Unit Testing
part 1

CSCI 2300

Bugs and testing

- **software reliability**: Probability that a software system will not cause failure under specified conditions.
  - Measured by uptime, MTTF (mean time till failure), crash data.

- **Bugs** are inevitable in any complex software system.
  - Industry estimates: 10-50 bugs per 1000 lines of code.
  - A bug can be visible or can hide in your code until much later.

- **testing**: A systematic attempt to reveal errors.
  - Failed test: an error was demonstrated.
  - Passed test: no error was found (for this particular situation).

Difficulties of testing

- Perception by some developers and managers:
  - Testing is seen as a novice's job.
  - Assigned to the least experienced team members.
  - Done as an afterthought (if at all).
    - "My code is good; it won't have bugs. I don't need to test it."
    - "I'll just find the bugs by running the client program."

- Limitations of what testing can show you:
  - It is impossible to completely test a system.
  - Testing does not always directly reveal the actual bugs in the code.
  - Testing does not prove the absence of errors in software.

Unit testing

- **unit testing**: Looking for errors in a subsystem in isolation.
  - Generally a "subsystem" means a particular class or object.
  - The Java library **JUnit** helps us to easily perform unit testing.

- The basic idea:
  - For a given class `Foo`, create another class `FooTest` to test it, containing various "test case" methods to run.
  - Each method looks for particular results and passes / fails.

- JUnit provides "**assert**" commands to help us write tests.
  - The idea: Put assertion calls in your test methods to check things you expect to be true. If they aren't, the test will fail.

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`**`)`
  - Why is there no `pass` method?

ArrayIntList JUnit test

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

public class TestArrayIntList {
    @Test
    public void testAddGet1() {
        ArrayIntList list = new ArrayIntList();
        list.add(42);
        list.add(-3);
        list.add(15);
        assertEquals(42, list.get(0));
        assertEquals(-3, list.get(1));
        assertEquals(15, list.get(2));
    }

