CSE332: Data Abstractions

Section 4

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CSE 331 Slides (JUnit)

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Section Agenda

- **Project 2**: Shake-n-Bacon
  - More Generics
  - Comparator
  - Inheritance review
  - Iterator / Anonymous class
  - JUnit Testing & Other Debugging tools
- B^+-Tree
- HW2, HW3 question & Tip

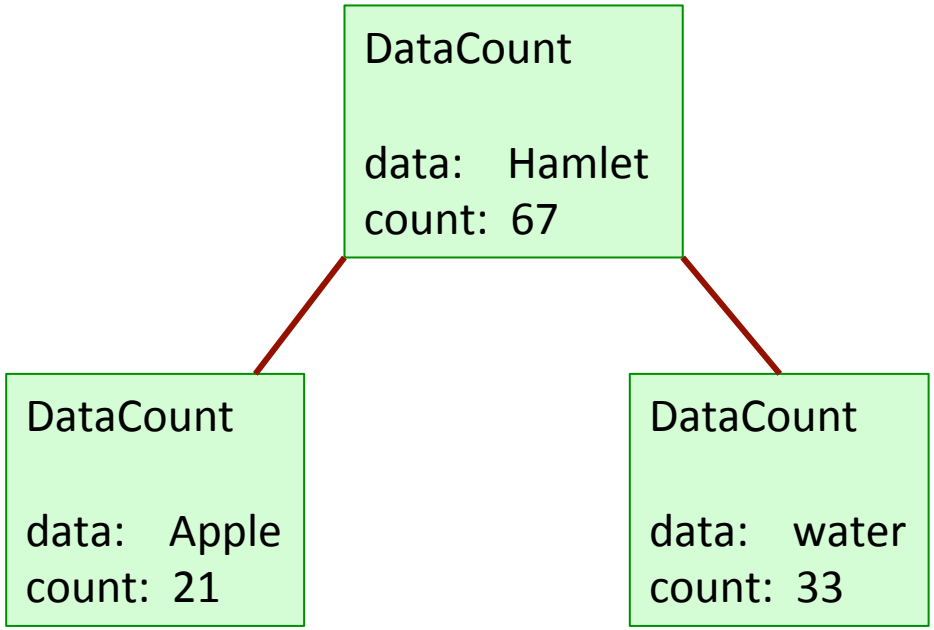
Project 2

Shake-n-Bacon

Word Frequency Analysis

- **Phase A:** Implement 3 ADTs + Heap sort
  - Due next Wednesday!
  - Word frequency analysis using different DataCounters

- **AVLTree**
- **MoveToFrontList**
- **FourHeap**



Generics

Generic Arrays & Wildcard

Generic Arrays

- **Field & variable can have generic array type**

```
E[] elemArray;
```

- **Cannot create new generic array**

```
E[] elemArray = new E[INITIAL_CAPACITY];    // Error
```

  - Arrays need to “know their element type”
  - Type “E” is unknown type

- **Workaround with Object[]** - Unavoidable warning

```
E[] elemArray = (E[]) new Object[INITIAL_CAPACITY];
// Generates warning, but ok
```

Array of Parameterized type

- **Cannot create array of parameterized type**

```
DataCount<E>[] dCount = new DataCount<E>[SIZE]; //Error
```

- **Object[] does not work** - ClassCastException

```
DataCount<E>[] dCount = (DataCount<E>[])
                        new Object[SIZE]; //Exception
```

  - Arrays need to “know their element type”
  - Object not guaranteed to be DataCount

- **Specify it will always hold “DataCount”**

```
DataCount<E>[] dCount = (DataCount<E>[])
                        new DataCount[SIZE]; // ok
```

Generics & Inner Class

- **Do not re-define type parameter**

```
class OuterClass<E> {
    class InnerClass<E> {}
}   // No ☹
```

```
class OuterClass<E> {
    class InnerClass {}
}   // Yes ☺
```

- Works, but not what you want!!
- Analogous of local variable shading field

```
class SomeClass {
    int myInt;
    void someMethod() {
        int myInt = 3;
        myInt ++;
    }  // Not the field
}
```

```
class OuterClass<E> {
    E myField;
    class InnerClass<E> {
        ...
        E data = myField;
    }  // Not the same type!!
}
```

