

# CS1632, Lecture 11: Test-Driven Development

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# THE DARK AGES

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# Nowadays...

- ▶ We know how important tests are to prevent issues like that
- ▶ Code quality is everyone's responsibility, including developers'
- ▶ Developers write tests (usually unit tests)

But...

- ▶ What to test?
- ▶ How deep to go into testing?
- ▶ How many edge cases?
- ▶ How to prioritize testing and development?
- ▶ What order should I write tests?
- ▶ How do I structure code to be testable?

# There is no one right answer

- ▶ Many studies done
- ▶ Different domains, different developers, different languages, etc...
- ▶ “No silver bullet”

# Test-Driven Development

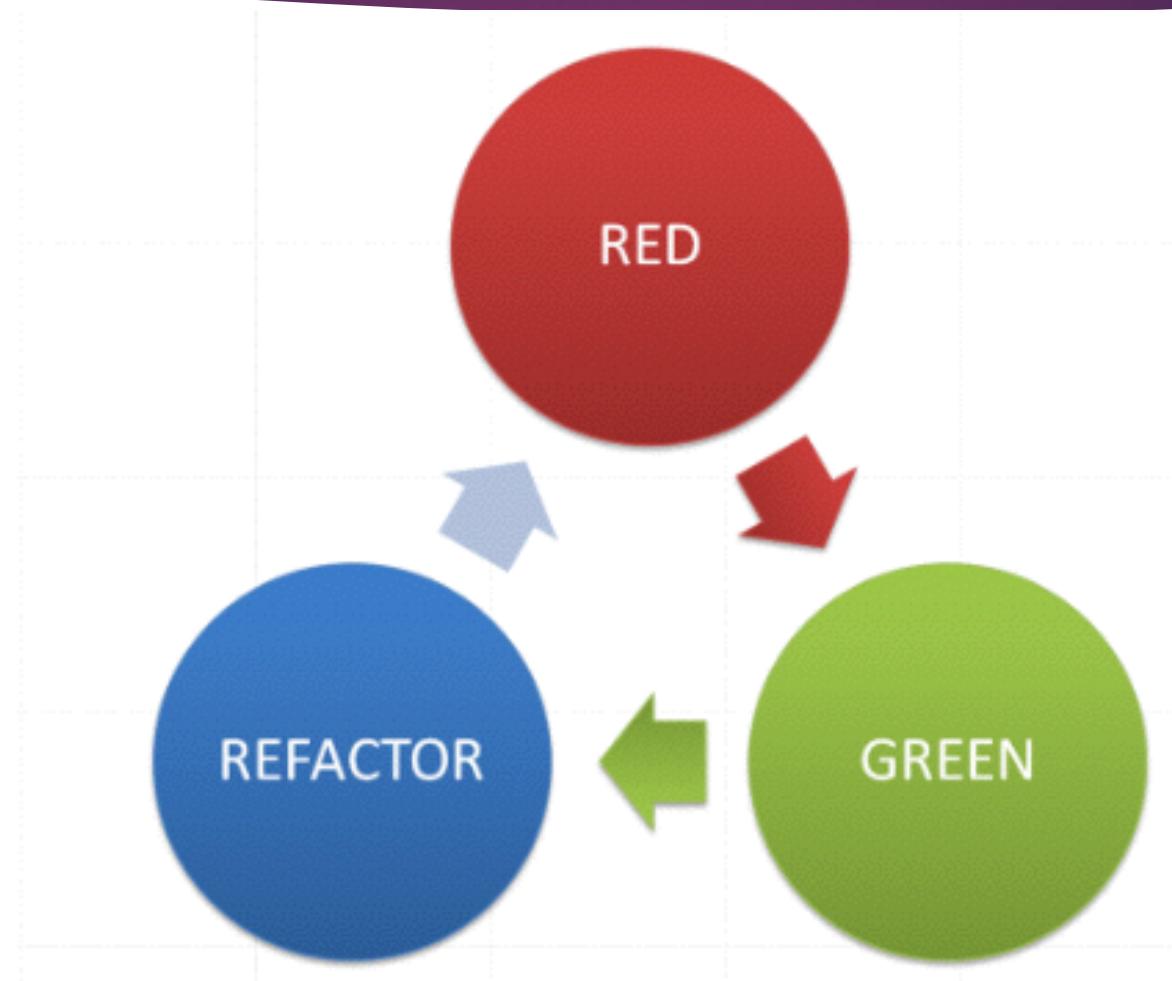
- ▶ A strategy for developing highly tested, quality software
- ▶ Not the be-all and end-all of strategies
- ▶ Google “TDD is dead” for a great argument against it
- ▶ Welcome to the still-forming world of software development!

