Building Tests and hw5

10-17-2012

Section 4

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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

- **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 roll
    @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 {

    ...

    // Te                                uses 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);
    }
```

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 testAddDaysWrapToNextMonth() {
        Date actual = new Date(2050, 3, 15);
        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 expecte                                    3, 1);
        assertEquals                                    ays", expected,
            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 = new Da
        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);
        [illegible]("date after +14 days", expected,

    }
```

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?

- 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

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

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)

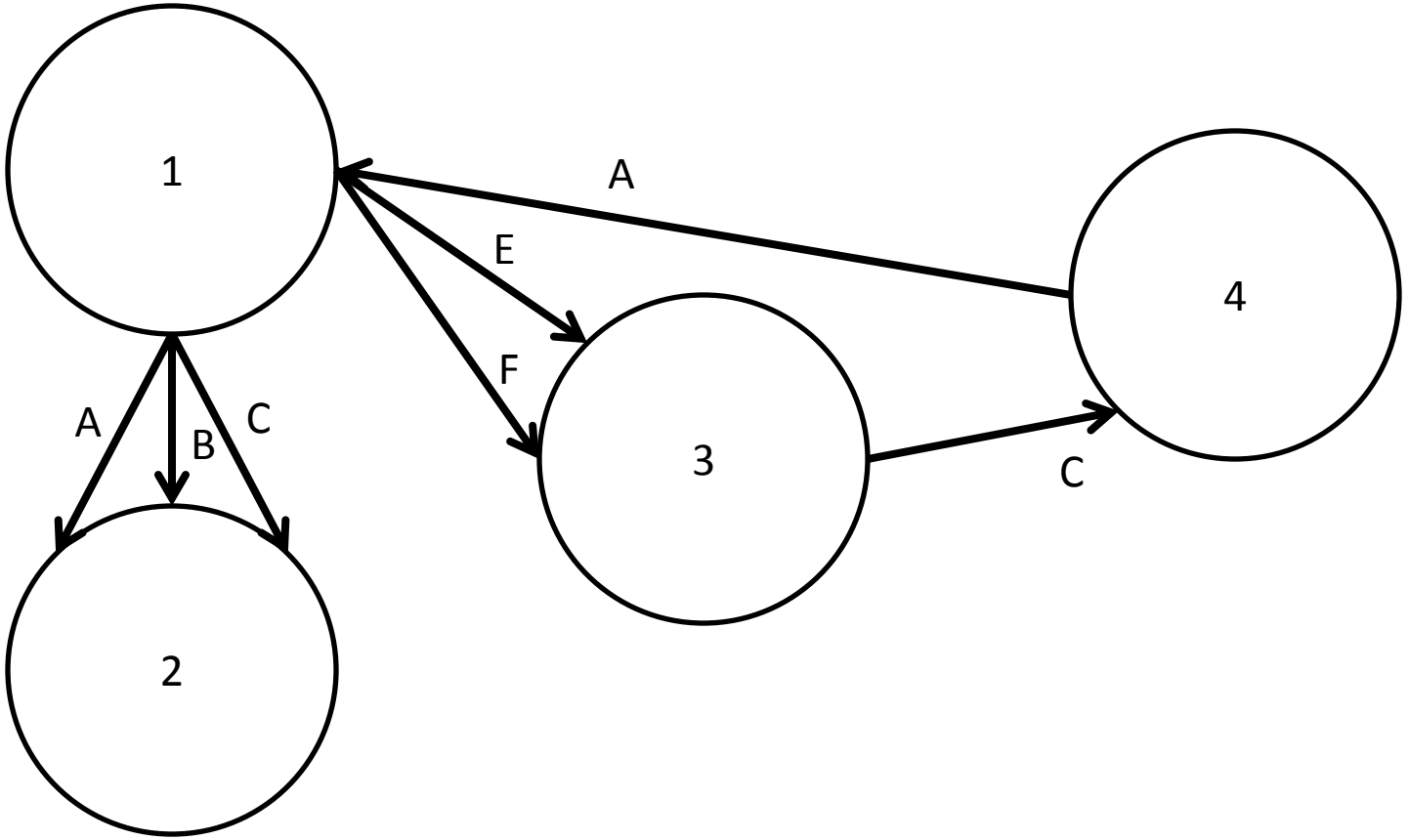
JUnit Summary

- 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

Cross-checker

Student cross-checking rank	Points earned (out of 15)	% incorrect tests	bugs found in fellow students' code (%)	% fellow students whose correct tests found bugs in this code
Staff		*all tests correct*	*found bugs in 67%*	*0%*
1. NODE-BANG	13 points	all tests correct	found bugs in 47%	100%
2. RING-DOUG	12 points	all tests correct	found bugs in 44%	3%
3. NIB-ADEN	11 points	all tests correct	found bugs in 42%	17%
4b. SEEK-HIDE	10 points	4% bad tests	found bugs in 58%	0%
4a. ALAN-HARK	10 points	all tests correct	found bugs in 39%	17%
4c. HEED-AJAR	10 points	all tests correct	found bugs in 39%	0%
5b. LESK-NOAH	9 points	4% bad tests	found bugs in 53%	0%
5a. RENA-BID	9 points	all tests correct	found bugs in 36%	19%
6a. ROE-AHOY	8 points	1% bad tests	found bugs in 47%	36%
6b. BATE-MUM	8 points	11% bad tests	found bugs in 47%	100%
7a. CLAM-SLAY	7 points	5% bad tests	found bugs in 44%	0%
7b. RIG-TURF	7 points	all tests correct	found bugs in 31%	17%
8c. FIR-CURL	6 points	7% bad tests	found bugs in 42%	31%
8b. FUND-LA	6 points	3% bad tests	found bugs in 42%	0%
8a. MOT-DIAL	6 points	10% bad tests	found bugs in 42%	0%
9a. BAH-BLOW	5 points	13% bad tests	found bugs in 39%	56%
9b. SANG-BARK	5 points	2% bad tests	found bugs in 39%	0%
9d. SUB-SHAY	5 points	11% bad tests	found bugs in 39%	31%
9c. SKIM-FORT	5 points	6% bad tests	found bugs in 39%	3%
10b. COED-OLIN	4 points	4% bad tests	found bugs in 36%	100%
10a. HAS-DAWN	4 points	6% bad tests	found bugs in 36%	0%

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