2", "Canada");
     Customer customer = new Customer(99, "John", "Doe", new BigDecimal("30"),
           billingAddress, shippingAddress);
     Product product = new Product(88, "SomeWidget", new BigDecimal("19.99"));
     Invoice invoice = new Invoice(customer);
     // Exercise SUT
     invoice.addItemQuantity(product, QUANTITY);
     // Verify Outcome
     List lineItems = invoice.getLineItems();
     if (lineItems.size() == 1) {
       LineItem actualLineItem = (LineItem)lineItems.get(0);
       assertEquals(invoice, actualLineItem.getInvoice());
       assertEquals(product, actualLineItem.getProduct());
       assertEquals(quantity, actualLineItem.getQuantity());
       assertEquals(new BigDecimal("30"), actualLineItem.getPercentDiscount());
       assertEquals(new BigDecimal("19.99"), actualLineItem.getUnitPrice());
       assertEquals(new BigDecimal("69.96"), actualLineItem.getExtendedPrice());
     } else {
       assertTrue("Invoice should have exactly one line item", false);
     }
  } finally {
     deleteObject(expectedLineItem);
     deleteObject(invoice);
     deleteObject(product);
     deleteObject(customer);
     deleteObject(billingAddress);
     deleteObject(shippingAddress);
  }
```


Verifying the Outcome

```
List lineItems = invoice.getLineItems();
if (lineItems.size() == 1) {
  LineItem actualLineItem = (LineItem)lineItems.get(0);
  assertEquals(invoice, actualLineItem.getInvoice());
  assertEquals(product, actualLineItem.getProduct());
  assertEquals(quantity, actualLineItem.getQuantity());
  assertEquals(new BigDecimal("30"),
       actualLineItem.getPercentDiscount());
  assertEquals(new BigDecimal("19.99"),
       actualLineItem.getUnitPrice());
  assertEquals(new BigDecimal("69.96"),
       actualLineItem.getExtendedPrice());
} else {
  assertTrue("Invoice should have exactly one line item",
                        false);
}
```

Obtuse Assertion

Use Better Assertion

```
List lineItems = invoice.getLineItems();
if (lineItems.size() == 1) {
  LineItem actualLineItem = (LineItem)lineItems.get(0);
  assertEquals(invoice, actualLineItem.getInvoice());
  assertEquals(product, actualLineItem.getProduct());
  assertEquals(quantity, actualLineItem.getQuantity());
  assertEquals(new BigDecimal("30"),
       actualLineItem.getPercentDiscount());
  assertEquals(new BigDecimal("19.99"),
       actualLineItem.getUnitPrice());
  assertEquals(new BigDecimal("69.96"),
       actualLineItem.getExtendedPrice());
} else {
  fail("invoice should have exactly one line item");
}}
```


Use Better Assertion

```
List lineItems = invoice.getLineItems();
if (lineItems.size() == 1) {
  LineItem actualLineItem = (LineItem)lineItems.get(0);
  assertEquals(invoice, actualLineItem.getInvoice());
  assertEquals(product, actualLineItem.getProduct());
  assertEquals(quantity, actualLineItem.getQuantity());
  assertEquals(new BigDecimal("30"),
       actualLineItem.getPercentDiscount());
  assertEquals(new BigDecimal("19.99"),
       actualLineItem.getUnitPrice());
  assertEquals(new BigDecimal("69.96"),
       actualLineItem.getExtendedPrice());
} else {
  fail("invoice should have exactly one line item");
}}
```

Hard-Wired Test Data

Fragile Tests

Expected Object

```
List lineItems = invoice.getLineItems();
if (lineItems.size() == 1) {
  LineItem actualLineItem = (LineItem)lineItems.get(0);
  LineItem expectedLineItem =
          newLineItem(invoice, product, QUANTITY);
  assertEquals(expectedLineItem.getInvoice(),
         actualLineItem.getInvoice());
  assertEquals(expectedLineItem.getProduct(),
         actualLineItem.getProduct());
  assertEquals(expectedLineItem.getQuantity(),
         actualLineItem.getQuantity());
  assertEquals(expectedLineItem.getPercentDiscount(),
         actualLineItem.getPercentDiscount());
  assertEquals(expectedLineItem.getUnitPrice(),
         actualLineItem.getUnitPrice());
  assertEquals(expectedLineItem.getExtendedPrice(),
         actualLineItem.getExtendedPrice());
} else {
  fail("invoice should have exactly one line item");
```

Expected Object