# So What is TDD?

**A software development methodology that comprises:**

1. Writing tests BEFORE writing code
2. Writing ONLY code that is tested
3. Writing ONLY tests that test the code
4. A very short turnaround cycle
5. Refactoring early and often

# The Red-Green-Refactor Loop



# The Red-Green-Refactor Loop

- ▶ Red – Write a test for new functionality
  - ▶ This should immediately fail!
- ▶ Green
  - ▶ Write only enough code to make the test pass
- ▶ Refactor
  - ▶ Review code and make it better

# Detailed Run-Through of RGR Loop

1. Write a test for new functionality
2. Run test suite - only the new test should fail
3. Write only enough code to make test pass
4. Run test suite
5. If any tests fail, go to step 3
6. Refactor code
7. Run test suite
8. If any tests fail, go to step 6
9. If any more functionality, go to step 1; otherwise done

# TDD = A Kind of Test-First Development

- ▶ Basic idea is to think about expected behavior FIRST, before code
- ▶ You don't want to “corrupt” your mind with implementation details
- ▶ Figure out what the program should do (requirements!)
  
- ▶ Side note: there are other kinds of test-first development, such as ATDD (Acceptance Test Driven Development) and BDD (Behavior Driven Development)

# Step 1 – Write a test

- ▶ This test should be a small unit of functionality, say one input value and output value for a method.
- ▶ For pure TDD, you should not write multiple tests or tests which are very complex.

## Step 2 – Run Test Suite

- ▶ Run all the tests - only the one you've just added should fail.
- ▶ If it doesn't fail, you've already written the code for it! This might be a redundant test.
- ▶ If other tests fail, something weird happened. Completed tests should always be passing at this point.

## Step 3 – Write the Code

- ▶ Write just enough code to have the test pass.
- ▶ Avoid the temptation to over-engineer your solution or add more functionality than the test covers!

# Step 4 – Re-run the Test Suite

- ▶ All the tests should pass this time, assuming you actually added the functionality.
- ▶ Otherwise:
  - ▶ If only your new test fails:
    - ▶ You have not written your code (or possibly test) correctly.
  - ▶ If other tests fail:
    - ▶ You have created a regression failure; that is, you've broken other functionality on the system!
  - ▶ Note that these are not mutually exclusive!

## Step 5 – Check Test Results

- ▶ If any tests fail, fix them – either tests or code!
- ▶ Never move on before having an ENTIRELY GREEN (i.e. passing) test suite!

# Step 6 - Refactor

- ▶ Your first attempt at writing code will probably not be perfect
  - ▶ Poor algorithm choice?
  - ▶ Bad variable names?
  - ▶ Poor performance?
  - ▶ Badly documented?
  - ▶ Magic numbers?
  - ▶ Not easily comprehensible?
  - ▶ General bad design?

# Step 6 - Refactor

- ▶ Remember – you already have a working version before you refactor
  - ▶ We know it works because it provides the correct expected behavior according to the unit test suite
- ▶ When it comes to code, being right is more important than being good-looking

## Step 7 – Re-run Test Suite Again

- ▶ Make sure that your refactoring did not cause any problems
- ▶ It should have the same functionality (according to the unit test suite), just better code
- ▶ That is, all unit tests should still pass

## Step 8 – Check test results

- ▶ If any tests fail, something broke.
- ▶ Go and fix it before moving on!
- ▶ We are always aiming to have all-green tests

## Step 9 - Done

**Congratulations! You now have working code and can prove it with a test.**

**If there is more functionality to add, go back to step 1 and write a new test.**

**If not, SHIP IT.**

# YAGNI

- ▶ "You Ain't Gonna Need It"
- ▶ Don't add functionality you don't need right now.  
Chances are you won't need it and you're just going to waste time writing code for it.
- ▶ Code to the test!

# KISS

- ▶ “Keep It Simple, Smarty-pants”
- ▶ Don't try to write overly complex, clever, over-engineered code. Make it easy to understand and modify.
- ▶ “Premature optimization is the root of all evil” –Donald Knuth
- ▶ Prefer:

```
i++;
```

over

```
i += (NUM_A / (c.getNum() - d.getNum()));
```

# Fake It 'til You Make It

- ▶ Obviously applies to mocks/stubs
- ▶ But you can apply to smaller levels of functionality

Test:

```
assertEquals(sqrt(4), 2);
```

Code:

```
public void sqrt(int n) {  
    return 2;  
}
```

# Avoid Slow-Running Tests

- ▶ Note that each iteration requires at least three test suite runs. If your tests take a long time to run, TDD is impractical.

# Principles, Not Laws

- ▶ Nobody will throw you in jail if you write two tests during an iteration
- ▶ Sometimes tests are hard to make fast
- ▶ Etc.
- ▶ But they're code smells if you are using TDD.