    @Test
    public void testIsEmpty() {
        ArrayIntList list = new ArrayIntList();
        assertTrue(list.isEmpty());
        list.add(123);
        assertFalse(list.isEmpty());
        list.remove(0);
        assertTrue(list.isEmpty());
    }
```

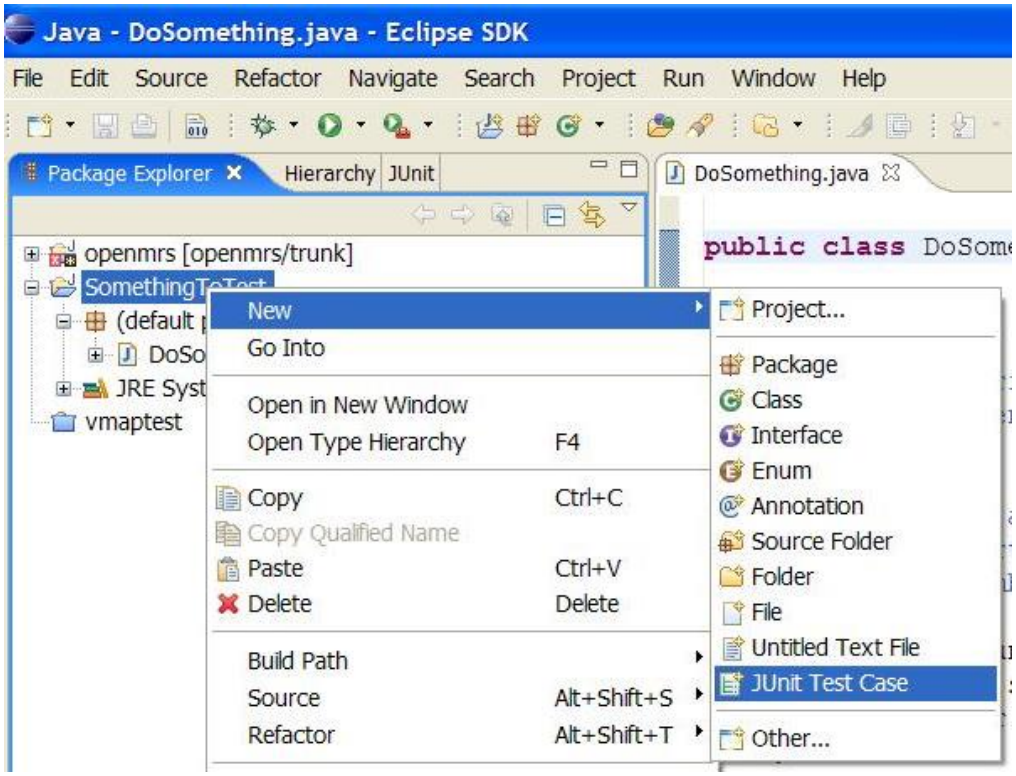
Junit on command line

- javac -cp <path to junit.jar>:. MyTest.java
- Example:
  javac -cp /usr/share/java/junit.jar:. DayTest.java
- You can set CLASSPATH variable:
  - In ~/.bashrc add:
    CLASSPATH=$CLASSPATH:/usr/share/java/junit.jar:.
- Run your test:
  java -cp $CLASSPATH org.junit.runner.JUnitCore DayTest
- You can use an ‘alias’ to simplify your life:
  - In ~/.bashrc add:
    alias junit=“java -cp $CLASSPATH org.junit.runner.JUnitCore”
  - Open a new terminal and run: junit DayTest

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.



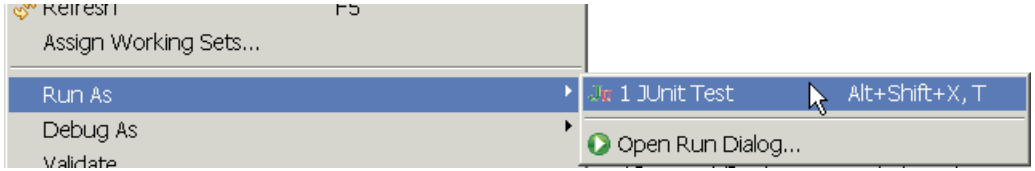
Running a test

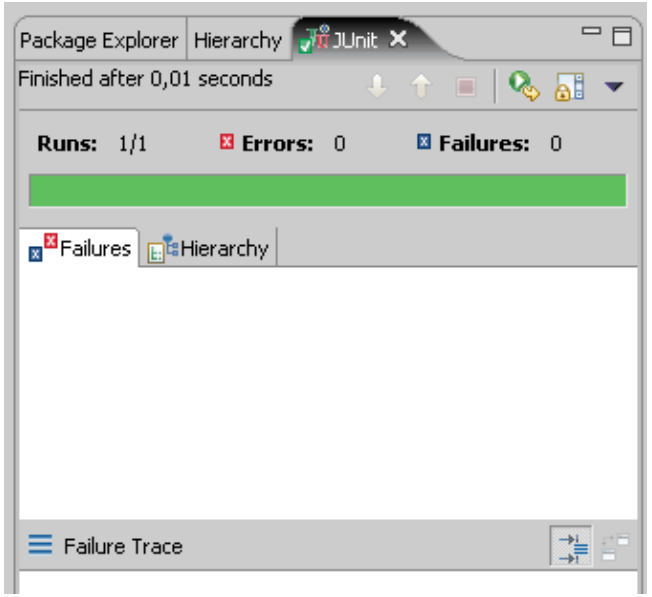
- Right click it in the Eclipse Package Explorer at left; choose:

  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.





Well-structured assertions

```
public class DateTest {
    @Test
    public void test1() {
        Date d = new Date(2050, 2, 15);
        d.addDays(4);
        assertEquals(2050, d.getYear());  // expected
        assertEquals(2, d.getMonth());    // value should
        assertEquals(19, d.getDay());     // be at LEFT
    }

    @Test
    public void test2() {
        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());
    }   // test cases should usually have messages explaining
}       // what is being checked, for better failure output
```

Expected answer objects

```
public class DateTest {
    @Test
    public void test1() {
        Date d = new Date(2050, 2, 15);
        d.addDays(4);
        Date expected = new Date(2050, 2, 19);
        assertEquals(expected, d);  // use an expected answer
    }                               // object to minimize tests

                                    // (Date must have toString
    @Test                           //  and equals methods)
    public void test2() {
        Date d = new Date(2050, 2, 15);
        d.addDays(14);
        Date expected = new Date(2050, 3, 1);
        assertEquals("date after +14 days", expected, d);
    }
}
```

Naming test cases

```
public class DateTest {
    @Test
    public void test_addDays_withinSameMonth_1() {
        Date actual = new Date(2050, 2, 15);
        actual.addDays(4);
        Date expected = new Date(2050, 2, 19);
        assertEquals("date after +4 days", expected, actual);
    }
    // give test case methods really long descriptive names

    @Test
    public void test_addDays_wrapToNextMonth_2() {
        Date actual = new Date(2050, 2, 15);
        actual.addDays(14);
        Date expected = new Date(2050, 3, 1);
        assertEquals("date after +14 days", expected, actual);
    }
    // give descriptive names to expected/actual values
}
```

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
```