UNIT TESTING: PHILOSOPHY AND TOOLS

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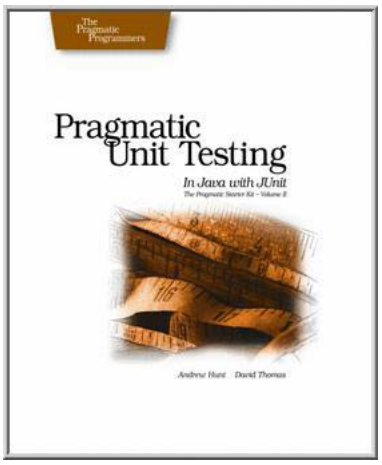
Credit Where Credit is Due



- Significant sections of this lecture are derived from "Pragmatic Unit Testing."
- *Andrew Hunt and David Thomas*
- An excellent, practical book. You should buy it.
- Available in Java and .NET flavors.

Today's Lecture:

- Unit Tests
  - Testing classes and methods against a contract
- Unit testing is good for YOU!
- Testing Harnesses*
  - Making tests automatic, repeatable and independent
- Mock Objects*
  - Testing one piece of code at a time

*Demo included!

Unit Tests

- Do you spend a large amount of time using the debugger?
- Do you ever find yourself saying things like,
  - "That's impossible!"
  - "I don't understand how this could happen."
- Unit tests be a big help.

Unit Tests: Definitions

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- Key Metaphor: I.C. Testing
  - Integrated Circuits are tested individually for functionality before the whole circuit is tested.

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- Whitebox – Unit tests are written with full knowledge of implementation details.

Unit Tests: Definitions

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- Developers – Unit tests are written by you, the developer, concurrently with implementation.

Unit Tests: Definitions

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- Small Units – Unit tests should isolate one piece of software at a time.
  - Individual methods and classes

Unit Tests: Definitions

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- Verify – Make sure you built 'the software right.' Testing against the contract.
  - Contrast this with validation.

Testing Against a Contract

- A method's contract is a statement of the responsibilities of that method, and the responsibilities of the code that calls it.
- Think, a legal contract
  - If you pay me exactly $30,000
  - I will build a new room on your house
- Helps to pinpoint responsibility.

More on Contracts

- Methods and objects all have contracts!
  - Sometimes they are explicit
  - Sometimes implicit
- Let's see some examples…

Implicit Contracts

- Sometimes the contract exists implicitly in the code and the mind of the programmer.

```
public boolean isThisALeapYear(Calendar today)
{
   return (today.get(Calendar.YEAR) % 4 == 0);
}
```


Informal Contracts

- Sometimes a method's contract is informally described in comments.

Informal Contracts

```
 /** Applies a move to a board. This assumes
that the move is one that was returned by
getAllMoves. Upon applying the move, it will
also update the value of the board and switch
the board's turn.  */
public void applyMove(Move mv) {
     byte row = 0, col = 0, bck = 0, ...;
     byte opTurn = (mTurn == BLK) ? WHT : BLK;
     OthelloMove appM = null;
     boolean good = false;
```


Pre/Post Conditions, Invariants

- You may remember these from early computer science classes.
  - And you may never use them!
- **Precondition**
  - Things that must be true of parameters and fields for call to be 'legal.'
- **Postcondition**
  - Things this method guarantees will be true of fields and the return value after being called.
- **Invariants**
  - Something that will always be true.
  - Usually describe objects and fields.

Pre/Post Conditions, Invariants

```
public class BankingExample {

   public static final int MAX_BALANCE = 1000;
   //Invariant: The balance will always be greater than
   //  zero, but less than MAX_BALANCE.
   private int balance;

   //Precondition: amount is greater than zero
   //Postcondition: the new balance is set to the
   //  old balance plus amount.
    public void credit(int amount) { ... }

    //Precondition: amount is greater than zero
    //Postcondition: balance set to the old balance
    //  minus amount
    public void debit(int amount) { ... }
```


Machine-Readable

```
public class BankingExample {

   public static final int MAX_BALANCE = 1000;
   //@ invariant balance >= 0 && balance <=MAX_BALANCE;
   private int balance;

    //@ requires amount > 0;
    //@ ensures balance = \old(balance) + amount;
    public void credit(int amount) { ... }

    //@ requires amount > 0;
    //@ ensures balance = \old(balance) - amount;
    public void debit(int amount) { ... }
```

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Unit testing is good for YOU!

- Unit testing
  - Seems like a good idea, in theory.
  - Often, people just don't do it.
  - Let's look at some common excuses why developers often don't.

Writing Unit Tests Takes Too Long!

