Software Development: Testing

CPSC 233: Introduction to Computer Science for Computer Science Majors II
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Importance of Testing

- in large complex systems, **50%** of the systems development budget may be spent on testing
- this time should be reduced with modern design techniques on less complex systems, but it is still **very high.**
- Studies have shown that **virtually all non-trivial** software ships with errors!
- Thus, good testing is as important **(more?)** than programming

Psychological Problem of Acceptance of Testing

- we think if we're good, there will be no bugs. Therefore finding errors shows incompetence - who wants that?

- BUT everyone writes code with bugs

- Good programs have approximately 1 bug per 100 lines. So take the attitude that the more bugs you find, the BETTER tester you are.

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When to Test

- **Throughout** the development lifecycle, not just at the end.

- **earlier** you find error **the better,** so test the design before coding ---> prevents errors

- Benefits:
  - **require less testing & debugging time**
  - **cost less**

Who should Test

- developers
  - know code so can be more efficient (e.g. no 2 tests which test exactly same stuff)
  - but have blind spots (i.e. if didn't realize system has to do X, will never test for that)
- **professional testers** (Q/A department)
  - include people from user department to test functionality

- Note - need both - they have different mind sets.
  - Programmer - **hopes not** to find bugs
  - Tester - **aggressively looking** for bugs (programmers will not like you)

How to Test

- **Exhaustive testing** (testing every possible input), would be ideal, but clearly impossible

- Instead, a **methodical approach** to testing is used: try to develop test cases to “cover all the bases”.

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Black Box Testing

Black Box Testing

- assumes you **know nothing** of the internals of a program
- tests functionality
  - i. e. checks that program **satisfies requirement specifications**

---> checks for "blind spots" on part of designer.

- consider all types of input
- for each, divide it into **equivalence classes** - all data in each class is "equivalent" to each other
- Then choose test data such that at least one piece of data for each equivalence class is included.

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Black Box Testing (cont'd)

- you must look at the positive cases (you expect program will work), as well as negative cases (you expect these to fail). **Junior programmers often are weak at testing all the negative cases**

e.g. Size of array to store courses enrolled in - # courses

Valid	Invalid
1 <= courses <= 5	< 1
	> 5

- Therefore need to include data from 3 test areas
  - Note: 8 is equivalent to 12 - i.e. if one handled properly other will be

Black box Testing (cont'd)

- BUT boundaries more likely to have errors than inside therefore:

  test e.g. 4, 5, 6.

  (Note - strictly speaking, this goes beyond black box testing -you might call it "grey box" testing - but because of the frequency of boundary errors, these extra tests should be included).

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Equivalence Classes

Equivalence classes of test data

Partition possible input (and states) into categories

These categories are also known as ***equivalence classes***

- Test at least <u>one</u> data set from each class

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Equivalence classes of test data

e.g.

```
If (n > 4 and n < 10) {
  //Do something
} else{
  //Do something else
{
```


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Equivalence classes of test data

- in this case there are three equivalence classes:

We might choose 5 tests:

< 4 = 4 5 .. 9 = 10 > 10

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White Box Testing

White Box Testing

- **look inside** at details of program to determine what to test, analyzing the flow of control
- **based on coverage testing**. The various test cases must "cover" the entire source code:
  - **ensure all statements are executed**
  - **ensure all expressions are evaluated**
  - **various paths** through the code must be considered

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White Box Testing

- **look inside** at details of program to determine what to test, analyzing the flow of control
- **based on coverage testing**. The various test cases must “cover” the entire source code:
  - **ensure all statements are executed (weak) Statement Testing**
  - **ensure all choices/branches are evaluated (stronger) Conditional Testing**
  - **various paths** through the code must be considered (strongest) **(Path Testing)**

Testing and Debugging

Definition of Testing

testing = the process of detecting run-time errors (*bugs)* in code and
evaluating the functionality of the code (≈ logic errors)

- testing can tell you that you have bugs
- but it does not prove you don't have bugs

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Debugging

- Some techniques for locating bugs:

1. use “trace messages” – print statements saying where you are, and values of some variables (most programmers start here)
2. use a debugger (built into IDEs, BREAKPOINTS!!!)
3. use “assertions” – statements that say what should be the case – if it is not true, program automatically gives error. Tool used in automatic testing (have to enable to have them run)

Debugging

- Testing helps discover bugs, i.e. you may know a bug exists, but not much more.