```
List lineItems = invoice.getLineItems();
if (lineItems.size() == 1) {
  LineItem actualLineItem = (LineItem)lineItems.get(0);
  LineItem expectedLineItem =  newLineItem(invoice,
        product, QUANTITY, product.getPrice()*QUANTITY );
  assertEquals(expectedLineItem.getInvoice(),
        actualLineItem.getInvoice());
  assertEquals(expectedLineItem.getProduct(),
        actualLineItem.getProduct());
  assertEquals(expectedLineItem.getQuantity(),
        actualLineItem.getQuantity());
  assertEquals(expectedLineItem.getPercentDiscount(),
        actualLineItem.getPercentDiscount());
  assertEquals(expectedLineItem.getUnitPrice(),
        actualLineItem.getUnitPrice());
  assertEquals(expectedLineItem.getExtendedPrice(),
        actualLineItem.getExtendedPrice());
} else {
  fail("invoice should have exactly one line item");
}
```

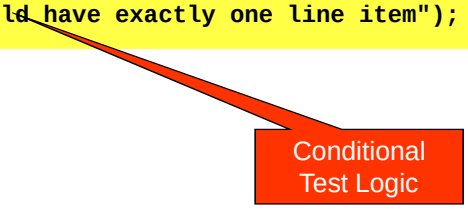
Verbose Test

Introduce Custom Assert

```
List lineItems = invoice.getLineItems();
if (lineItems.size() == 1) {
  LineItem actualLineItem = (LineItem)lineItems.get(0);
  LineItem expectedLineItem =  newLineItem(invoice,
        product, QUANTITY, product.getPrice()*QUANTITY );
  assertLineItemsEqual(expectedLineItem, actualLineItem);
} else {
  fail("invoice should have exactly one line item");
}
```

Introduce Custom Assert

```
List lineItems = invoice.getLineItems();
if (lineItems.size() == 1) {
  LineItem actualLineItem = (LineItem)lineItems.get(0);
  LineItem expectedLineItem =  newLineItem(invoice,
        product, QUANTITY, product.getPrice()*QUANTITY );
  assertLineItemsEqual(expectedLineItem, actualLineItem);
} else {
  fail("invoice should have exactly one line item");
}
```



Replace Conditional Logic with Guard Assertion

```
List lineItems = invoice.getLineItems();
assertEquals("number of items",lineItems.size(),1);
LineItem actualLineItem = (LineItem)lineItems.get(0);
LineItem expectedLineItem =  newLineItem(invoice,
  product, QUANTITY, product.getPrice()*QUANTITY );
assertLineItemsEqual(expectedLineItem, actualLineItem);
```

The Whole Test

```
public void testAddItemQuantity_severalQuantity () throws Exception {
  try {
     // Setup Fixture
     final int QUANTITY = 5;
     Address billingAddress = new Address("1222 1st St SW", "Calgary", "Alberta", "T2N
           2V2", "Canada");
     Address shippingAddress = new Address("1333 1st St SW", "Calgary", "Alberta", "T2N
           2V2", "Canada");
     Customer customer = new Customer(99, "John", "Doe", new BigDecimal("30"),
           billingAddress, shippingAddress);
     Product product = new Product(88, "SomeWidget", new BigDecimal("19.99"));
     Invoice invoice = new Invoice(customer);
     // Exercise SUT
     invoice.addItemQuantity(product, QUANTITY);
     // Verify Outcome
     List lineItems = invoice.getLineItems();
     assertEquals("number of items",lineItems.size(),1);
     LineItem actualLineItem = (LineItem)lineItems.get(0);
     LineItem expectedLineItem = newLineItem(invoice, product, QUANTITY);
     assertLineItemsEqual(expectedLineItem, actualLineItem);
  } finally {
     deleteObject(expectedLineItem);
     deleteObject(invoice);
     deleteObject(product);
     deleteObject(customer);
     deleteObject(billingAddress);
     deleteObject(shippingAddress);                                    :
  }
```


The Whole Test

```
public void testAddItemQuantity_severalQuantity () throws Exception {
  try {
     // Setup Fixture
     final int QUANTITY = 5;
     Address billingAddress = new Address("1222 1st St SW", "Calgary", "Alberta", "T2N
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     Address shippingAddress = new Address("1333 1st St SW", "Calgary", "Alberta", "T2N
           2V2", "Canada");
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           billingAddress, shippingAddress);
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     LineItem expectedLineItem = newLineItem(invoice, product, QUANTITY);
     assertLineItemsEqual(expectedLineItem, actualLineItem);
  } finally {
     deleteObject(expectedLineItem);
     deleteObject(invoice);
     deleteObject(product);
     deleteObject(customer);
     deleteObject(billingAddress);
     deleteObject(shippingAddress);                                    :
  }
```


Inline Fixture Teardown - Naive