Generic Methods

- **A method can be generic when the class is not**

```
public static <E> void insertionSort
(E[] array, Comparator<E> comparator);
```

  - Define the type variable at the method

- **More generics**

  http://docs.oracle.com/javase/tutorial/java/generics/index.html

Wildcard

- **Used to denote super/subtype of type parameter**
- **Upper bounded wildcard:** `<? extends E>`
  - E and every subtype (subclass) of E
- **Lower bounded wildcard:** `<? super E>`
  - E and every supertype (superclass) of E
- **Consider `<? extends E>` for parameters, `<? super E>` for return type**
  - The only use in this project is with comparator

```
public BinarySearchTree(Comparator<? super E> c);
```

Inheritance

Superclass & Interface

Interface & Inheritance

- **Interface provides list of methods a class promise to implement**

  - Inheritance: is-a relationship *and* code sharing.
    - `AVLTree` can be treated as `BinarySearchTree` and inherits code.

  - Interfaces: is-a relationship *without* code sharing.
    - `FourHeap` can be treated as `PriorityQueue` but inherits no code.

- **Inheritance provides code reuse** **Style Points!!**
  - Take advantage of inherited methods
  - Do not re-implement already provided functionality
  - Override only when it is necessary

Comparing Objects

`Comparable` & `Comparator`

Comparing objects

- Operators <, > do not work with objects in Java

  - **Two ways of comparing**:

    1. Implement Comparable Interface

       - Natural Ordering: 1, 2, 3, 4 …

       - One way of ordering

    2. Use Comparator **<- Project 2**

       - Many ways of ordering

The Comparable interface

```
public interface Comparable<T> {
    public int compareTo(T other);
}
```

- A call of **A**.`compareTo(`**B**`)` should return:
  - a value <0 if **A** comes "before" **B** in the ordering,
  - a value >0 if **A** comes "after" **B** in the ordering,
  - or exactly 0 if **A** and **B** are considered "equal" in the ordering.

What's the "natural" order?

```
public class Rectangle implements Comparable<Rectangle> {
    private int x, y, width, height;

    public int compareTo(Rectangle other) {
        // ...?
    }
}
```

- What is the "natural ordering" of rectangles?
  - By x, breaking ties by y?
  - By width, breaking ties by height?
  - By area? By perimeter?

- Do rectangles have any "natural" ordering?
  - Might we ever want to sort rectangles into some order anyway?

Comparator interface

```
public interface Comparator<T> {
    public int compare(T first, T second);
}
```

- Interface `Comparator`:
  - External object specifies comparison function
  - Can define multiple orderings

Comparator examples

```
public class RectangleAreaComparator
        implements Comparator<Rectangle> {
    // compare in ascending order by area (WxH)
    public int compare(Rectangle r1, Rectangle r2) {
        return r1.getArea() - r2.getArea();
    }
}

public class RectangleXYComparator
        implements Comparator<Rectangle> {
    // compare by ascending x, break ties by y
    public int compare(Rectangle r1, Rectangle r2) {
        if (r1.getX() != r2.getX()) {
            return r1.getX() - r2.getX();
        } else {
            return r1.getY() - r2.getY();
        }
    }
}
```

Using Comparators

- `TreeSet` and `TreeMap` can accept a `Comparator` parameter.

```
Comparator<Rectangle> comp = new RectangleAreaComparator();
Set<Rectangle> set = new TreeSet<Rectangle>(comp);
```

- Searching and sorting methods can accept `Comparator`s.

```
Arrays.binarySearch(array, value, comparator)
Arrays.sort(array, comparator)
Collections.binarySearch(list, comparator)
Collections.max(collection, comparator)
Collections.min(collection, comparator)
Collections.sort(list, comparator)
```

- Methods are provided to reverse a `Comparator`'s ordering:

```
Collections.reverseOrder()
Collections.reverseOrder(comparator)
```

Iterator

objects that traverse collections

Iterator

- Object that allows traverse elements of collection

  - Anonymous class: Combined class declaration and instantiation.

```
public SimpleIterator<DataCount<E>> getIterator() {

      return new SimpleIterator<DataCount<E>>() {
           // Returns true if there are more elements to examine
           public boolean hasNext() {
                ...
           }
           // Returns the next element from the collection
           public DataCount<E> next() {
                if(!hasNext()) {
                     throw new NoSuchElementException();
                }
                ...
           }
      };
}
```

