Building Tests and hw5

10-17-2012

Section 4

by Kellen Donohue, with material from Krysta Yousoufian

Agenda

- Assignments
  - hw2 will be returned soon
  - hw3 being returned
  - hw4 due tonight
  - hw5 released
- Building a test suite
- HW5 warm-up

Unit Test Best Practices

How to craft well-written JUnit tests

#1: Use descriptive asserts, test names

- When a test fails, JUnit tells you:
  - Name of test method
  - Message passed into failed assertion
  - Expected and actual values of failed assertion
  - Stack trace

- The more descriptive this information is, the easier it is to diagnose failures

- Avoid System.out.println()
  - Want any diagnostic info to be captured by JUnit and associated with that test method

#1: Use descriptive asserts, test names

- **Test name:** describe what’s being tested
  - Good: “testAddDaysWithinMonth,” …
  - Not so good: “testAddDays1,” “testAddDays2,” …
  - Useless: “test1,” “test2,” …
  - Overkill: “testAddDaysOneDayAndThenFiveDaysThenNegativeFourDaysStartingOnJanuaryTwentySeventhAndMakeSureItRollsBackToJanuaryAfterRollingToFebruary()”

#1: Use descriptive asserts, test names

- **Test name:** describe what’s being tested
  - Good: “testAddDaysWithinMonth,” …
  - Not so good: “testAddDays1,” “testAddDays2,” …
  - Useless: “test1,” “test2,” …
  - Overkill: “testAddDaysOneDayAndThenFiveDaysThenNegativeFourDaysStartingOnJanuaryTwentySeventhAndMakeSureItRollsBackToJanuaryAfterRollingToFebruary()”

#1: Use descriptive asserts, test names

- **Assertions:** take advantage of expected & actual values
- Make sure you have the right order:

```
assertEquals(message, expected, actual)
```

- Use the right assert for the occasion:

`assertEquals(expected, actual)` instead of `assertTrue(expected.equals(actual))` or `assertTrue(expected==actual)`

`assertTrue(b)` instead of `assertEquals(true, b)`

#1: Use descriptive asserts, test names

- **Assertion message:** contribute new information
  - No need to repeat expected/actual values or info in test name
  - e.g. details of what happened before the failure

Example:

```
@Test
public void test_addDays_wrapToNextMonth() {
    Date actual = new Date(2050, 2, 15);
    actual.addDays(14);
    Date expected = new Date(2050, 3, 1);
    assertEquals("date after +14 days", expected, actual);
}
```

Let’s put it all together!

```
public class DateTest {

      ...

      // Test addDays when it causes a rollover between months
    @Test
    public void testAddDaysWrapToNextMonth() {
        Date actual = new Date(2050, 2, 15);
        actual.addDays(14);
        Date expected = new Date(2050, 3, 1);
        assertEquals("date after +14 days", expected,    actual);
    }
```

Let’s put it all together!

```
public class DateTest {

      ...

      // Test addDays when it causes a rollover between
    @Test
    public void testAddDaysWrapToNextMonth() {
        Date actual = new Date(2050, 2, 15);
        actual.addDays(14);
        Date expected = new Date(2050, 3, 1);
        assertEquals("date after +14 days", expected,    actual);
    }
```

Descriptive method name

Let’s put it all together!

```
public class DateTest {

       ...

       // Test ad                rollover between months
    @Test
    public void testAddDaysWrapToNextMonth() {
        Date actual = new Date(2050, 2, 15);
        actual.addDays(14);
        Date expected = new Date(2050, 3, 1);
        assertEquals("date after +14 days", expected,
actual);
    }
```

Tells JUnit that this method is a test to run

Let’s put it all together!

```
public class DateTest {

      ...

      // Test addDays when it causes a rollover between months
    @Test
    public void testAddDaysW
        Date actual = new Da
        actual.addDays(14);
        Date expected = new Date(2050, 3, 1);
        assertEquals("date after +14 days", expected,    actual);
    }
```

Variables names describe function of each object

Let’s put it all together!

```
public class DateTest {

      ...

      // Test addDays when it causes a rollover between months
    @Test
    public void testAddDaysWrapToNextMonth() {
        Date actual = new Date(2050, 2, 15);
        actual.addDays(14);
        Date expected = n
        assertEquals("da                          ted,    actual);
    }
```

Use assertion to check expected results

Let’s put it all together!

```
public class DateTest {

      ...

      // Test addDays when it causes a rollover between months
    @Test
    public void testAddDaysWrapToNextMonth() {
        Date actual = new Date(2050, 2, 15);
        actual.addDays(14);
        Date expected = new Date(2050, 3, 1);
        assertEquals("date after +14 days", expected,    actual);
    }
```

Message gives details about the test in case of failure

Let’s put it all together!

```
public class DateTest {

       ...

       // Test addDays when it causes a rollover between months
    @Test
    public void testAddDaysWrapToNextMonth() {
        Date actual = new Date(2050, 2, 15);
        actual.addDays(14)
        Date expected = ne                1);
        assertEquals("date after +14 days", expected, actual);
    }
```