```
public void testAddItemQuantity_severalQuantity () … {
   try {
      // Setup Fixture
      // Exercise SUT
      // Verify Outcome
   } finally {
      deleteObject(expectedLineItem);
      deleteObject(invoice);
      deleteObject(product);
      deleteObject(customer);
      deleteObject(billingAddress);
      deleteObject(shippingAddress);
   }
}
```


Inline Fixture Teardown - Robust

```
public void testAddItemQuantity_severalQuantity () … {
   try {
      // Setup Fixture
      // Exercise SUT
      // Verify Outcome
   } finally {
      try {
         deleteObject(expectedLineItem);
      } finally {
         try {
            deleteObject(invoice);
         } finally {
            try {
              deleteObject(product);
            } finally {
              :
```

Implicit Fixture Teardown - Naive

```
public void testAddItemQuantity_severalQuantity () … {
   // Setup Fixture
   // Exercise SUT
   // Verify Outcome
}

public void tearDown() {
   deleteObject(expectedLineItem);
   deleteObject(invoice);
   deleteObject(product);
   deleteObject(customer);
   deleteObject(billingAddress);
   deleteObject(shippingAddress);
}
```


Implicit Fixture Teardown - Robust

```
public void testAddItemQuantity_severalQuantity () … {
   // Setup Fixture
   // Exercise SUT
   // Verify Outcome
}

public void tearDown() {
   try {
      deleteObject(expectedLineItem);
   } finally {
      try {
         deleteObject(invoice);
      } finally {
         try {
            deleteObject(product);
         } finally {
                  :
```

Automated Fixture Teardown

```
public void testAddItemQuantity_severalQuantity () … {
   final int QUANTITY = 5;
   Address billingAddress = new Address("1222 1st St SW",
             "Calgary", "Alberta", "T2N 2V2", "Canada");
   addTestObject( billingAddress );
   Address shippingAddress = new Address("1333 1st St SW",
             "Calgary", "Alberta", "T2N 2V2", "Canada");
   addTestObject(shippingAddress );

            :
}

public void tearDown() {
   deleteAllTestObjects();
}
```


Automated Fixture Teardown

```
public void deleteAllTestObjects() {
     Iterator i = testObjects.iterator();
     while (i.hasNext()) {
         try {
             Deletable object = (Deletable) i.next();
             object.delete();
         } catch (Exception e) {
             // do nothing if the remove failed
         }
     }
}
```

Transaction Rollback Teardown

```
public void setUp() {
    TransactionManager.beginTransaction();
}

public void tearDown() {
    TransactionManager.abortTransaction();
}
```

Important: SUT must not commit transaction

- DFT Pattern: Humble Transaction Controller

The Whole Test

```
public void testAddItemQuantity_severalQuantity () throws Exception {
    // Setup Fixture
    final int QUANTITY = 5;
    Address billingAddress = new Address("1222 1st St SW", "Calgary", "Alberta",
         "T2N 2V2", "Canada");
    addTestObject(billingAddress);
    Address shippingAddress = new Address("1333 1st St SW", "Calgary", "Alberta",
         "T2N 2V2", "Canada");
    addTestObject(billingAddress);
    Customer customer = new Customer(99, "John", "Doe", new BigDecimal("30"),
         billingAddress, shippingAddress);
    addTestObject(billingAddress);
    Product product = new Product(88, "SomeWidget", new BigDecimal("19.99"));
    addTestObject(billingAddress);
    Invoice invoice = new Invoice(customer);
    addTestObject(billingAddress);
    // Exercise SUT
    invoice.addItemQuantity(product, QUANTITY);
    // Verify Outcome
    assertEquals("number of items",lineItems.size(),1);
    LineItem actualLineItem = (LineItem)lineItems.get(0);
    LineItem expectedLineItem = newLineItem(invoice, product, QUANTITY);
    assertLineItemsEqual(expectedLineItem, actualLineItem);
}
```

// No Visible Fixture Tear Down!

The Whole Test

