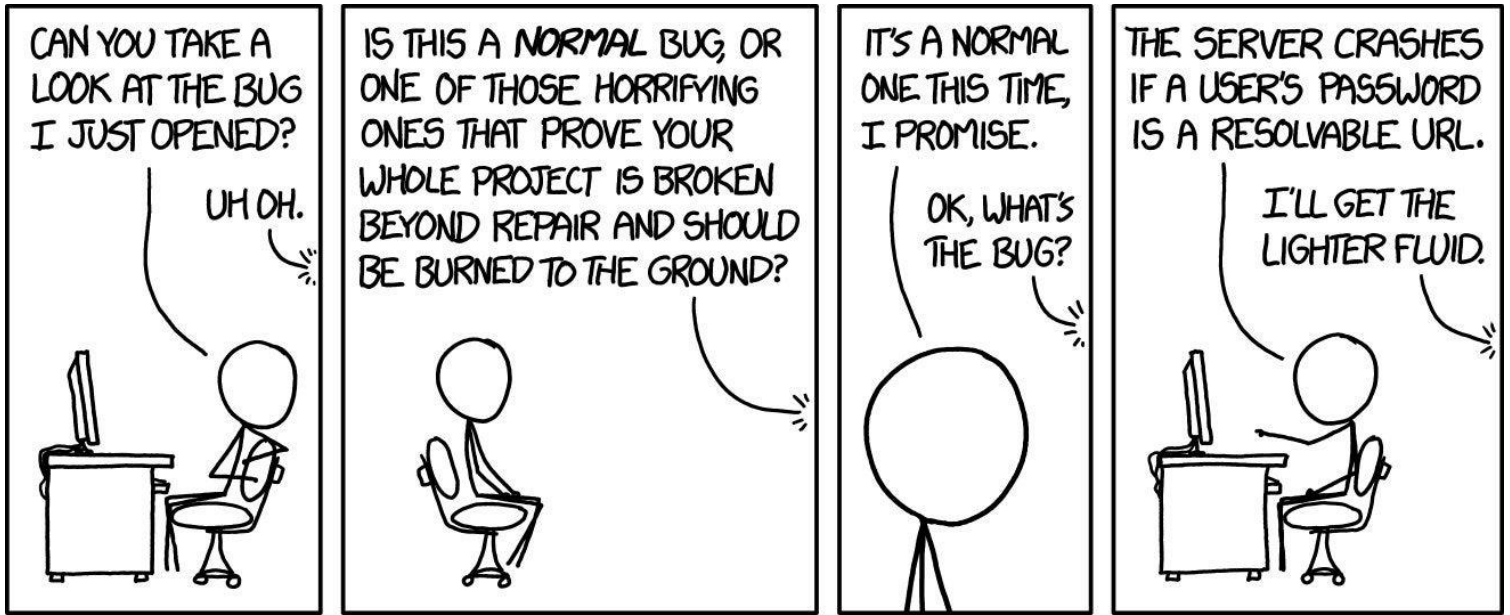
CSci 3081W: Program Design and Development

Lecture 7 – Testing

Testing

Program testing can be used to show the presence of bugs, but never their absence.

– Dijkstra, 1969



Testing

• As the number of detected defects in a piece of software increases, the probability of the existence of more undetected defects also increases

• Assign your best programmers to testing

• Exhaustive testing is impossible

• You cannot test a program completely

• Even if you do find the last bug, you’ll never know it

• It takes more time than you have to test less than you’d like

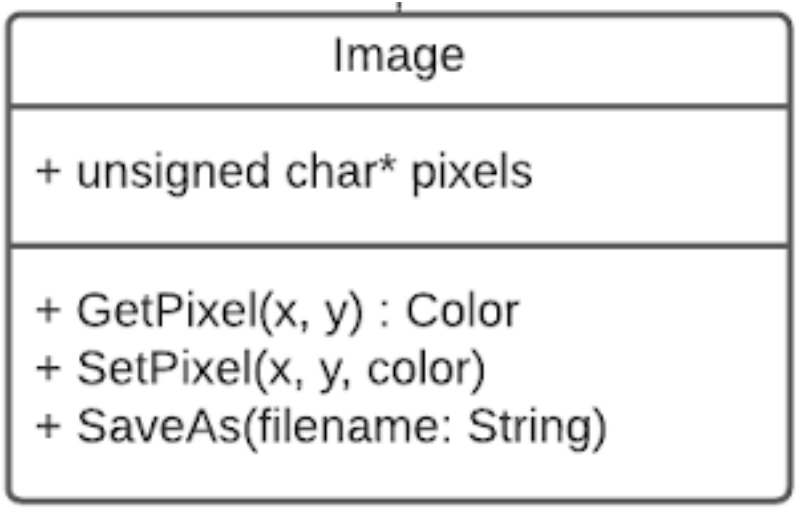
• You will run out of time before you run out of test cases

Types of Testing

- Different standards on types of testing
- According to the optional textbook, there are five types of tests:
  - Unit Testing – testing a single class
  - Component Testing – testing a subsystem
  - Integration Testing – testing multiple classes
  - Regression Testing – testing that future changes don’t break the system
  - System Testing – testing the entire system including hardware performance, security, etc.

