Testing and Debugging
Lecture 11

Waterford Institute of Technology

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Thought for the day

Or perhaps longer?

If builders built buildings
The way programmers wrote programs
Then the first woodpecker that came along
Would destroy civilization.

Gerald Weinberg

Software

Computer programs

Douglas Crockford: Javascript expert

- "Computer programs most complex things humans make"

Here is an interesting definition:

- Software is applied thought.

Some of the challenges:

- How to communicate thoughts?
- How to understand **your** code next day?

Program errors

Syntax

- **Syntax errors**
  - Relate to structure and grammar of code.
  - Usually easily identified.
  - Compile-time errors generated

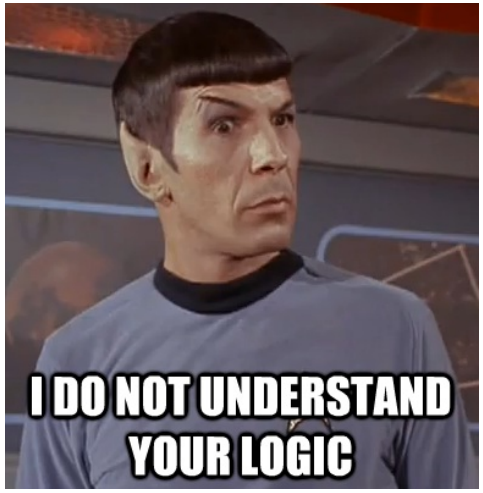
```
public Person setAge(int age) {
    this.age = age
    return this;
}
```

```
1  package ie.wit.people;
2
3  public class Person
4  {
5    public Person setAge(int age) {
6      this.age
7      return this;
8    }
9  }
10
```

Program errors

Semantic or logic errors

- Compiles without error
- Runs to completion but with incorrect results
- Runs error-free for most but not all inputs
- Error-generating input may occur long after program released
- Generally much more difficult to detect.



Semantic errors

Unfortunately semantic errors rule rather than exception

- Producing programs free semantic errors extremely difficult
- Much non-trivial commercial software shipped with bugs
- Detection of semantic bugs cannot be automated
- Some industries have better track record than others
  - Aerospace
  - Military

Ariane 5: A semantic error

Software failures

Some examples software failures:

- Therac radiation therapy machine (c1985)
  - Massive overdose (100 times)
  - Three people died
- Mars orbiter disentegration (1998)
  - Ground computer used imperial units
  - Satellite used metric
  - Burned up
  - Loss: 300 million dollars
- London Ambulance Service (1992)
  - Newly commissioned system rapidly slowed to a crawl
  - System abandoned
  - Reputed cause: memory leak.
- Ariane 5 (1996)
  - Rocket downed by floating point error
  - Loss: 500 million dollars

Software failures

- Mariner 1 (1962)
  - NASA's first spacecraft
  - Off course minutes into flight
  - Safety officer hit auto-destruct
  - Cause: incorrectly transcribed math symbol.
- Year 2000 bug
  - Known about for decades
    - Decision to continue producing not-fit-for-purpose code.
  - House of Commons report
    - Estimated repair cost: $400 billion
    - A cost to clients but revenue to software industry
- British NHS IT system (2013)
  - Patient record system
  - Project launched 2002
  - Now abandoned
  - Loss: Euro 10 billion and climbing

Software quality

General product quality

- Fit for purpose
  - Possess appropriate functionality
- Merchantable quality
  - High quality processes and standards

Software quality

- Meet customers' needs
  - Easy to use
  - Correct results
  - Doesn't crash
  - Easy to debug and extend

Testing

Exhaustive testing not feasible

- One 64 bit variable
  - One nanosecond per test
  - 500 years required

Divide and conquer

- Different tests at different development stages
  - Unit test within a class
  - Modular test across classes
  - Integration test: check interfaces between modules
    - Consistent assumptions.
    - Correctly communicate.
  - Regression test

Customer acceptance test

Unit Testing

Unit test

- Test to determine if a unit of code behaves as designed
- Unit can be considered smallest testable part of program
- In our labs we test to the level of a method

```
/**
* Unit test
* Checks making appointment
* @return returns true if test succeeds else false
*/
public boolean twoHourAppointment() {
        Day day = new Day(1);
        Appointment appointm1 = new Appointment("Course board meet", 2);
        return day.makeAppointment(16, appointm1);
  }
```