```
public void testAddItemQuantity_severalQuantity () throws Exception {
    // Setup Fixture
    final int QUANTITY = 5;
    Address billingAddress = new Address("1222 1st St SW", "Calgary",
         "Alberta", "T2N 2V2", "Canada");
    addTestObject(billingAddress);
    Address shippingAddress = new Address("1333 1st St SW", "Calgary",
         "Alberta", "T2N 2V2", "Canada");
    addTestObject(billingAddress);
    Customer customer = new Customer(99, "John", "Doe", new BigDecimal("30"),
         billingAddress, shippingAddress);
    addTestObject(billingAddress);
    Product product = new Product(88, "SomeWidget", new BigDecimal("19.99"));
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    // Exercise SUT
    invoice.addItemQuantity(product, QUANTITY);
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    assertEquals("number of items",lineItems.size(),1);
    LineItem actualLineItem = (LineItem)lineItems.get(0);
    LineItem expectedLineItem = newLineItem(invoice, product, QUANTITY);
    assertLineItemsEqual(expectedLineItem, actualLineItem);
}
```


Hard-Coded Test Data

```
public void testAddItemQuantity_severalQuantity() {
    final int QUANTITY = 5;
    Address billingAddress = new Address("1222 1st St SW",
        "Calgary", "Alberta", "T2N 2V2", "Canada");

    Address shippingAddress = new Address("1333 1st St SW",
        "Calgary", "Alberta", "T2N 2V2", "Canada");

    Customer customer = new Customer(99, "John", "Doe", new
        BigDecimal("30"), billingAddress, shippingAddress);

    Product product = new Product(88, "SomeWidget",
        BigDecimal("19.99"));

    Invoice invoice = new Invoice(customer);
    // Exercise SUT
    invoice.addItemQuantity(product, QUANTITY);
```

Hard-coded Test Data (Obscure Test)

Unrepeatable Tests

Distinct Generated Values

```
public void testAddItemQuantity_severalQuantity() {
    final int QUANTITY = 5 ;
    Address billingAddress = new Address(getUniqueString(),
        getUniqueString(), getUniqueString(),
        getUniqueString(), getUniqueString());
    Address shippingAddress = new Address(getUniqueString(),
        getUniqueString(), getUniqueString(),
        getUniqueString(), getUniqueString());
    Customer customer = new Customer(
        getUniqueInt(), getUniqueString(),
        getUniqueString(), getUniqueDiscount(),
        billingAddress, shippingAddress);
    Product product = new Product(
        getUniqueInt(), getUniqueString(),
        getUniqueNumber());
    Invoice invoice = new Invoice(customer);
```


Distinct Generated Values

```
public void testAddItemQuantity_severalQuantity() {
    final int QUANTITY = 5 ;
    Address billingAddress = new Address(getUniqueString(),
        getUniqueString(), getUniqueString(),
        getUniqueString(), getUniqueString());
    Address shippingAddress = new Address(getUniqueString(),
        getUniqueString(), getUniqueString(),
        getUniqueString(), getUniqueString());
    Customer customer1 = new Customer(
        getUniqueInt(), getUniqueString(),
        getUniqueString(), getUniqueDiscount(),
        billingAddress, shippingAddress);
    Product product = new Product(
        getUniqueInt(), getUniqueString(),
        getUniqueNumber());
    Invoice invoice = new Invoice(customer);
```

Irrelevant Information (Obscure Test)

Creation Method

```
public void testAddItemQuantity_severalQuantity() {
   final int QUANTITY = 5;
   Address billingAddress = createAnonymousAddress();


   Address shippingAddress = createAnonymousAddress();


   Customer customer = createCustomer( billingAddress,
       shippingAddress);


   Product product = createAnonymousProduct();


   Invoice invoice = new Invoice(customer);
```


Obscure Test - Irrelevant Information

```
public void testAddItemQuantity_severalQuantity() {
   final int QUANTITY = 5;
   Address billingAddress = createAnonymousAddress();
   Address shippingAddress = createAnonymousAddress();
   Customer customer = createCustomer(
       billingAddress, shippingAddress);
   Product product = createAnonymousProduct();
   Invoice invoice = new Invoice(customer);
   // Exercise
   invoice.addItemQuantity(product, QUANTITY);
   // Verify
   LineItem expectedLineItem =    newLineItem(invoice,
       product, QUANTITY, product.getPrice()*QUANTITY );
   List lineItems = invoice.getLineItems();
   assertEquals("number of items", lineItems.size(), 1);
   LineItem actualLineItem = (LineItem)lineItems.get(0);
   assertLineItemsEqual(expectedLineItem, actualLineItem);
}
```

Irrelevant Information (Obscure Test)

Remove Irrelevant Information