Expected value first, actual value second

Let’s put it all together!

```
public class DateTest {

      ...

      // Test addDays when it causes a rollover between months
    @Test
    public void testAddDaysWrapToNextMonth() {
        Date actual = new Date(2050, 2, 15);
        actual.addDays(14);
        Date expected = new Date(2050, 3, 1);
                              after +14 days", expected,    actual);
    }
```

That’s it! Test is short & sweet

#2: Keep tests small

- Ideally, each test only tests one “thing”
  - One “thing” usually means one method under one input condition

- Where possible, only test one method at a time
  - Not always possible – but if you test `x()` using `y()`, try to test `y()` in isolation in another test
  - E.g. if you test `add()` using `contains()`, separately test `contains()` before any items are added

#2: Keep tests small

- Only a few (likely one) assert statements per test
  - Test halts after first failed assertion
  - Don’t know whether later assertions would have failed
- Low-granularity tests help you isolate bugs
  - Tell you exactly what failed and what didn’t

What NOT to do

- IntArrayTest
- What’s wrong?

What NOT to do

- IntArrayTest
- What’s wrong?

What NOT to do

- IntArrayTest
- What’s wrong?

- testIntArray tests way too many things
  - Too many methods, array states
- Solution: break down by method being tested and/or state of array
- IntArrayTestBetter

#3: Choose the right tests

- Given a finite number of tests, want reasonable confidence in an infinite number of inputs

- Input = initial state of object + method arguments + …

#3: Choose the right tests

- For each method, ask: what are the equivalence classes?
  - Items in a collection: none, one, many

- Write a test for each equivalence class

#3: Choose the right tests

- Consider common input categories
  - `Math.abs()`: negative, zero, positive values

- Consider boundary cases
  - Inputs on the boundary between equivalence classes
  - Person.isMinor(): age < 18, **age == 18**, age > 18

- Consider edge cases
  - -1, 0, 1, empty list, `arr.length, arr.length-1`

- Consider error cases
  - Empty list, null object

#3: Choose the right tests

- Consider common input categories
  - `Math.abs()`: negative, zero, positive values

- Consider boundary cases
  - Inputs on the boundary between equivalence classes
  - Person.isMinor(): age < 18, **age == 18**, age > 18

- Consider edge cases
  - -1, 0, 1, empty list, `arr.length, arr.length-1`

- Consider error cases
  - Empty list, null object

Other guidelines

- Test all methods
  - Caveat: constructors don’t necessarily need explicit testing

- Keep tests simple – avoid complicated logic
  - minimize `if/else`, `loops`, `switch`, etc.
  - Don’t want to debug your tests!

- Tests should always have at least one assert
  - *Unless* testing that an exception is thrown
  - Simply testing that an exception is *not* thrown is not necessary
  - `assertTrue(true);` doesn’t count!

Other guidelines

- Tests should be *isolated*
  - Not dependent on side effects of other tests
  - Should be able to run in any order

- Use helper methods to factor out common operations
  - E.g. setting up initial state of an object

Setup and Teardown

- Methods to run before/after each test case method is called:

```
@Before
public void name() { ... }
@After
public void name() { ... }
```

- Methods to run once before/after the entire test class runs:

```
@BeforeClass
public static void name() { ... }
@AfterClass
public static void name() { ... }
```

Example: `Date`

```
public Date(int year, int month, int day)
public Date()                   // today
public int getDay(), getMonth(), getYear()
public void addDays(int days)   // advances by days
public int daysInMonth()
public String dayOfWeek()       // e.g. "Sunday"
public boolean equals(Object o)
public boolean isLeapYear()
public void nextDay()         // advances by 1 day
public String toString()
```

- Come up with unit tests to check the following:
  - That no `Date` object can ever get into an invalid state.
  - That the `addDays` method works properly.
  - It should be efficient enough to add 1,000,000 days in a call.

Example: `IntStack`

- What tests should we write?

More examples

- How would we test the following Collections interface methods:
- Collections.binarySearch
- Collections.sort
- …
- (Assume the `List` we pass in has already been tested)