- Unit testing implies a pay-as-you-go model, rather than pay-at-the-end.
- But there's more
  - Unit testing implies linear work, rather than exponential.
  - Think of clearing a field
    - Regular mowing, versus
    - Bushwhacking

Linear vs. Exponential Work

- Unit testing implies:
  - Steady productivity throughout the development cycle.
- Without unit testing:
  - Productivity starts off higher, but dives at the end when the testing starts.
  - Relearn code you wrote weeks or months ago.

Questions Worth Asking

- How much time do you spend debugging code you or others have written?
- How much time do you spend reworking code that you thought was working but turned out to have major bugs?
- How much time do you spend isolating a bug to its source?

- Often, this time add up fast.
- Unit testing can help reduce it.

It's Not My Job to Test!

- If you're worried about taking your testers' jobs, don't!
  - They have plenty to worry about with integration, acceptance tests, etc.

- As programmers, our job is to create *working* code.
  - Until you write a unit test, you have no idea.

They Aren't in the Process!

- Often developers say things like,
  - "Our company runs different types of tests."
  - "Our test machine isn't set up for unit tests."
  - "We have a different process."

Unit Tests are Personal

- Unit tests test the code you write.
- They are meant to be run on a developer's workstation.
  - If they are not part of source control, no problem!
  - If no one else on your team uses them, no problem!

Unit Tests are Personal

- Think of unit testing the same way you think of your text editor.
  - "I use Notepad, he uses Emacs."
  - The main difference being, the relative quality of *your* code.
- Of course, there are benefits to a culture of unit testing.
  - Automated regression tests & source control
  - Easier Integration
  - But it isn't necessary to reap the benefits

The Take-Away Message

- Unit tests are a tool, just like an IDE, that help you, the individual developer, write better code.

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Testing Harnesses

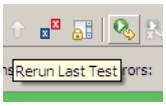
- Testing harnesses are tools that help manage and run your unit tests.
- Help us to achieve three properties of good unit tests, which are:
  - Automatic
  - Repeatable
  - Independent

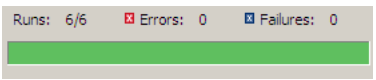
Meaning…

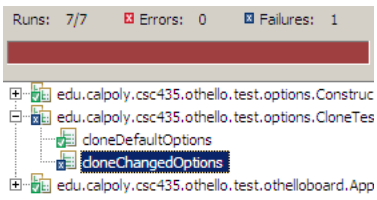
- Automatic
  - With one touch, our tests should be run and checked for completion. We want a fuzzy feeling with as little work as possible.
- Repeatable
  - Any developer can run the tests and they will work right away.
- Independent
  - Your tests can be run in any order and they will still work.

JUnit: A Java Unit Testing Harness

- Provides one-touch functionality for running all of your tests.
- Easy to verify success or failure.
- Source of failure is immediately obvious.







JUnit is Also a Testing Framework

- We write tests using code included in the JUnit framework.
  - `@Test` annotation tells the harness that you have written a test.
  - `org.junit.Assert` is full of helpful assertion tools.

JUnit Demo Time

- Testing the ShoppingCart

Other Helpful JUnit Features

- @BeforeClass
  - Run once before all test methods in class.
- @AfterClass
  - Run once after all test methods in class.
- Together, these methods are used for setting up computationally expensive test elements.
  - E.g., database, file on disk, network…

Other Helpful JUnit Features

- @Before
  - Run before each test method.
- @After
  - Run after each test method.
- Make tests independent by setting and resetting your testing environment.
  - E.g., creating a fresh object

```
foreach class:
  setUpBeforeClass();

  foreach test:
    setUp();
    run test;
    tearDown();

  tearDownAfterClass();
```


Helpful JUnit Assert Statements

- `assertEquals(float expected, float actual, float delta)`
  - Used for so that floating point equality is unnecessary.
- `assertSame(Object expected, Object actual)`
  - Tests for two objects are the same in memory.
- `assertNull(java.lang.Object object)`
  - Asserts that a reference is null.
- `assertNotNull(String message, Object object)`
  - Many 'not' asserts exists.
  - Most asserts have an optional message that can be printed.

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Unit Testing and Isolation

- Unit testing is all about isolating bugs.
  - When a unit test fails, we should know almost exactly in the source code where the bug lies.
- Mock objects to the rescue!
  - Allow us this isolation.

Unit Testing and Speed

- Running our tests should be fast…
  - If they aren't people won't run them.
- But what about bringing up and down environment code?
  - E.g, network sockets, databases, date-related code
- Mock objects to the rescue!
  - We make our own, simplified versions.