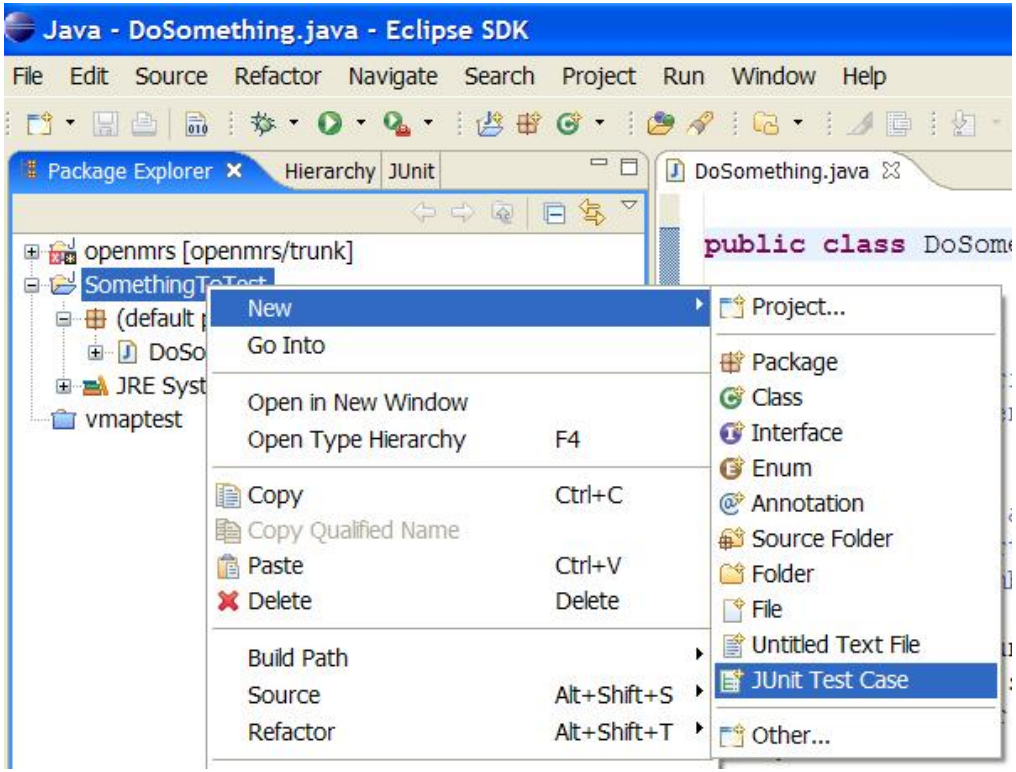
JUnit

Unit testing: Looking for errors in a subsystem in isolation

JUnit and Eclipse

- To add JUnit to an Eclipse project, click:
  - **Project → Properties → Build Path → Libraries → Add Library... → JUnit → JUnit 4 → Finish**

- To create a test case:
  - right-click a file and choose **New → Test Case**
  - or click **File → New → JUnit Test Case**
  - Eclipse can create stubs of method tests for you.



A JUnit test class

```
import org.junit.*;
import static org.junit.Assert.*;

public class name {
    ...

    @Test
    public void name() {  // a test case method
        ...
    }
}
```

- A method with `@Test` is flagged as a JUnit test case.
  - All `@Test` methods run when JUnit runs your test class.

JUnit assertion methods

`assertTrue(`**`test`**`)`	fails if the boolean test is `false`
`assertFalse(`**`test`**`)`	fails if the boolean test is `true`
`assertEquals(`**`expected, actual`**`)`	fails if the values are not equal
`assertSame(`**`expected, actual`**`)`	fails if the values are not the same (by ==)
`assertNotSame(`**`expected, actual`**`)`	fails if the values *are* the same (by ==)
`assertNull(`**`value`**`)`	fails if the given value is *not* `null`
`assertNotNull(`**`value`**`)`	fails if the given value is `null`
`fail()`	causes current test to immediately fail

- Each method can also be passed a string to display if it fails:
  - e.g. `assertEquals(`**`"message", expected, actual`**`)`

Trustworthy tests

- Test **one thing at a time** per test method.
  - 10 small tests are much better than 1 test 10x as large.