```
public void testAddItemQuantity_severalQuantity() {
   final int QUANTITY = 5 ;


   Customer customer = createAnonymousCustomer();

   Product product = createAnonymousProduct();
   Invoice invoice = new Invoice(customer);
   // Exercise
   invoice.addItemQuantity(product, QUANTITY);
   // Verify
   LineItem expectedLineItem =    newLineItem(invoice,
       product, QUANTITY, product.getPrice()*QUANTITY );
   List lineItems = invoice.getLineItems();
   assertEquals("number of items", lineItems.size(), 1);
   LineItem actualLineItem = (LineItem)lineItems.get(0);
   assertLineItemsEqual(expectedLineItem, actualLineItem);
}
```

Irrelevant Information (Obscure Test)

Remove Irrelevant Information

```
public void testAddItemQuantity_severalQuantity() {
   final int QUANTITY = 5 ;




   Product product = createAnonymousProduct();
   Invoice invoice = createAnonymousInvoice()
   // Exercise
   invoice.addItemQuantity(product, QUANTITY);
   // Verify
   LineItem expectedLineItem =    newLineItem(invoice,
       product, QUANTITY, product.getPrice()*QUANTITY );
   List lineItems = invoice.getLineItems();
   assertEquals("number of items", lineItems.size(), 1);
   LineItem actualLineItem = (LineItem)lineItems.get(0);
   assertLineItemsEqual(expectedLineItem, actualLineItem);
}
```

Introduce Custom Assertion

```
public void testAddItemQuantity_severalQuantity() {
   final int QUANTITY = 5 ;



   Product product = createAnonymousProduct();
   Invoice invoice = createAnonymousInvoice()
   // Exercise
   invoice.addItemQuantity(product, QUANTITY);
   // Verify
   LineItem expectedLineItem =    newLineItem(invoice,
       product, QUANTITY, product.getPrice()*QUANTITY );
   List lineItems = invoice.getLineItems();
   assertEquals("number of items", lineItems.size(), 1);
   LineItem actualLineItem = (LineItem)lineItems.get(0);
   assertLineItemsEqual(expectedLineItem, actualLineItem);
}
```

Mechanics hides Intent

Introduce Custom Assertion

```
public void testAddItemQuantity_severalQuantity() {
   final int QUANTITY = 5 ;



   Product product = createAnonymousProduct();
   Invoice invoice = createAnonymousInvoice()
   // Exercise
   invoice.addItemQuantity(product, QUANTITY);
   // Verify
   LineItem expectedLineItem =    newLineItem(invoice,
       product, QUANTITY, product.getPrice()*QUANTITY );
   assertExactlyOneLineItem(invoice, expectedLineItem );

}
```

The Whole Test – Done

```
public void testAddItemQuantity_severalQuantity() {
   final int QUANTITY = 5 ;
   Product product = createAnonymousProduct();
   Invoice invoice = createAnonymousInvoice();
   // Exercise
   invoice.addItemQuantity(product, QUANTITY);
   // Verify
   LineItem expectedLineItem =    newLineItem(invoice,
       product, QUANTITY, product.getPrice()*QUANTITY );
   assertExactlyOneLineItem(invoice, expectedLineItem );
}
```

This Looks a Lot Like Keyword-Driven Testing

Same Underlying Principles:
- Use Domain-Specific Language
- Say Only What is Relevant

Agenda

- Introduction
- Economics of Maintainability
- Intro to Test Smells & Patterns
- Refactoring Smelly Test Code
- Writing New Tests Quickly
- Behaviour Smells
- Wrap Up

Test Coverage

```
TestInvoiceLineItems extends TestCase {
   TestAddItemQuantity_oneItem {..}
   TestAddItemQuantity_severalItems {..}
   TestAddItemQuantity_duplicateProduct {..}
   TestAddItemQuantity_zeroQuantity {..}
   TestAddItemQuantity_severalQuantity {..}
   TestAddItemQuantity_discountedPrice {..}
   TestRemoveItem_noItemsLeft {..}
   TestRemoveItem_oneItemLeft {..}
   TestRemoveItem_ severalItemsLeft {..}
}
```

Pattern: Testcase Class per Feature

Rapid Test Writing