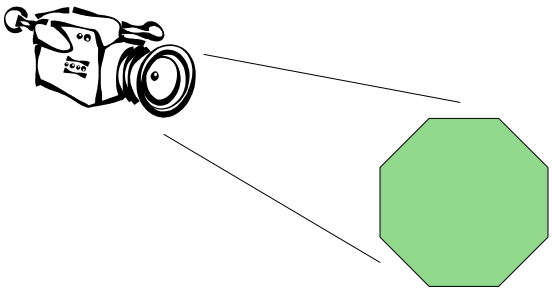
Unit Testing and Unusual Situations

- We want to test our code in weird situations.
  - E.g., daylight-saving time, network outages, file permission errors
- We can't force a network outage.
  - At least, not in a repeatable way…
- Mock objects to the rescue!
  - We define the behavior.

Additional Benefit: Protocol Checks

- We want to make sure our code uses other code correctly.
  - E.g., network sockets are open before they are read.
- Mock objects to the rescue!
  - Protocol conformance can be verified.

How EasyMock Works



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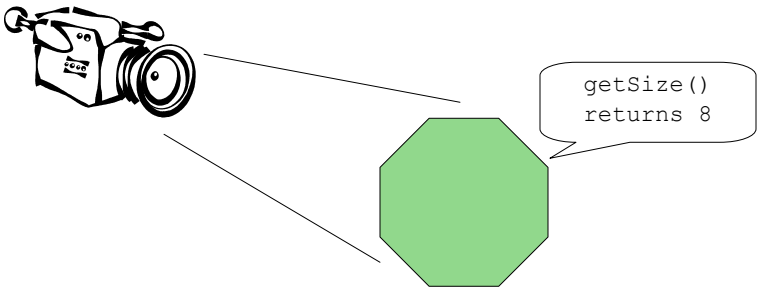

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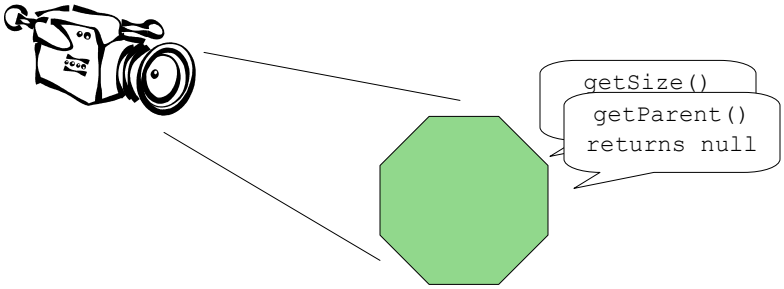

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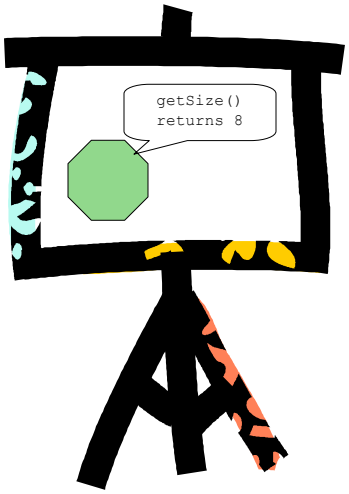

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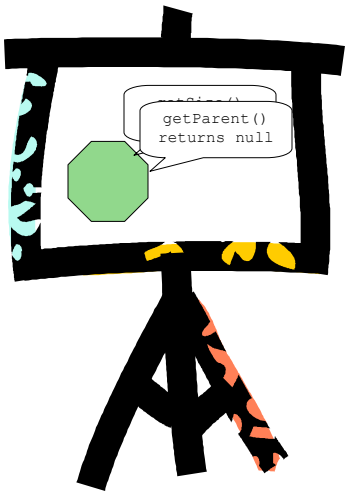

EasyMock Demo Time

- Exceptional Conditions (NTP)
- Interacting Code (AST)
- Protocol Conformance (Iterator)

- (easymock.org, for more!)

Other Neat Features

- EasyMock has a ton of features.
  - Stub behavior
    - When you don't really care if or when a method is called.
  - Nice mocks
    - Return defaults instead of throwing exceptions.
  - Check calling order between several mocks
  - Mock Reset
  - Argument Matchers
  - Different behavior for same call
  - Intricate return behavior

Take-Away Points

- Unit tests are tests by and for programmers.
  - Think of them as a tool, like an IDE.
- Testing harnesses and mock objects make the hard parts easier.
  - Automatic, repeatable, independent
- Unit test generation is a viable option.
  - Helps to achieve high code coverage.
  - Be careful about code intent versus implementation.

THE END

Slides and source code available online.