- Each test method should have few (likely 1) assert statements.
  - If you assert many things, the first that fails stops the test.
  - You won't know whether a later assertion would have failed.

- Tests should minimize logic – Bug in test code is hard to debug!
  - minimize `if/else`, `loops`, `switch`, etc.

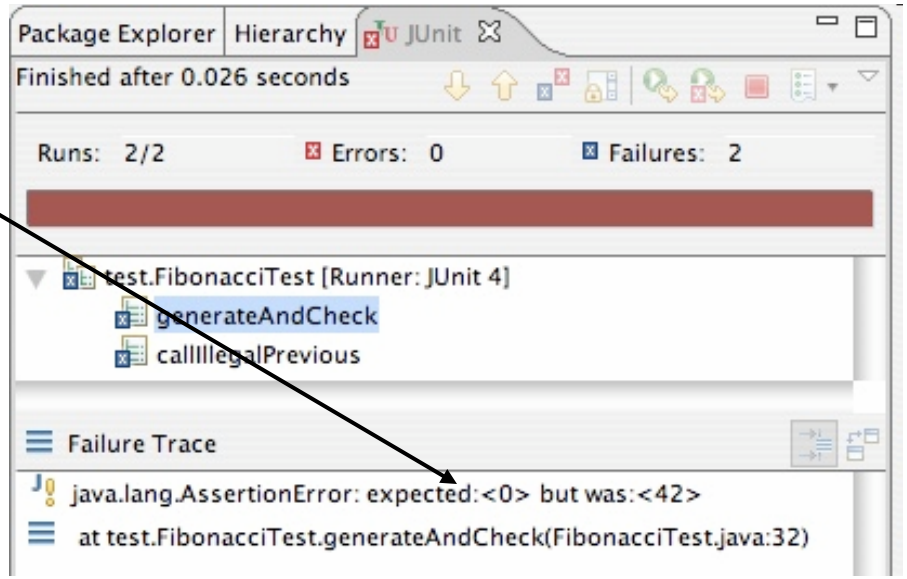
- Torture tests are okay, but only *in addition to* simple tests.

Good Practices

```
public class DateTest {

    // Give test case methods really long descriptive names
    @Test
    public void test_addDays_withinSameMonth() { ... }

    @Test
    public void test_addDays_wrapToNextMonth() { ... }


    // Expected value should be at LEFT
    // Give messages explaining what is being checked
    @Test
    public void test_add_14_days() {
        Date d = new Date(2050, 2, 15);
        d.addDays(14);
        assertEquals("year after +14 days", 2050, d.getYear());
        assertEquals("month after +14 days", 3, d.getMonth());
        assertEquals("day after +14 days", 1, d.getDay());
    }
}
```

Good assertion messages

```
public class DateTest {
    @Test
    public void test_addDays_addJustOneDay_1() {
        Date actual = new Date(2050, 2, 15);
        actual.addDays(1);
        Date expected = new Date(2050, 2, 16);
        assertEquals("adding one day to 2050/2/15",
            expected, actual);
    }
    ...
}

// JUnit will already show
// the expected and actual
// values in its output;
//
// don't need to repeat them
// in the assertion message
```



Tests with a timeout

```
@Test(timeout = 5000)
public void name() { ... }
```

- The above method will be considered a failure if it doesn't finish running within 5000 ms

```
private static final int TIMEOUT = 2000;
...

@Test(timeout = TIMEOUT)
public void name() { ... }
```

- Times out / fails after 2000 ms

Testing for exceptions

```
@Test(expected = ExceptionType.class)
public void name() {
    ...
}
```

- Will pass if it *does* throw the given exception.
  - If the exception is *not* thrown, the test fails.
  - Use this to test for expected errors.

```
@Test(expected = ArrayIndexOutOfBoundsException.class)
public void testBadIndex() {
    ArrayIntList list = new ArrayIntList();
    list.get(4);   // should fail
}
```

Setup and teardown

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

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

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

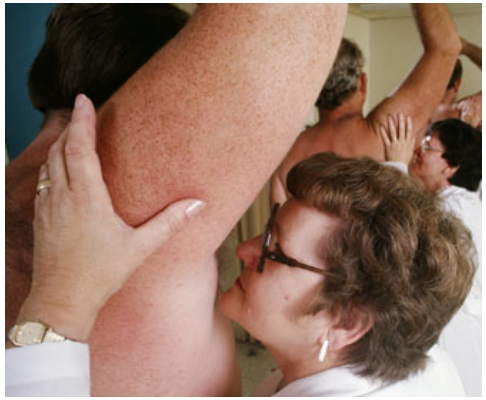
- methods to run once before/after the entire test class runs