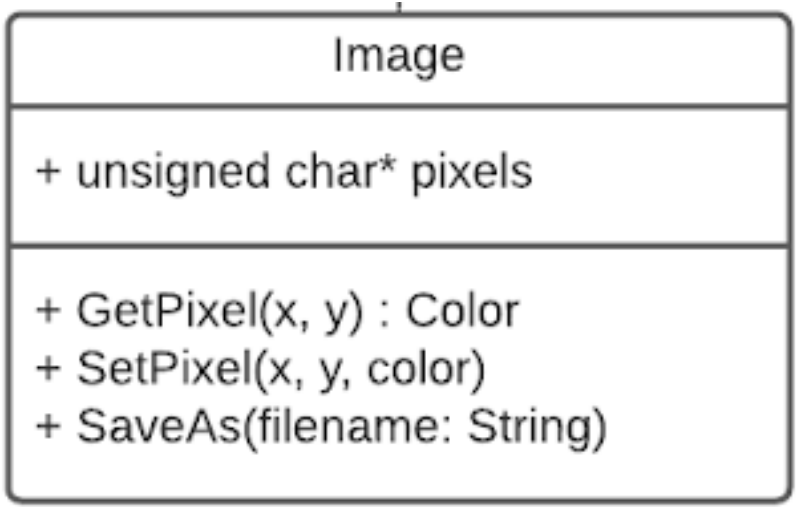
Unit Test

```
TEST_F(ImageTest, SavesImage) {
        Image image("input.png");
        image.SaveAs("output.png");
        ASSERT_TRUE(fileExists("output.png"));
}
```



Integration Test

```
TEST_F(ImageTest, ColorCorrect) {
        Image image("red.png");
        Color c = image.GetPixel(0,0);
        EXPECT_FLOAT_EQ(c.Red(), 1.0)
}
```



Testing

Testing can be done at multiple levels of knowledge

Testing

Figure: Developer

Figure: Independent Tester

Understands the system
Will test gently
Driven by deadlines

Must learn the system
Will attempt to break it
Driven by "quality"

Quality Tests

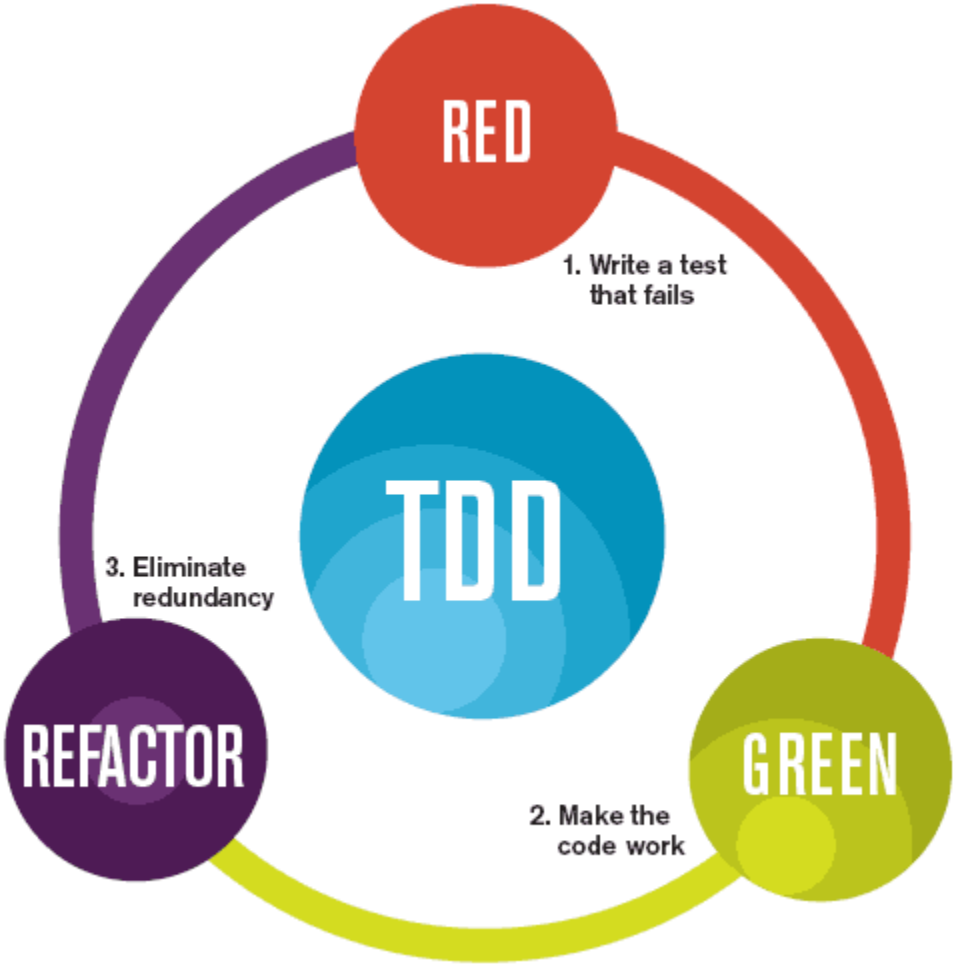
Test Driven Development

Statistical & Boundary Analysis

Structured Basis Testing

Mutant Analysis

Test Driven Development



The mantra of Test-Driven Development (TDD) is "red, green, refactor."