Positive Unit Testing

A positive unit test

- Expected to return true on success

```
/**
* This is a positive unit test
* It returns true on success
* Makes appointment at 4 p.m. day 1 for a lab
*/
public boolean oneHourAppointment() {
    Day day = new Day(1);
    Appointment appointm1 = new Appointment("Lab", 1);
    return day.makeAppointment(16, appointm1);
  }
```

Negative Unit Testing

A negative unit test

- Expected to return false on success
- Tends to be overlooked but important to include

```
/**
* Attempted double booking
* This is a negative unit test
* We expect the method to return a false
* Returning true would indicate a bug
*/
public boolean doubleBooking()
{
    Day day = new Day(1);
    Appointment appointm1 = new Appointment("Java lecture", 1);
    Appointment appointm2 = new Appointment("Java lab", 1);
    day.makeAppointment(10, appointm1);//make booking at 10
    return day.makeAppointment(10, appointm2);//try 2nd booking at 10
}
```

Negative Unit Testing

Test *doubleBooking*

- Attempt to double book should not succeed
- *boolean false* expected when *doubleBooking* invoked
- Use JUnit *assertsEqual* to test for *false*

```
@Test
public void negativeTests()
{
    assertEquals(false, diaryTester.doubleBooking());
}
```

Regression Testing

Unit tests

- Performed on smallest testable portions
- Number unit tests grows as development progresses

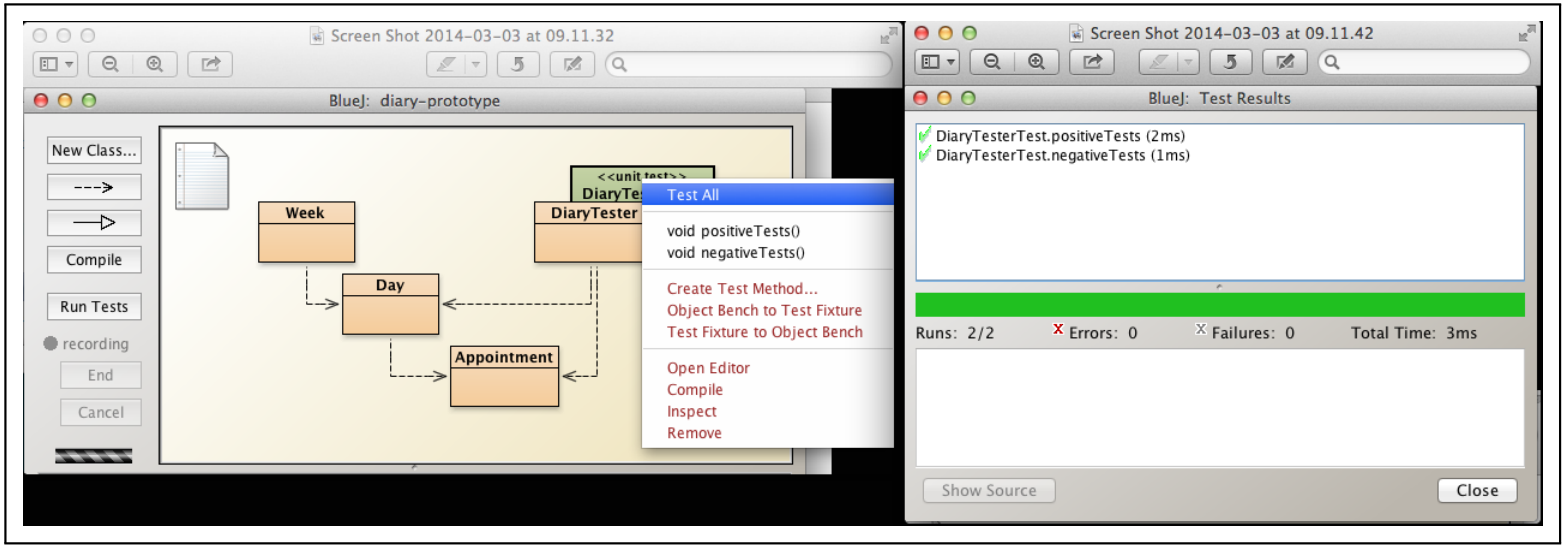
Regression testing

- Re-running suite of unit tests
  - As development progresses (daily)
  - At key milestones
  - Before shipping
  - Following bug fixes