- You must also:
  - locate the error
  - explain the error's cause -> scientific hypothesis
  - correct the error -> scientific experiment
  - re-test -> analysis of experiment

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Debugging

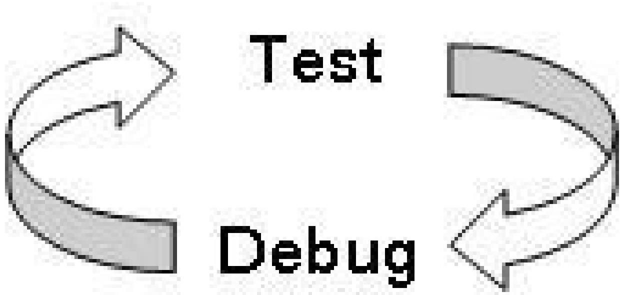
Note:

- The location of the error may not be the statement at which it manifests itself (e.g. if you return the pointer to a class variable, rather than a copy of that object, you won't get incorrect values until later in the program).
- A bug can be:
  - a simple programmer error (more easily fixed)
  - a design error (less easily fixed)

Debugging ≠ Testing

debugging = the process of correcting errors

- testing and debugging are cyclic

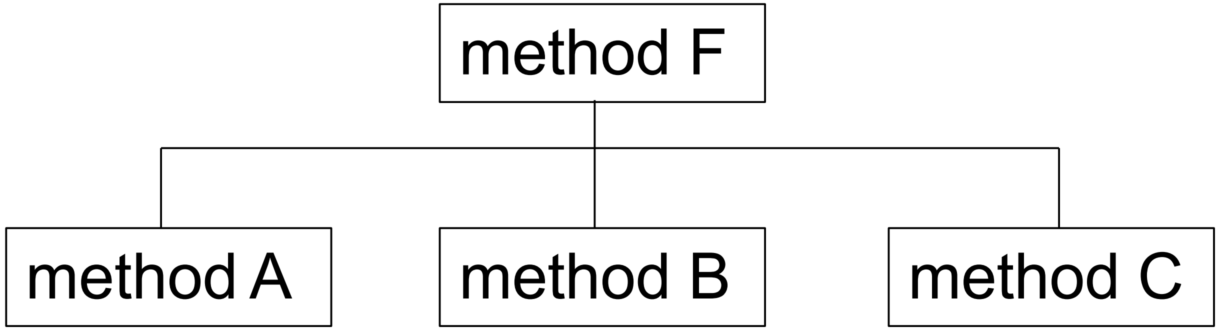


Modular Testing

Modular Testing

- if you write whole program and test it, and it doesn't work (e.g. infinite loop) very hard to find error
- **better to test each module separately** ---> much smaller bit of code to examine to find error.
- Most important concept: test each module individually as you implement!

Modular Testing (cont'd)



- Test & debug method A.
- Test & debug method B.
- Test & debug method C.
- Finally, test method F.
- If it fails the testing then you can be (mostly) sure that the error is in F, and not a sub-method.

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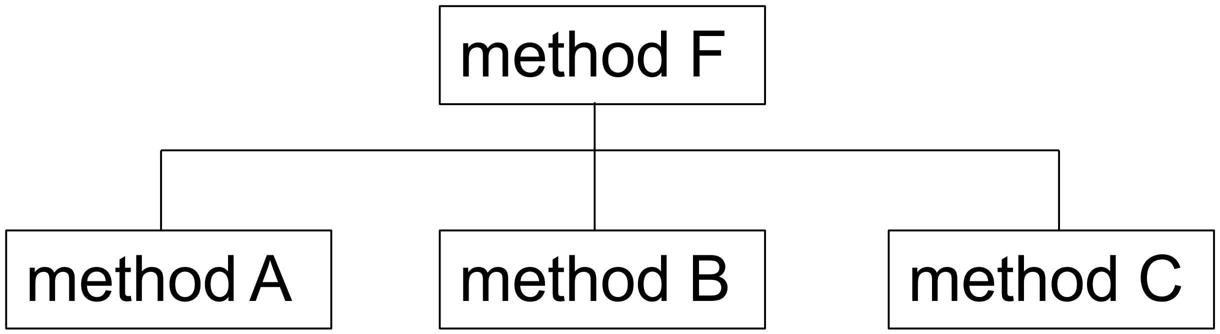
Modular Testing (cont'd)



- Test & debug method A.   (unit test)
- Test & debug method B. (unit test)
- Test & debug method C.   (unit test)
- Finally, test method F.   (integration test)
- If it fails the testing then you can be (mostly) sure that the error is in F, and not a sub-method.

Onward to … JUnit

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