Objects First With Java
A Practical Introduction Using BlueJ

Well-behaved objects

Main concepts to be covered

- Testing
- Debugging
- Test automation
- Writing for maintainability

We have to deal with errors

- Early errors are usually *syntax errors*.
  - Syntax errors are grammar faults.
  - The compiler will spot these.
- Later errors are usually *logic errors*.
  - The compiler cannot help with these.
  - Also known as bugs (not features ☺).
- Some logical errors have no immediately obvious manifestation.
  - Commercial software is rarely free of errors.
  - Formal proofs of correctness or code verifications are a tough job – but important!

Prevention vs. Detection
(Developer vs. Maintainer)

- We can lessen the likelihood of errors.
  - Use software engineering techniques, such as encapsulation ➔ avoid errors!
- We can improve the chances of detection.
  - Use software engineering practices, such as modularization and documentation ➔ detect errors!
- We can develop detection skills.
- This means experiments – more and more important for informatics.

Testing and debugging

- These are crucial skills.
- Testing searches for the presence of errors (in your own as well as in others' programs).
- Debugging searches for the source and location of errors.
  - The manifestation of an error may well occur some 'distance' from its source.
  - Another aspect of concern: side effects.

Testing and debugging techniques

- Unit testing (within BlueJ)
- Test automation
- Manual walkthroughs
- Print statements
- Debuggers

Unit testing

- Each unit of an application may be tested individually (in contrast to application testing).
  - Units in this context: methods, classes, modules (packages in Java).
- Unit testing can (should) be done early during development.
  - Finding and fixing errors early lowers development costs (e.g. programmer time).
  - A (relevant/realistic) test suite is built up.

Testing fundamentals

- Understand what the unit should do – its *contract*.
  - You will be looking for violations.
  - Use positive tests (what should work well) and negative tests (what should go wrong).
- Test and check *boundaries* or *extreme cases*.
  - Zero, One, Full.
    - Search an empty collection.
    - Add to a full collection.
    - Assign zero.

Test automation

- Good testing is a creative process, but ...
- ... thorough testing is time consuming and repetitive.
- *Regression testing* involves re-running tests.
  - Corrections may introduce new errors.
  - Hence: re-start the tests done so far.
- Use of a *test rig* or *test harness* can relieve some of the burden.
  - Special classes are written just to perform the testing.
  - Creativity focused in creating these.

Test automation

- Explore through the *diary-testing* project.
  - Human analysis of the results still required (check the printed results of the test rig).
- Explore fuller automation through the *diary-test-junit* projects.
  - Intervention only required if a failure is reported.

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).

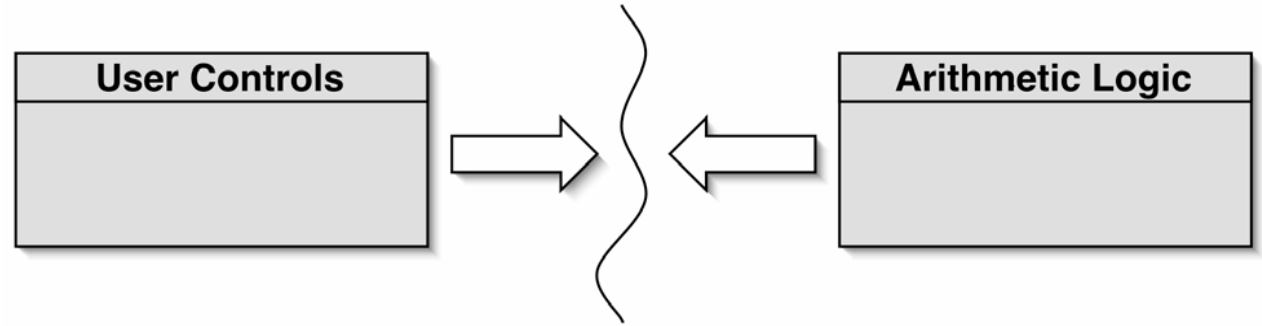
Unit testing within Eclipse

- Objects of individual classes can be created.
- Individual methods can be invoked.
- Inspectors provide an up-to-date view of an object's state.
- Try it in/with the exercises!

Modularization and interfaces

- Applications often consist of different modules.
  - E.g. so that different teams can work on them.
- The *interface* between modules must be clearly specified.
  - Supports independent concurrent development.
  - Increases the likelihood of successful integration later.

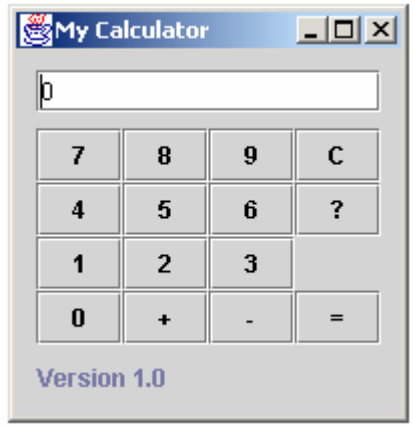
Modularization in a calculator



- 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 the plus operator is pressed
public void plus();

// Call when the 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.
  - Learning to program means learning to *write* and to *read* programs – try some code reading!
- Techniques and tools exist to support the debugging process.

Commenting and style

- Give comments to
  - Classes (purpose, author, version, …)
  - Methods (purpose, return type, parameters, …)
- Blocking structure/layout supports visual understanding:

```
aaaa aaaa
    bbbb bbbb
    cccc cccc
dddd dddd
```

- Expressive naming – but not

```
TheVariableExpressingTemperature
```

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 is usually determined by its state.
- Incorrect behaviour is often the result of an incorrect state.
- Tabulate the values of all fields.
- Document state changes after each method call.

Verbal walkthroughs

- Explain to someone else what the code is doing.
  - They might spot the error for you.
  - The process of explaining might help you to spot it for yourself.
- Group-based processes exist for conducting formal walkthroughs or *inspections*.

Print statements

- The most popular technique – even among experts.
- 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.

Print statements

- Typical information provided:
  - which methods have been called
  - the values of parameters
  - the order in which methods have been called
  - the values of local variables and fields at strategic points
- Use it to locate an error, then create an automated test for it!

Choosing a test strategy

- Be aware of the available strategies.
- Choose strategies appropriate to the point of development.
- Automate whenever possible.
  - Reduces tedium.
  - Reduces human error.
  - Makes (re)testing more likely.

Debuggers

- Debuggers are both language- and environment-specific.
  - BlueJ has an integrated debugger (demo).
  - Eclipse has an integrated debugger (demo).
- Support breakpoints.
- Step and Step-into controlled execution.
- Call sequence (stack).
- Object state.
- (Explore through the *calculator-engine* or *debugdemo* project).

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.
- Practice a range of debugging skills.