```
public void testAddItemQuantity_duplicateProduct() {
   final int QUANTITY = 1 ;
   final int QUANTITY2 = 2 ;
   Product product1 = createAnonymousProduct();
   Invoice invoice = createAnonymousInvoice();
   // Exercise
   invoice.addItemQuantity(product1, QUANTITY);
   invoice.addItemQuantity(product1, QUANTITY2);
   // Verify
   LineItem expectedLineItem1 =   newLineItem(invoice,
       product, QUANTITY+QUANTITY2,
       product.getPrice() * (QUANTITY+QUANTITY2) );

   assertExactlyOneLineItem(invoice, expectedLineItem1 );

}
```

"Pull" applied to statements in Test Method

Test Coverage

```
TestInvoiceLineItems extends TestCase {
   TestAddItemQuantity_oneItem {..}
   TestAddItemQuantity_severalItems {..}
   TestAddItemQuantity_duplicateProduct {..}
   TestAddItemQuantity_zeroQuantity {..}
   TestAddItemQuantity_severalQuantity {..}
   TestAddItemQuantity_discountedPrice {..}
   TestRemoveItem_noItemsLeft {..}
   TestRemoveItem_oneItemLeft {..}
   TestRemoveItem_ severalItemsLeft {..}
}
```

Pattern: Testcase Class per Feature

Rapid Test Writing

```
public void testAddItemQuantity_severalItems() {
   final int QUANTITY = 1 ;
   Product product1 = createAnonymousProduct();
   Product product2 = createAnonymousProduct();
   Invoice invoice = createAnonymousInvoice();
   // Exercise
   invoice.addItemQuantity(product1, QUANTITY);
   invoice.addItemQuantity(product2, QUANTITY);
   // Verify
   LineItem expectedLineItem1 =  newLineItem(invoice,
       product, QUANTITY, product.getPrice()*QUANTITY );
   LineItem expectedLineItem2 =  newLineItem(invoice,
       product2, QUANTITY, product2.getPrice()*QUANTITY );

   assertExactlyTwoLineItems(invoice,
                    expectedLineItem1, expectedLineItem2 );

