Testing and Debugging

# (Reminder) Zuul Assignment

- Two deliverables:
  - Code (to your submission folder *by 23:59*)
  - Report (to your submission folder *or hard copy to the CAS office by 4pm*)
  - Deadline is Tuesday, December 8, 2009

# Code snippet of the day

```
public void test ()
{
    int sum = 1;

    for (int i = 0; i <= 4; i++);
    {
        sum = sum + 1;
    }

    System.out.println
        ("The result is: " + sum);
    System.out.println
        ("Double result: " + sum + sum);

}
```

What is the output?

# Code snippet of the day

```
public void test ()
{
    int sum = 1;

    for (int i = 0; i <= 4; i++);
    {
        sum = sum + 1;
    }

    System.out.println
        ("The result is: " + sum);
    System.out.println
        ("Double result: " + sum + sum);

}
```

What is the output?

This semi-colon marks the end of an ***empty statement***, which is the loop body.

This code block follows the loop. With the semi-colon above, it is ***not the loop body***.

```
The result is:  2
```

# Code snippet of the day

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public void test ()
{
    int sum = 1;

    for (int i = 0; i <= 4; i++);
    {
        sum = sum + 1;
    }

    System.out.println
        ("The result is: " + sum);
    System.out.println
        ("Double result: " + sum + sum);

}
```

What is the output?

This arithmetic is never done – the number is converted to a string and appended to the opening string *(twice)*.

```
The result is:  2
Double result is: 22
```

# We have to deal with errors

- Early errors are usually *syntax errors*:
  - the compiler will spot these
- Later errors are usually *logic errors*:
  - the compiler cannot help with these
  - also known as bugs
- Some logical errors have *intermittent manifestation* with no obvious trigger:
  - also known as ****** bugs
- Commercial software is rarely error free:
  - often, it is much worse than this …

# Prevention vs Detection (Developer vs Maintainer)

- We can lessen the likelihood of errors:
  - encapsulate data in *fields* of an *object*
  - design each *class* to be *responsible* for *one* kind of thing

- We can improve the chances of detection:
  - write documentation *as we go*
  - think about how to test *as we go*
  - test *as we go* (e.g. interact with classes/objects/methods using the facilities of BlueJ, build a suite of testing classes – see Unit Testing and Regression Testing in Chapter 6)

- We can develop detection skills. ☺ ☺ ☺ ☺ ☺

# Testing and Debugging

- These are crucial skills.
- *Testing* searches for the *presence* of errors.
- *Debugging* searches for the *source* of errors.
  - the manifestation of an error may well occur some *'distance'* from its source.

# Unit Testing

- Each *unit* of an application may be tested:
  - *each method*
  - *each class*
  - *each package*
- Can *(should)* be done during development:
  - finding and fixing *early* lowers development costs *(e.g. programmer time)*.
  - finding problems *after deployment* is very expensive. This is what usually happens.
  - if the system design *lacks cohesion* and has *high coupling* between units, the bugs may *never be found* and, if found, be *unfixable*.

# Testing Fundamentals

- Understand what the unit should do *(its contract):*
  - look for violations *(negative tests)*
  - look for fulfillment *(positive tests)*
- Test *boundaries:*
  - for example, search an empty collection
  - for example, add to a full collection

# Unit Testing within BlueJ

- *Objects* of individual classes can be created.
- *Individual methods* can be invoked.
- *Inspectors* provide an up-to-date view of an object's state.
- Explore through the **`diary-prototype`** project (Chapter 6). *This contains bugs!!!*

# Test Automation

- Good testing is a creative process.
- Thorough testing is time consuming and repetitive.
- *Regression* testing involves re-running tests *whenever* anything is changed.
- Use of a *test rig* can relieve some of the burden:
  - write classes to perform the testing
  - creativity focused in creating these
  - BlueJ offers help for this:
    - explore the `diary-testing` project (Chapter 6). Human checking of the results still needed here.
    - explore the `diary-test-junit` projects (Chapter 6). Machine checking of results – human intervention only if one or more checks fail.

# Debugging Techniques

- OK, we found errors … how do we fix them?
  - manual walkthoughs:
    - *read your code!*
    - *why should it work? [**Not:** why doesn't it work?!!]*
    - *it helps to explain this to someone else …*
  - if light has not dawned:
    - *add print statements to your code to show the state of variables (at key points)…*
    - *do they show what you expect?*
  - if light has not still not dawned:
    - *run your code under an interactive debugger …*
    - *BlueJ has support for this (see chapter 3.13)*

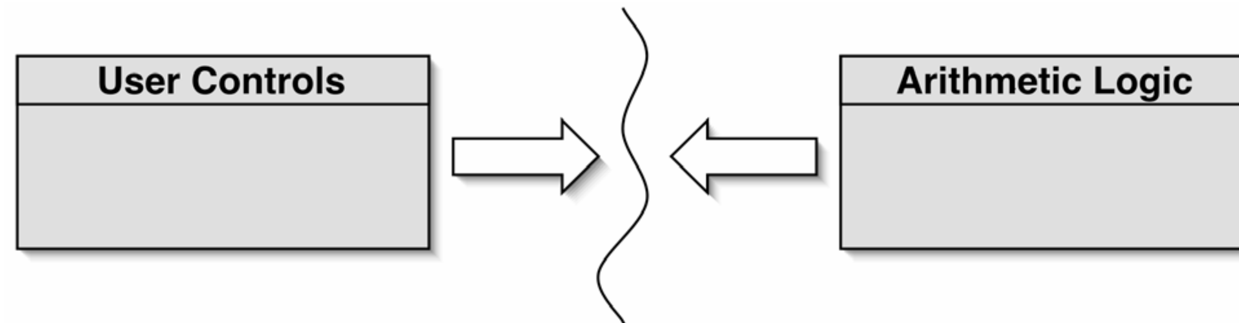
## Hofstadter's Law

It always takes longer than you expect, even when you take Hofstadter's Law into account.

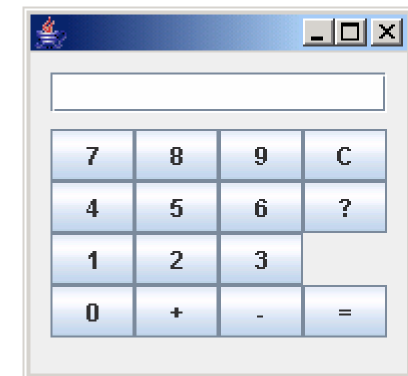
## 90% Rule of Project Schedules

The first ninety percent of the task takes ninety percent of the time … and the last ten percent takes the other ninety percent.

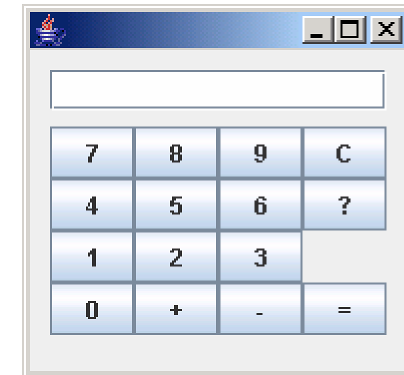
# Modularisation in a Calculator




- Each module does not need to know implementation details of the other.
  - User controls could be a GUI or a hardware device.
  - Logic could be hardware or software.



# Method Signatures as an *'Interface'*