Flexible helpers

```
public class DateTest {
    @Test(timeout = DEFAULT_TIMEOUT)
    public void addDays_multipleCalls_wrapToNextMonth2x() {
        Date d = addHelper(2050, 2, 15, +14, 2050, 3, 1);
        addhelper(d, +32, 2050, 4, 2);
        addhelper(d, +98, 2050, 7, 9);
    }

    // Helpers can box you in; hard to test many calls/combine.
    // Create variations that allow better flexibility
    private Date addHelper(int y1, int m1, int d1, int add,
                           int y2, int m2, int d2) {
        Date date = new Date(y, m, d);
        addHelper(date, add, y2, m2, d2);
        return d;
    }

    private void addHelper(Date date, int add,
                           int y2, int m2, int d2) {
        date.addDays(add);
        Date expect = new Date(y2, m2, d2);
        assertEquals("date after +" + add + " days", expect,
  d);
    }
```

Test case "smells"

- Tests should be self-contained and not care about each other.



- "**Smells**" (bad things to avoid) in tests:
  - *Constrained test order* : Test A must run before Test B.
    (usually a misguided attempt to test order/flow)
  - *Tests call each other* : Test A calls Test B's method
    (calling a shared helper is OK, though)
  - *Mutable shared state* : Tests A/B both use a shared object.
    (If A breaks it, what happens to B?)

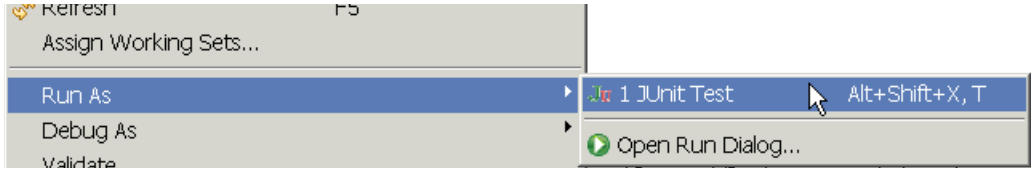
Running a test

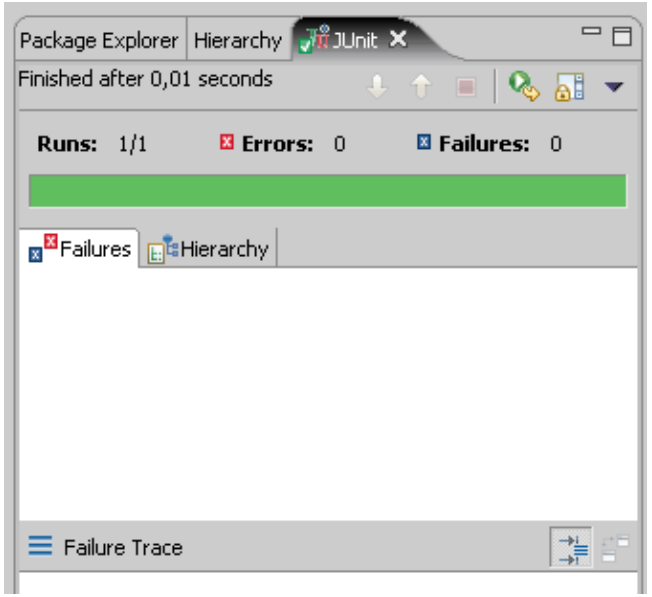
- Right click it in the Eclipse Package Explorer at left; choose:

  Run As → JUnit Test

- The JUnit bar will show **green** if all tests pass, **red** if any fail.

- The Failure Trace shows which tests failed, if any, and why.





Project 2 Tips

Style Guide

Project 2 Tips

- **Take advantage of superclass's implementation when writing subclass**
- **Minimize casting**
  - Remember **AVLNode is-a BSTNode**
  - AVLNode can be treated as BSTNode, **only except** when accessing its **height** information
  - Consider some private function like (**only cast in this function**):

```
int height(BSTNode node)
void updateHeight(BSTNode node)
```