}
```

"Pull" also applied to new Custom Assertion

Testability Patterns

- **Humble Object**
  - Objects closely coupled to the environment should not do very much (be humble)
  - Should delegate real work to a context-independent testable object
- **Dependency Injection**
  - Client "injects" depended-on objects into SUT
  - Tests can pass a Test Double to control "indirect inputs" from dependents
- **Dependency Lookup**
  - SUT asks another object for it's dependencies
  - Service Locator, Object Factory, Component Registry
- **Test-Specific Subclass**
  - Can extend the SUT to all access by test

Agenda

- **Introduction**
- **Economics of Maintainability**
- **Intro to Test Smells & Patterns**
- **Refactoring Smelly Test Code**
- **Writing New Tests Quickly**
- **Behaviour Smells**
- **Wrap Up**

What's a Behavior Smell

- **A problem seen when running tests.**
- **Tests fail when they should pass**
  - or pass when they should fail (rarer)
- **The problem is with how tests are coded;**
  - not a problem in the SUT
- **Sniff Test:**
  - Detectable via compile or execution behavior of tests

Common Behavior Smells

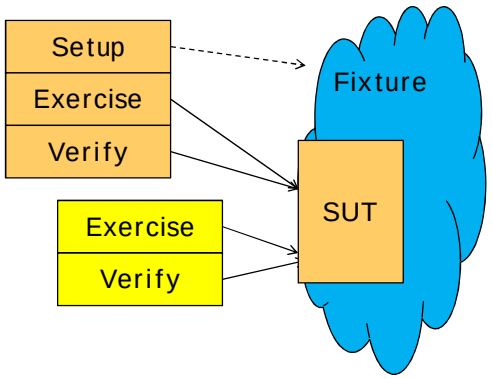
- **Slow Tests**
- **Erratic Tests**
  - Too many variants to list here
- **Fragile Tests**
  - The 4 sensitivities
- **Assertion Roulette**
- **Frequent Debugging**
- **Manual Intervention**

Slow Tests

- **Slow Tests**
  - It takes several minutes to hours to run all the tests
- **Impact**
  - Lost productivity caused by waiting for tests
  - Lost quality due to running tests less frequently
- **Causes:**
  - Slow Component Usage
    - » **e.g. Database**
  - Asynchronous Test
    - » **e.g. Delays or Waits**
  - General Fixture
    - » **too much fixture being setup**

Shared Test Fixture

- **What it is:**
  - Improves test run times by reducing setup overhead.
  - A "standard" test environment applicable to all tests is built and the tests reuse the same fixture instance.



Shared Test Fixture

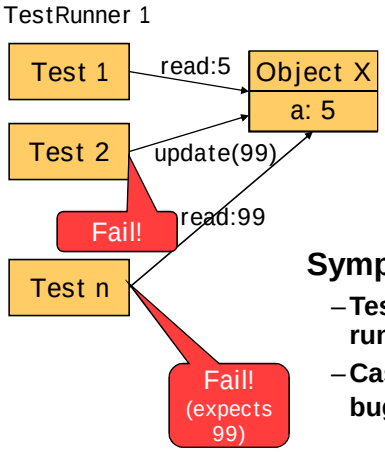
- **Variations:**
  - Fixture is shared between some/all the tests in a single test run
  - Fixture may be shared across many TestRunners (Global Text Fixture)
- **Examples:**
  - Standard Database contents
  - Standard Set of Directories and Files
  - Standard set of objects

Bad Smell Alert:
•Erratic Tests

Erratic Tests

- **Interacting Tests**
  - When one test fails, a bunch of other tests fail for no apparent reason because they depend on other tests' side effects
- **Unrepeatable Tests**
  - Tests can't be run repeatedly without intervention
- **Test Run War**
  - Seemingly random, transient test failures
  - Only occurs when several people testing simultaneously
- **Resource Optimism**
  - Tests depend on something in the environment that isn't avaiable
- **Non-Deterministic Tests**
  - Tests depend on non-deterministic inputs

Erratic Tests – Interacting Tests



If many tests use same objects, tests can affect each other's results.

– Test 2 failure may leave Object X in state that causes Test n to fail.

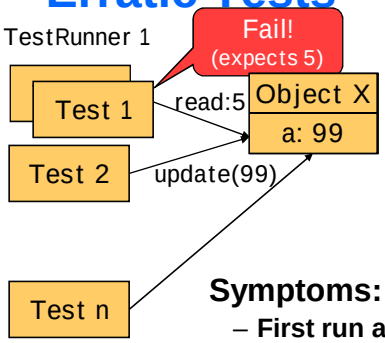
Symptoms:

– **Tests that work by themselves fail when run in a suite.**

– **Cascading errors caused by a single bug failing a single test.**

» **Bug need not affect other tests directly but leaves fixture in wrong state for subsequent tests to succeed.**

Erratic Tests – Unrepeatable Tests



If many test runs use same objects, test runs can affect each other's results.

– Test 2 update may leave Object X in state that causes Test 1 to fail on next run.

Symptoms:

– **First run after opening the TestRunner or re-initializing Shared Fixture behaves differently**

» **Succeed, Fail, Fail, Fail**

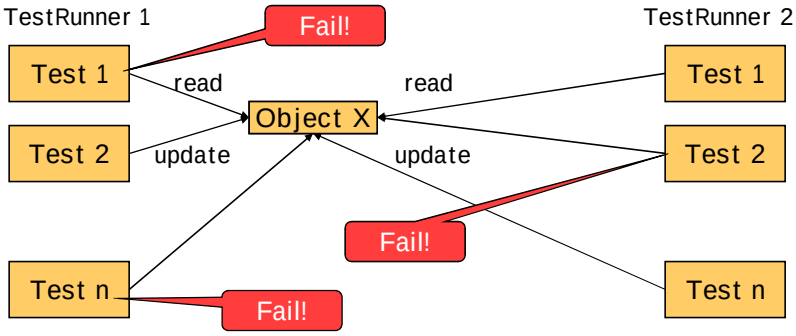