```
// Return the value to be displayed.
public int getDisplayValue();

// Call when a digit button is pressed.
public void numberPressed(int number);

// Call when a plus operator is pressed.
public void plus();

// Call when a minus operator is pressed.
public void minus();

// Call to complete a calculation.
public void equals();

// Call to reset the calculator.
public void clear();
```

# Debugging

- It is important to develop code-reading skills.
    - *Debugging will often be performed on others' code.*
- Techniques and tools exist to support the debugging process.
- Explore through the *calculator-engine* project.

# Manual Walkthroughs

- Relatively underused.
  - *A low-tech approach.*
  - *More powerful than appreciated.*
- Get away from the computer!
- 'Run' a program by hand.
- High-level (Step) or low-level (Step into) views.

# Tabulating Object State

- An object's behaviour usually depends on its state.
- Incorrect behaviour is often the result of incorrect state.
- Tabulate the values of all fields.
- Record state changes after each method call.

# Verbal Walkthroughs

- Explain to someone else what the code is doing:
  - *explain why should it work!*
  - *[don't ask: why doesn't it work?!!]*
  - *the process of explaining helps you spot errors for yourself;*
  - *often, it's easier for someone else!*
- Group-based processes exist for conducting formal walkthroughs or *inspections*.

# Print Statements

- The most popular technique.
- No special tools required.
- All programming languages support them.
- Only effective if the right methods are documented.
- Output may be voluminous!
- Turning off and on requires forethought.

# Interactive Debuggers

- Debuggers are language-specific and environment-specific.
  - *BlueJ has an integrated debugger.*
- Supports *breakpoints*.
- Provides *step* and *step-into* controlled execution.
- Shows the *call sequence (stack)*.
- Shows *object state*.
- Does not provide a permanent record.

# Review

- Errors are a fact of life in programs.
- Good software engineering techniques can reduce their occurrence.
- Testing and debugging skills are essential.
- Make testing a habit.
- Automate testing where possible.
- Practise a range of debugging skills.

# Review

- Unit testing *(with BlueJ)*
  - Chapter 6.3
- Test automation *(with BlueJ)*
  - Chapter 6.4
- Manual walkthroughs *(read the code!!!)*
  - Chapter 6.8
- Print statements *(see what's happening)*
  - Chapter 6.9
- Debuggers *(with BlueJ)*
  - Chapter 3.12-13, 6.11