CS1632, Lecture 10: 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)

Test-Driven Development

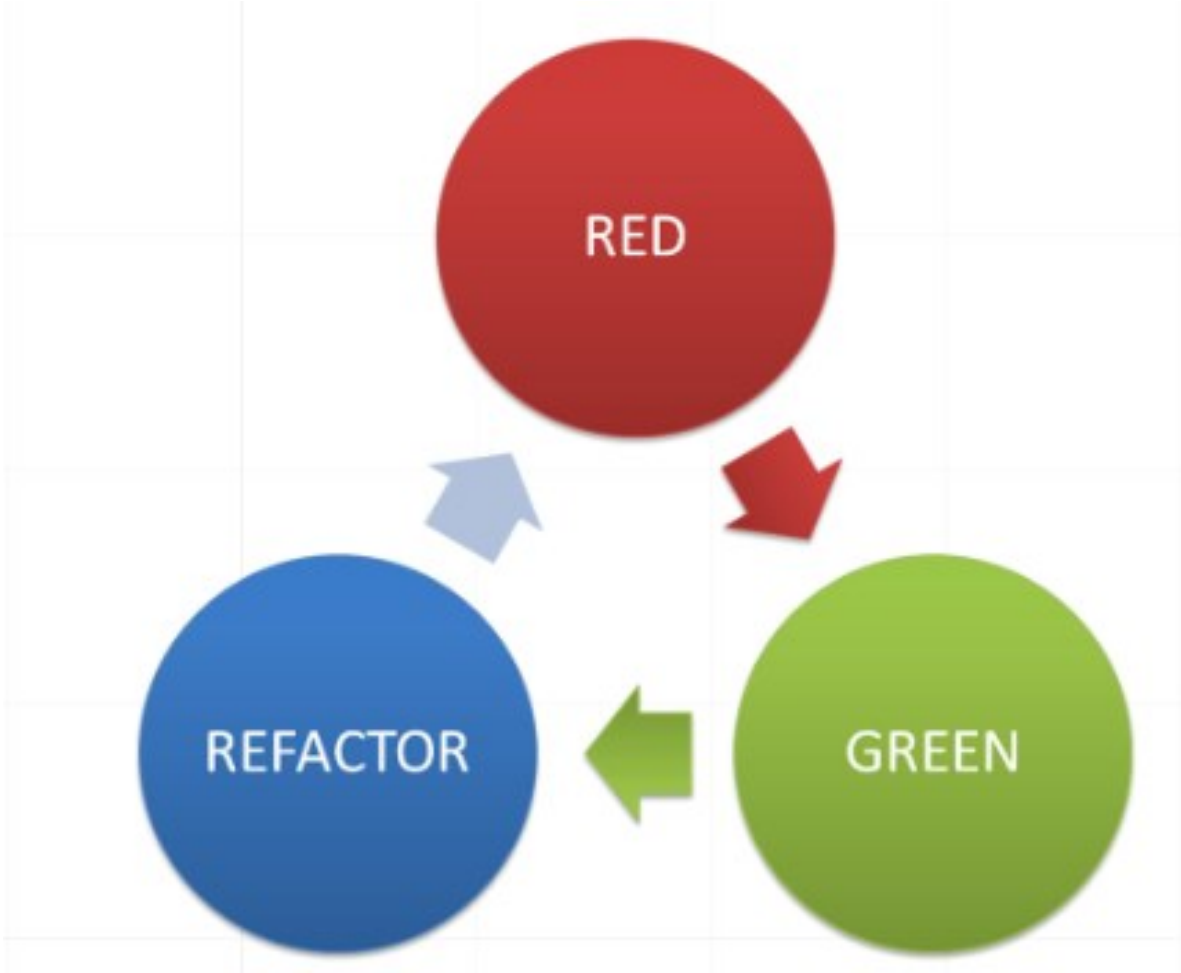
- A strategy for developing highly tested, quality software
- Not the be-all and end-all of strategies
- Google “TDD is dead” for a great argument against it
- Welcome to the still-forming world of software development!

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
  - Test should immediately fail! (Hence the Red)
- Green – Write only enough code to make the test pass
  - Now the test should pass. (Hence the Green)
- Refactor – Review code and make it better

Fizzbuzzin’ With TDD

- Requirements:

App shall print numbers from 1 to 100 delimited by spaces.

If number is a multiple of 3, app shall print "Fizz" instead.

If number is a multiple of 5, app shall print "Buzz" instead.

If number is a multiple of 3 and 5, app shall print "FizzBuzz" instead.

- Example output: 1 2 Fizz 4 Buzz Fizz 7 8 Fizz Buzz ...

Red - Start by adding a new test

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

… Which fails.


WELCOME
TO
FAIL
POPULATION: YOU

Green - Write code to make test pass

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

Nothing to Refactor.

Next test!

Red - Let’s Add Another Test

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


WELCOME
TO
FAIL
POPULATION: YOU

Green - Let's Make Another Change

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

But could be better!