JUnit Testing

JUnit

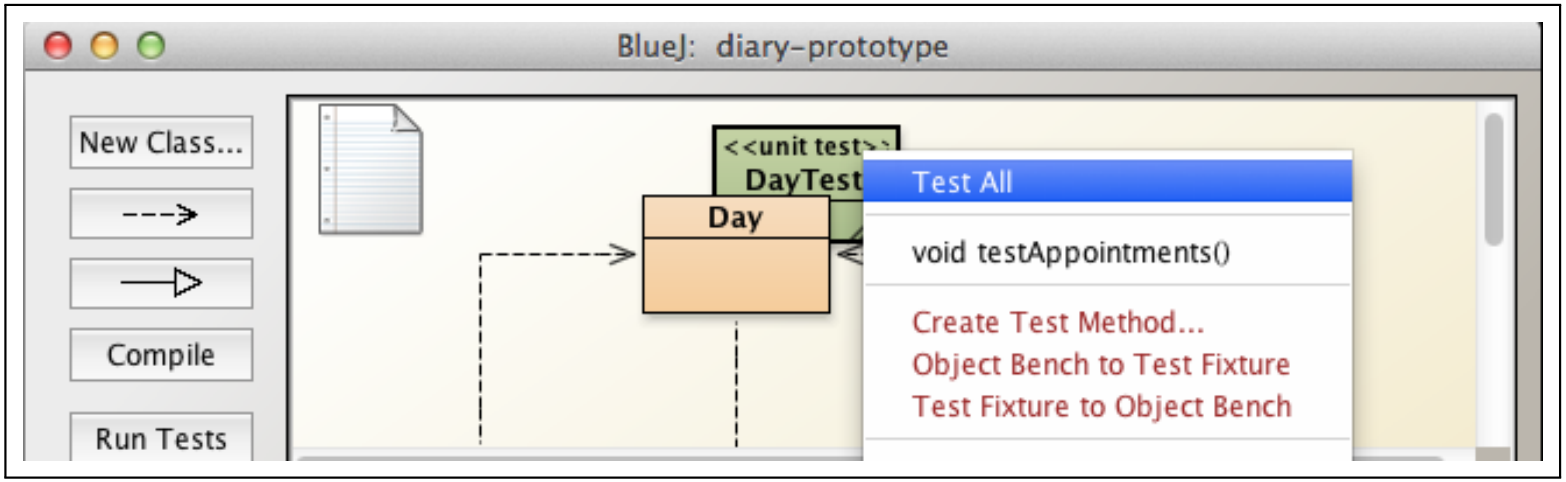
- Unit testing framework
- A framework can be considered
  - Reusable set of libraries or classes
  - Provider of some declared functionality
- JUnit widely used across different languages
- BlueJ has built-in JUnit



Automated Regression Testing

BlueJ framework includes JUnit

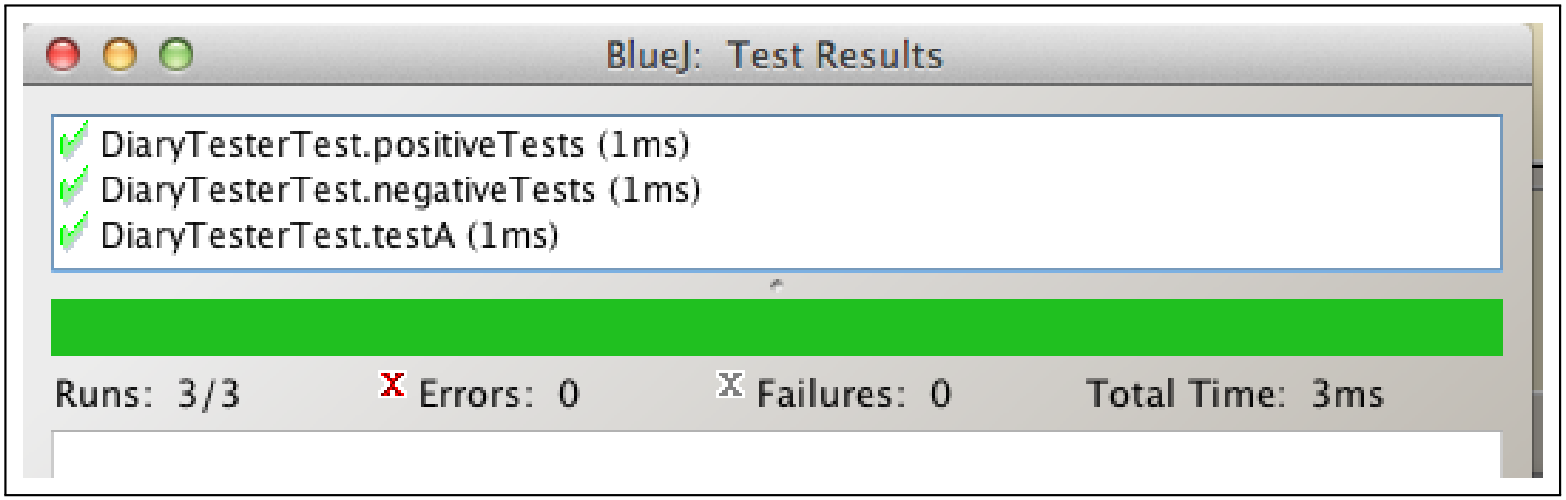
- For any class under development
  - Easy to create associated JUnit class
  - Write test methods in test class
  - Invoke individual test methods
  - Invoke testAll method