» **Fail, Succeed, Succeed, Succeed**

– **Resetting the fixture may "reset" things to square 1 (restarting the cycle)**

» **Closing and reopening the test runner for in-memory fixture**

» **Reinitializing the database**

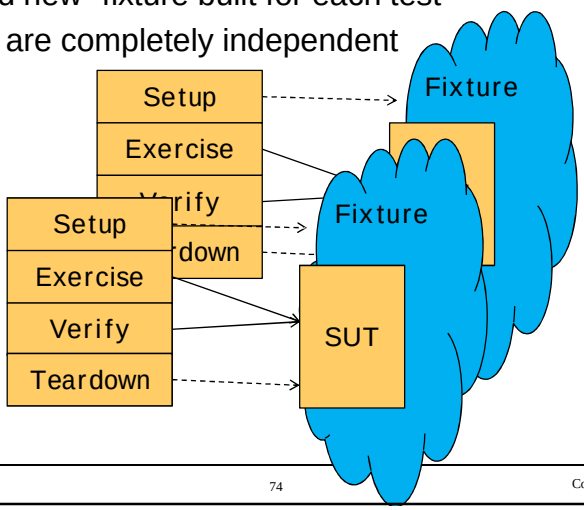
Erratic Tests – Test Run War



- **If many test runners use the same objects (from Global Fixture), random results can occur.**
  - Interleaving of tests from parallel runners makes determining cause very difficult

Avoiding Erratic Tests - Fresh Fixture

- **What it is:**
  - "Brand new" fixture built for each test
  - Tests are completely independent



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A Recipe for Success

1. **Write some tests**
   - start with the easy ones!
2. **Note the Test Smells that show up**
3. **Refactor to remove obvious Test Smells**
   - Apply appropriate xUnit Test Patterns
4. **Write some more tests**
   - possibly more complex
5. **Repeat from Step 2 until:**
   - All necessary tests written
   - No smells remain

What Next?

- **You have a better idea of:**
  - what can be achieved
  - problems to look for
    - » **Test Smells**
  - symptoms (smells) vs root causes
- **You have an initial list of patterns to address root causes**
  - More at the web site and in the book
- **Time to go "Smell Hunting"**

Be Pragmatic!

- **Not all Smells can (or should) be eliminated**
  - Cost of having smell vs. cost of removing it
  - Cost to remove it now vs. cost of removing it later
- **Catalog of Smells and Causes gives us the tools to make the decision intelligently**
  - Trouble-shooting flow chart
  - Suggested Patterns for removing cause
- **Catalog of Patterns gives us the tools to eliminate the Smells *when we choose to do so***
  - How it Works
  - When to Use It
  - Before/After Code samples
  - Refactoring notes

What *Does* it Take To be Successful?

Programing Experience

+ xUnit Experience

+ Testing Experience

+ Design for Testability

- Test Smells

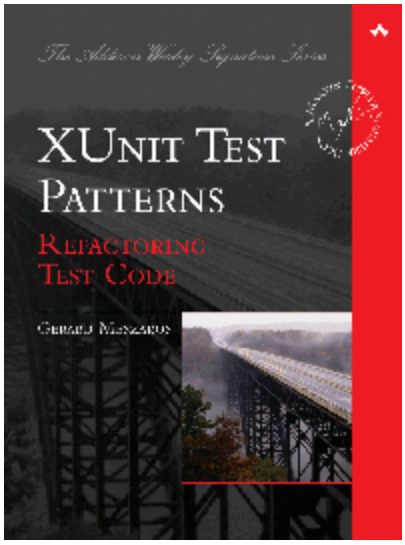
+ Test Automation Patterns

+ Fanatical Attention to Test Maintainability

= Robust, Maintainable Automated Tests

More on xUnit Patterns & Smells

- **Tutorial:**
  - **Friday Morning**
- **Book:**
  xUnit Test Patterns
  Refactoring Test Code
  - published by Addison Wesley
- **Website:**
  http://xunitpatterns.com
- **Onsite Training**
  - training at xunitpatterns.com
  - +1-403-827-2967
  - jaoo2009@xunitpatterns.com



Thank You!

Gerard

Questions & Comments?

Resources for Testing

Reminder:

Tutorial exercises and solutions available at:

http://tutorialexercises.xunitpatterns.com
http://tutorialsolutions.xunitpatterns.com

Books on xUnit Test Automation

- **xUnit Test Patterns – Refactoring Test Code**
  - Gerard Meszaros
- **Test-driven Development - A Practical Guide**
  - David Astels
- **Test-driven Development - By Example**
  - Kent Beck
- **Test-Driven Development in Microsoft .NET**
  - James Newkirk, Alexei Vorontsov
- **Unit Testing With Java - How tests drive the code**
  - Johannes Link
- **JUnit Recipes**
  - J.B. Rainsberger

Other Useful Books

- **Working Effectively with Legacy Code**
  - Michael Feathers
- **Fit for Software Development**
  - Rick Mugridge, Ward Cunningham
- **Refactoring - Improving the Design of Existing Code**
  - Martin Fowler plus contributors
- **Design Patterns: Reusable Elements of Design**
  - Erich Gamma, Richard Helm, Ralph Johnson, John Vlisides

Coding Objectives Comparison

	Production	*Testware*
Correctness	Important	Crucial
Maintainability	Important	Crucial
Execution Speed	Crucial	Somewhat
Reusability	Important	Somewhat
Flexibility	Important	Not
Simplicity	Important?	Crucial
Ease of writing	Important?	Crucial