

CS1632, Lecture 9: Unit Testing, part 2

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How to test this method?

```
public class Example {  
    public static int doubleMe(int x) {  
        return x * 2;  
    }  
}
```

```
// Perhaps something like this...
```

```
@Test
```

```
public void zeroTest() {  
    assertEquals(Example.doubleMe(0), 0);  
}
```

```
@Test
```

```
public void positiveTest() {  
    assertEquals(Example.doubleMe(10), 20);  
}
```

```
@Test
```

```
public void negativeTest() {  
    assertEquals(Example.doubleMe(-4), -8);  
}
```

OK, how about this?

```
public class Example {  
    public void doDuckStuff(Duck d, boolean q) {  
        if (q) {  
            d.quack();  
        } else {  
            d.eat();  
        }  
    }  
}
```

1. How can we test Example.doDuckStuff() without Duck?
2. What is there to test to begin with? There are no values to test!

Advance Unit Testing Techniques

- Doubles
- Stubs
- Mocks and Behavior Verification

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Dependency on other classes == bad

- Why?
 - If a failure occurs in a test, where is the problem?
 - This method?
 - Other method?
 - Yet another method that another method called?
 - Cannot be *localized*
 - What if quack() hasn't been completed yet?

Test doubles

- “Fake” objects you can use in your tests
- They can act in any way you want – they do not have to act exactly as their “real” counterparts

examples

1. A doubled database connection, so you don't need to actually connect to the database
2. A doubled File object, so you can test read/write failures without actually making a file on disk
3. A doubled RandomNumberGenerator, so you can always produce the same number when testing

Doubles help keep tests localized

- They let you test only the item under test, not the whole application, allowing you to focus on the current item.
- Remember, double objects of classes that the current class depends on; don't double the current class!
 - That would mean you are making a “fake” version of what you are testing

example

```
@Test
public void testDeleteFrontOneItem() {
    LinkedList<Integer> ll = new
LinkedList<Integer>();
    ll.addToFront(Mockito.mock(Node.class));
    ll.deleteFront();
    assertEquals(ll.getFront(), null);
}
```

Advance Unit Testing Techniques

- Doubles
- **Stubs**
- Mocks and Behavior Verification

stubs

- Doubles are “fake objects”.
- Stubs are “fake methods”.

stubs

- Stubbing a method says "hey, instead of actually calling that method, just do whatever I tell you."
- "Whatever I tell you" is usually just return a value.

Example

```
public int quackAlot(Duck d, int num) {  
    int numQuacks = 0;  
    for (int j=0; j < num; j++) {  
        numQuacks += d.quack();  
    }  
    return numQuacks;  
}
```

Create a test double, stub the method

```
@Test
public void testQuackAlot() {
    Duck mockDuck = mock(Duck.class);
    when(mockDuck.quack()).thenReturn(1);
    int val = quackAlot(mockDuck, 100);
    assertEquals(val, 100);
}
```


We have made the test independent

- We only care about testing our quackAlot() method
 - We don't care about whether Duck.quack() works, or Duck works
 - Duck.quack() is tested separately in the unit tests for Duck class
- Unit tests should only test the unit being tested
 - Otherwise, test becomes BRITTLE (breaks easily due to external changes)
 - Otherwise, on failure, hard to pinpoint where defect occurred

Advance Unit Testing Techniques

- Doubles
- Stubs
- Mocks and Behavior Verification

OK, how about this?

```
public class Example {  
    public void doDuckStuff(Duck d, boolean q) {  
        if (q) {  
            d.quack();  
        } else {  
            d.eat();  
        }  
    }  
}
```

1. How can we test `Example.doDuckStuff()` without `Duck`?
2. What is there to test to begin with? There are no values to test!