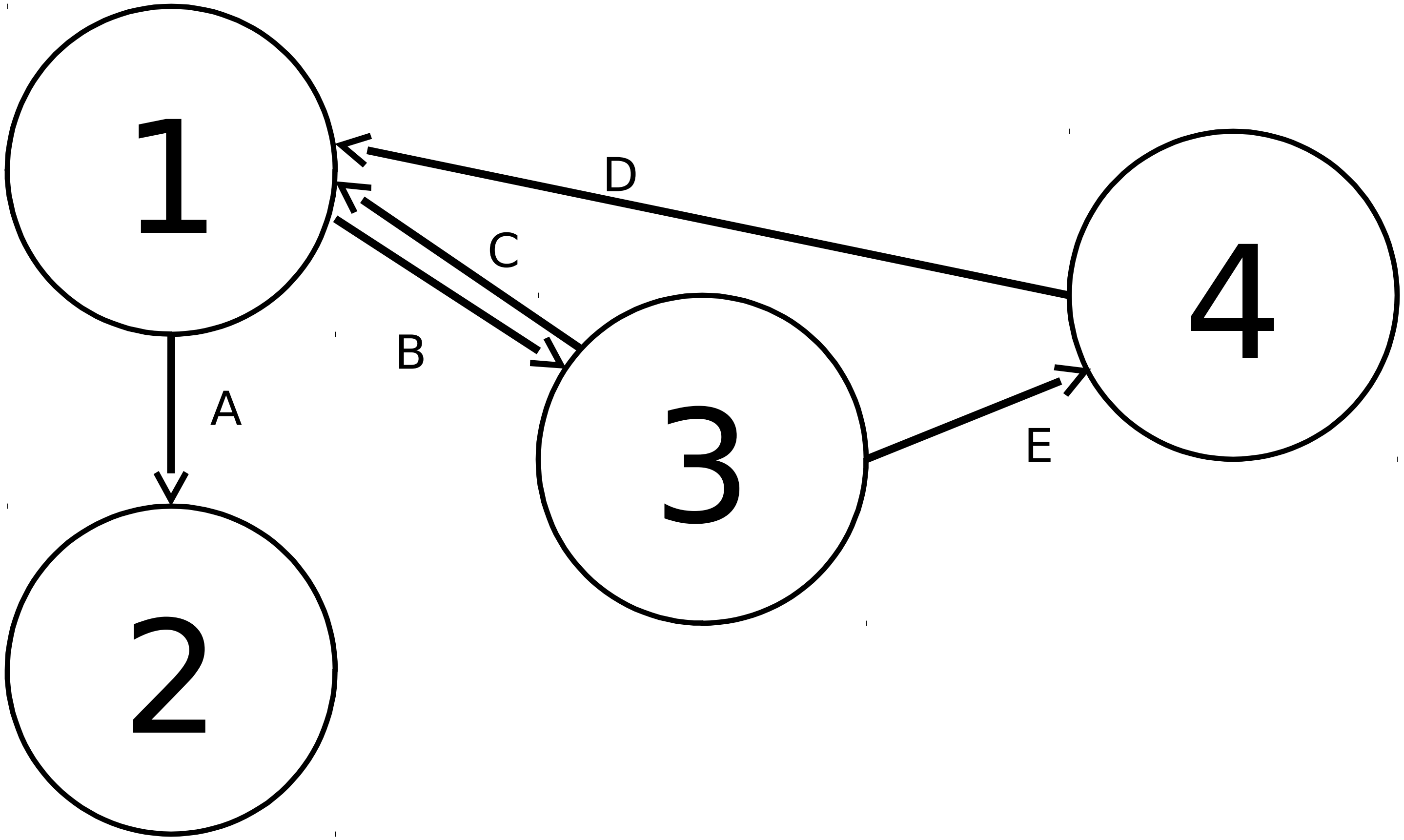
JUnit Summary

- Tests need *failure atomicity* (ability to know exactly what failed).
  - Each test should have a descriptive name.
  - Assertions should have clear messages to know what failed.
  - Write many small tests, not one big test.
- Test for expected errors / exceptions.
- Choose a descriptive assert method, not always `assertTrue`.
- Choose representative test cases from equivalent input classes.
- Avoid complex logic in test methods if possible.
- Use helpers, `@Before` to reduce redundancy between tests.

Homework 5

- Design, spec, build, and test your own Graph ADT
- No starter source code
- Unique testing framework

Graph Explanation



HW 5 Explanation

- Specification
  - Design your classes, how they fit together, what operations look like
  - Don’t write a “kitchen sink” or “god” class

HW 5 Testing

- Specification vs. Implementation Tests
  - Implementation tests
  - JUnit tests
  - Black box & White box
  - Specification tests
  - We want to see if your program actually implements a Graph properly
  - Issue commands like AddNode, AddEdge, ListNode, ListEdge, checked externally
  - Black box by necessity

HW5TestDriver

- Specification Tests
  - Commands run on your program
  - For each test
  - Run the commands in the file ending in .test
  - Save output in .actual
  - Compared to .expected
- Demo in Eclipse

Design Brainstorming

- Work by yourself first, then compare with neighbors
- Two implementation strategies
  - As an incidence list, in which each vertex stores its edges and each edge stores its connected vertices.
  - As an adjacency matrix, which explicitly represents, for every pair ⟨A,B⟩ of edges, whether there is a link from A to B, and how many.

Design Review

- Share what you came up with, RI, and AF
- Runtime/Space complexity of various operations
  - Which is faster for
  - Seeing if two vertices are adjacent?
  - Adding a vertex?
  - Adding an edge?
  - Which takes more memory on sparse/dense graphs