# Benefits of TDD

- ▶ Automatically create tests!
  - ▶ Research shows that more tests are correlated with fewer defects
- ▶ Makes writing tests easy because it's done often
  - ▶ Anything you do often, you learn how to do better
- ▶ Tests are relevant
  - ▶ They are testing the exact functionality you are implementing
- ▶ Developer is focused on end result, not code
  - ▶ Code is a way to get the functionality the user wants

# Benefits of TDD

- ▶ Ensures that you take small steps
  - ▶ You know where defects lie; help localize errors
  - ▶ Research shows more senior engineers take smaller steps
- ▶ Code is extensible
  - ▶ You are already constantly extending the codebase
- ▶ Large test suite automatically created for you!
  - ▶ Helps avoid regression errors
  - ▶ High code coverage
- ▶ Confidence in the codebase

# Drawbacks of TDD

- ▶ Focus on unit tests may mean other aspects of testing get short shrift
  - ▶ Remember that unit tests focus on small units of code, not integration
- ▶ Extra up-front time
  - ▶ May be saved in large projects due to fewer defects / test coverage
- ▶ May not appropriate for prototyping
  - ▶ You may not always know expected behavior
- ▶ Hard to do large architectural changes
  - ▶ Some things just aren't possible to do in small steps

# Drawbacks of TDD

- ▶ Complex or mission/life-critical systems will require a more robust testing strategy
- ▶ Tests become part of the overhead of the project
  - ▶ Especially if they are brittle/fragile, or poorly written!
- ▶ Could fall into trap of overtesting
  - ▶ More time-consuming test suite runs, which hurts productivity
- ▶ Can be difficult to implement TDD on existing projects developed in a different paradigm
  - ▶ TDD assumes easy-to-write, fast-to-execute tests

# Fizzbuzzin' With TDD

Print out the numbers from 1 to 100, each on a separate line. If a number is evenly divisible by 3, print "Fizz" instead. If a number is evenly divisible by 5, print "Buzz" instead. If a number is evenly divisible by 3 and 5, print "FizzBuzz" instead. Otherwise, just print the number.

1

2

Fizz

4

Buzz

Fizz

...

# Start Out Nice and Easy

```
@Test
public void testNumber() {
    assertEquals(_fb.value(1), "1");
}
// Code
public String value(int n) {
    return "1";
}
```



# Let's Add Another Test

```
@Test  
public void testNumber2() {  
    assertEquals(_fb.value(2), "2");  
}  
  
// Code  
public String value(int n) {  
    return "1";  
}
```



# Let's Make A Little Change

```
public String value(int n) {  
    if (n == 1) {  
        return "1";  
    } else {  
        return "2";  
    }  
}
```



But could be better!

Let's Refactor – now much nicer, and tests still pass!

```
public String value(int n) {  
    return String.valueOf(n);  
}
```

# Add Another Test – it fails

```
@Test  
public void testNumber3() {  
    assertEquals(_fb.value(3), "Fizz");  
}
```

# We Need to Add Fizzy Code!

```
private boolean fizzy(int n) {  
    return (n % 3 == 0);  
}  
  
public String value(int n) {  
    if (fizzy(n)) {  
        return "Fizz";  
    } else {  
        return String.valueOf(n);  
    }  
}
```

A middle-aged man with white hair and a beard is smiling broadly and pumping his right fist into the air. He is wearing a red Starfleet uniform with a black collar and a gold rank insignia on the chest. The background shows a metallic interior, likely a Star Trek set. The image has a white border.

**YESSS!!!**

Let's Add A Test For Buzziness -  
It should fail.

```
@Test  
public void testNumber5() {  
    assertEquals(_fb.value(5), "Buzz");  
}
```

# Add and Integrate buzzy(n) Method

```
private boolean buzzy(int n) {  
    return (n % 5 == 0);  
}  
public String value(int n) {  
    if (fizzy(n)) {  
        return "Fizz";  
    } else if (buzzy(n)) {  
        return "Buzz";  
    } else {  
        return String.valueOf(n);  
    }  
}
```



# The Final Equivalence Class

```
@Test  
public void testNumber15() {  
    assertEquals(_fb.value(15), "FizzBuzz");  
}
```

# Modify The value() Method

```
public String value(int n) {  
    if (fizzy(n) && buzzy(n)) {  
        return "FizzBuzz";  
    } else if (fizzy(n)) {  
        return "Fizz";  
    } else if (buzzy(n)) {  
        return "Buzz";  
    } else {  
        return String.valueOf(n);  
    }  
}
```



# Result?

- ▶ We now have a working, tested implementation of FizzBuzz
- ▶ We have automated test coverage for all equivalence classes
- ▶ We had a path forward at all points

TDD makes you feel...