Behavior Verification

- No relation to "verification" in "verification and validation".
- Behavior Verification vs. State Verification
 - State Verification: Tests the state of the program
 - Whether state changes correctly as a result of method call(s)
 - Done through **assertions** on **postconditions** (what we've done so far)
 - Behavior Verification: Tests the behavior of code
 - Whether certain methods have been called a certain number of times
 - Whether methods have been called with the correct parameters
 - Done through **verify** in Mockito

Mock

- Mock: A test double which uses behavior verification
- Many frameworks (such as Mockito, the one we are using) don't differentiate between doubles and mocks
- Technically, a mock is a specific kind of test double.

Example - A Slightly Modified quackAlot()

```
public void quackAlot(Duck d, int num) {  
    int throwaway = 0;  
    for (int j=0; j < num; j++) {  
        throwaway = d.quack();  
    }  
} // What can we test here?
```

Example test

```
@Test
public void testQuackAlot() {
    // Make a double of Duck
    Duck mockDuck = mock(Duck.class);
    // Stub the quack() method
    mockDuck.when(mockDuck.quack()).thenReturn(1);
    // Call quackAlot, resulting in 5 calls to mockDuck.quack()
    quackAlot(mockDuck, 5);
    // Make a true mock by verifying quack called 5 times
    Mockito.verify(mockDuck, times(5)).quack(); // make a true mock
    // Note no assertions! Assertions built in to verify
}
```

Structuring unit tests

- Two philosophies:
 - Test only public methods.
 - This is the true interface to an object. We should be allowed to change the implementation details at will.
 - Private methods will be tested as a side effect of any public method calls.
 - Private methods may be difficult to test due to language/framework.
 - Test every method – public and private.
 - Public/private distinction is arbitrary – you still want it all to be correct.
 - Unit testing means testing the lowest level; we should test as close to the actual methods as possible.

example

```
class Bird {  
    public int chirpify(int n) {  
        return nirpify(n) + noogiefy(n + 1);  
    }  
    private int nirpify(int n) { ... }  
    private int noogiefy(int n) { ... }  
    // Dead code, can never be called!  
    private void catify(double f) { ... }  
}
```

Another example

```
// Assume all the called methods are complex
public boolean foo(boolean n) {
    if (bar(n) && baz(n) && quux(n)) {
        return true;
    } else if (baz(n) ^ (thud(n) || baa(n)) {
        return false;
    } else if (meow(n) || chew(n) || chirp(n)) {
        return true;
    } else {
        return false;
    }
}
```

We have to come up with a decision!

- Like most software engineering decisions - it depends. I don't think that there is a right answer.
- That being said, for this class, we are going to follow the philosophy of testing all public methods, not private methods.
- If you are interested in testing private methods in Java, you need to use something called “reflection” – see Chapter 24 in AFIST

What inputs should I test on those methods?

- Ideally...
 - Each equivalence class
 - Boundary values
 - Any other edge cases
- And also failure modes
 - Failure modes: inputs where method is expected to fail
 - Failing where it should is also part of its requirements

What are The equivalence classes, boundary values, and failure modes we should test?

```
public int quack(int n) throws Exception {  
    if (n < 10) {  
        return 1;  
    } else if (n < 20) {  
        return 2;  
    } else {  
        throw new Exception("too many quacks");  
    }  
}
```

What if it is difficult to test things?

- It happens
- Especially when working with legacy code.
- Such is life.
- Don't give up!

My advice

- Try to add tests as soon as possible. DO NOT WRITE ALL OF YOUR CODE AND THEN TRY TO ADD TESTS.
- Ideally, write tests before coding (TDD).
- Develop in a way to make it easy for others to test.
- In legacy systems, add tests as you go. Don't fall into the morass!

Unit Testing != System Testing

- The manual testing that you've already done is a system test – it checks that the whole system works.
- This is not the goal of unit tests! Unit tests check that very small pieces of functionality work, not that the system as a whole works together.
- A proper testing process will include both –unit tests to pin down errors in particular pieces of code, system tests to check that all those supposedly-correct pieces of code work together.

Now Please Read Textbook Chapter 14

- In addition, look at code using Mockito in our JUnit example:
`sample_code/junit_example/LinkedListTest.java`