Refactor – now much nicer, and tests still pass!

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

Red - Add Another Test – it fails

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

Green - 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);
   }
}
```


YESSS!!!
quickmeme.com

Refactor – Nothing to do here

```
private boolean fizzy(int n) {
  return (n % 3 == 0);
}

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

Red - Let’s Add A Test For Buzziness

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

… and of course it fails

Green - 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);
    }
}
```

Red - The Final Equivalence Class

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

… and it fails

Green - 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);
   }
}
```

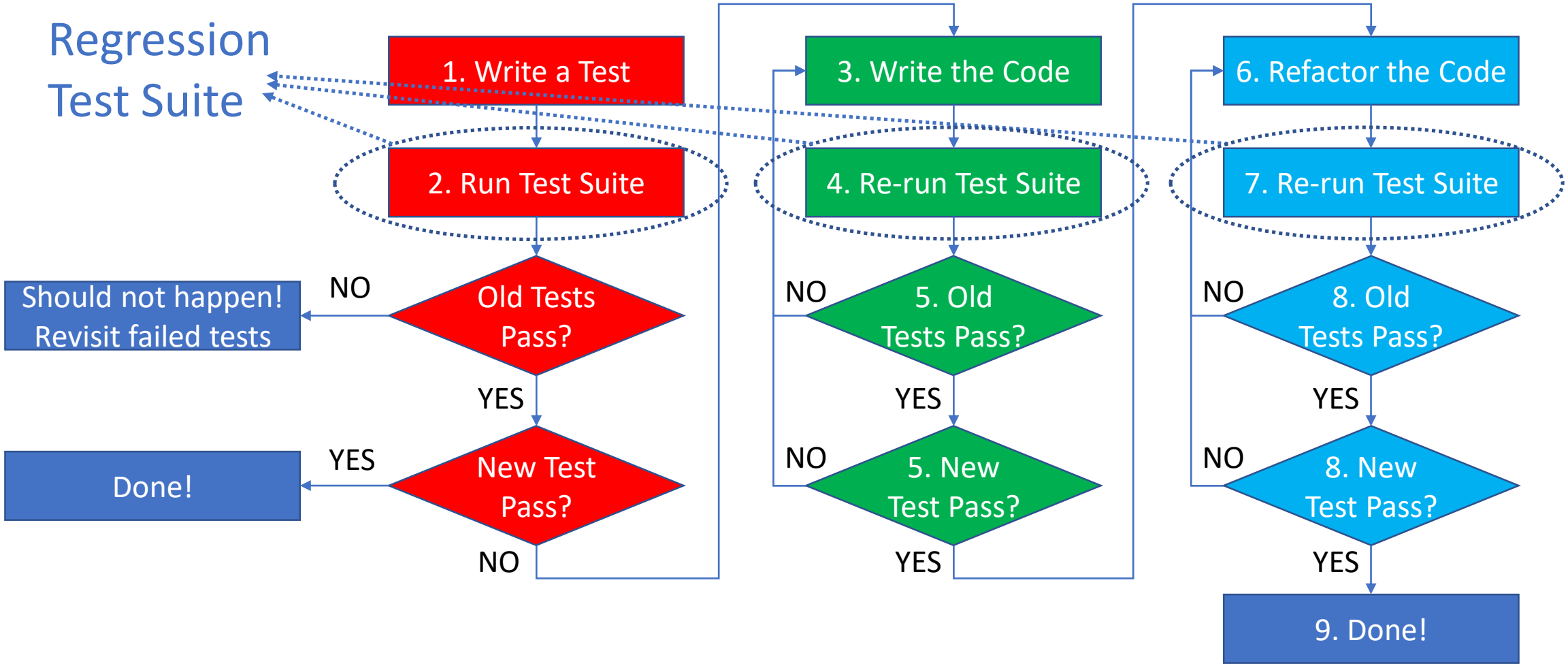
Refactor – Nothing to do

```
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);
   }
}
```