BlueJ JUnit Automated Regression Test

Run all tests example

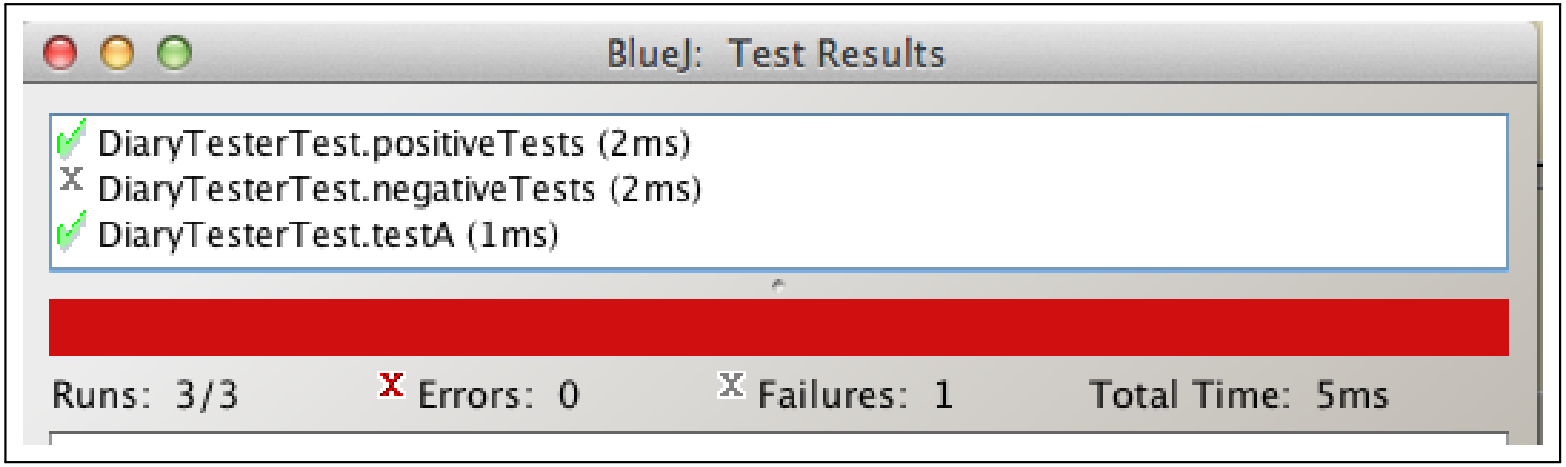
- Three methods invoked
  - positiveTests
  - negativeTests
  - individual testA
- Green progress bar indicates overall success



BlueJ JUnit Automated Regression Test

Run all tests example

- Individual and overall results published
  - positiveTests succeeded
  - negativeTests failed
  - individual testA succeeded
- Red progress bar indicates overall failure



Summary

- Overview software quality
- Explored definition of software
- Error types syntactic and semantic
- Syntax errors generally easy to identify and fix
- Semantic or logical errors often extremely difficult to diagnose
- Sample software failures
- Importance of testing
- Unit testing positive and negative
- Regression testing
- JUnit testing
- Automated regression testing

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