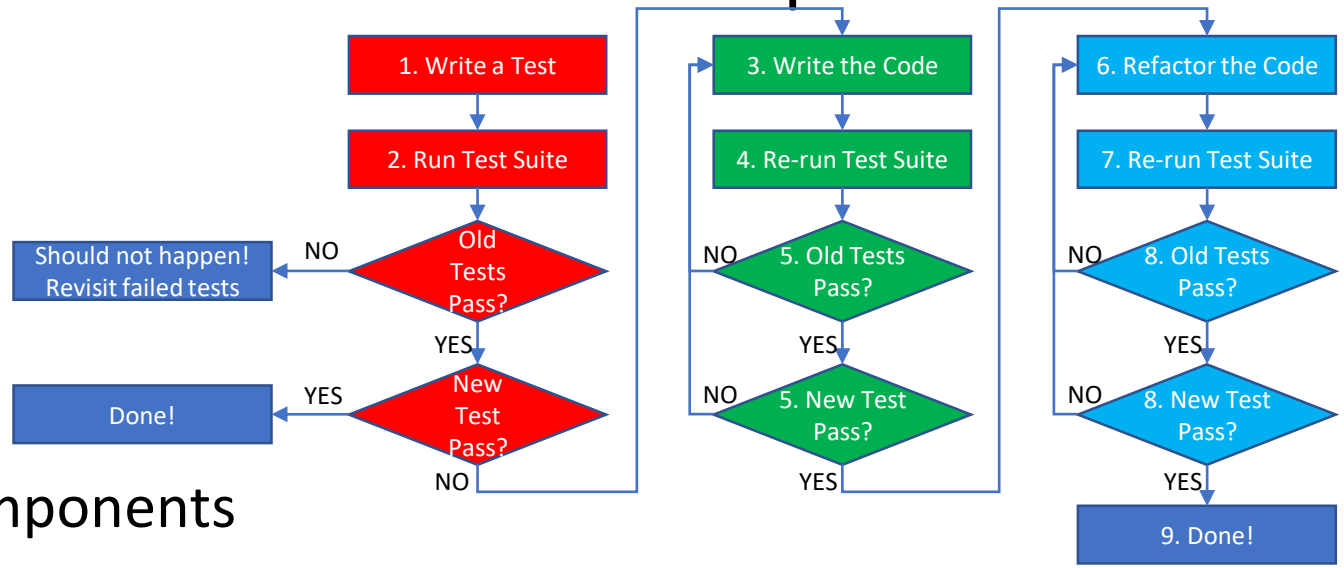
Result?

- 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

Flow Chart of Red-Green-Refactor Loop



Flow Chart of Red-Green-Refactor Loop



- Write one small test at a time
  - Keep a tight turnaround cycle!
- Run the entire test suite
  - Look out for regression errors!
  - Ensures continuous testing of all components
- Write just enough code to pass test
  - Resist temptation to go into untested territory
  - Ensures all code you are writing and all previous code is continuously covered
- Refactor at every iteration
  - Encourages focus on correctness since you will have a chance to refactor soon
  - Don’t forget to regression test after refactoring

What does Refactor involve?

- 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?
- Remember you already had a working version before refactoring
  - Being correct is more important than being good-looking

Key - Do not Write Code Beyond the Test

- Some jingles to curb your enthusiasm …
- *YAGNI* - You Ain't Gonna Need It
  - If you are not testing it, that means you don’t need it right now
  - If you don’t need it now, chances are you do won’t need it in the future
- *KISS* - Keep It Simple, Smarty-pants
  - Don't write overly complex, clever, over-engineered code
  - It just makes it harder to understand and modify later
  - “Premature optimization is the root of all evil” –Donald Knuth
- Fake It ‘til You Make It
  - Don’t get mired in implementing something strictly not necessary to pass test

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;
}
```

Make Unit Tests Fast and Independent

- Notice we are running an entire test suite on every small change?
  - That means testing time is going to heavily impact development cycle
- How do we avoid long testing delays?
- Fast: Make individual unit tests run quickly
  - Make heavy use of test doubles and stubbing for delay-prone components (e.g. databases, files, network I/O)
- Independent: Make sure tests do not rely on the result of other tests
  - Allows developer to arbitrarily choose only unit tests related to modified code
  - Allows tests to be split up and run in parallel

Benefits of TDD

- Ensures tests are relevant
  - Tests are written for the exact functionality you are implementing
  - Not some imaginary functionality you may implement in the future (or not)
- Ensures code is relevant
  - Code does not veer far from user needs, expressed in the form of unit tests
- Ensures that you take small steps
  - Experience programmers know small steps help localize errors
- Large test suite automatically created (at least it feels like it)
  - Helps avoid regression errors through 100% code coverage at all times
- Confidence in the codebase through continuous testing

Drawbacks of TDD

- Tests become part of the overhead of the project
  - In terms of maintenance: especially if there are tons of mocks
  - In terms of development cycle: sheer testing time slows down RGR loop
    (If you stub to speed up testing, it increases maintenance cost … sad)
- Hard to do large, complex architectural designs / redesigns
  - TDD keeps you short-sighted; you need long term thinking for a good design
  - Some things just aren't feasible to do in small steps
- Focus on unit tests may mean other aspects of testing get short shrift
  - Unit testing actively avoids integration testing through the use of mocks
  - Unit testing means a module or the system is never tested in its entirety
  - Unit tests are code-centric and do not incorporate end-user input

TDD = A Kind of Test-First Development

- Basic idea is to think about expected behavior FIRST, before coding
- Figure out what the program should do (requirements!)
- Write tests towards the requirements
- Write code towards the tests

* Side note: there are other kinds of test-first development, such as ATDD (Acceptance Test Driven Development) and BDD (Behavior Driven Development)

Now Please Read Textbook Chapter 15

- “TDD is dead. Long live testing.” - David Heinemeier Hansson: https://dhh.dk/2014/tdd-is-dead-long-live-testing.html