Test Driven Development

THE RULES OF TDD

RULE 1

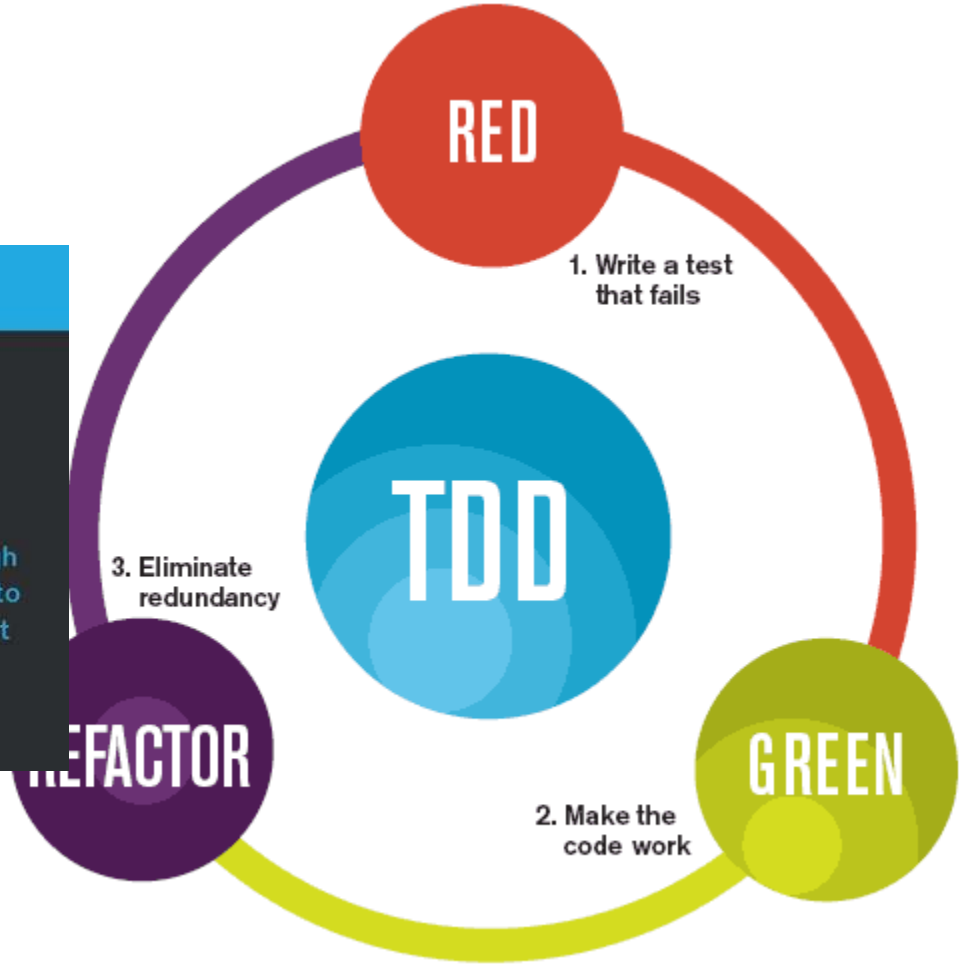
Don't write production code unless it's to help a failing unit test pass.

RULE 2

Only write enough of a unit test to fail.

RULE 3

Only write enough production code to help a failing unit test pass.



The mantra of Test-Driven Development (TDD) is "red, green, refactor."

Test Driven Development (TDD)

Beginner:

- able to write a unit test prior to writing the corresponding code
- able to write code sufficient to make a failing test pass

We can do blue

Test Driven Development (TDD)

Intermediate

- practices “test driven bug fixing”: when a defect is found, writes a test exposing the defect before correction
- able to decompose a compound program feature into a sequence of several unit tests to be written
- knows and can name a number of tactics to guide the writing of tests (for instance “when testing a recursive algorithm, first write a test for the recursion terminating case”)
- able to factor out reusable elements from existing unit tests, yielding situation-specific testing tools

Test Driven Development (TDD)

Advanced

• able to formulate a “roadmap” of planned unit tests for a macroscopic features (and to revise it as necessary)
• able to “test drive” a variety of design paradigms: object-oriented, functional, event-drive
• able to “test drive” a variety of technical domains: computation, user interfaces, persistent data access…

Test Driven Development (TDD)

More info / further reading:

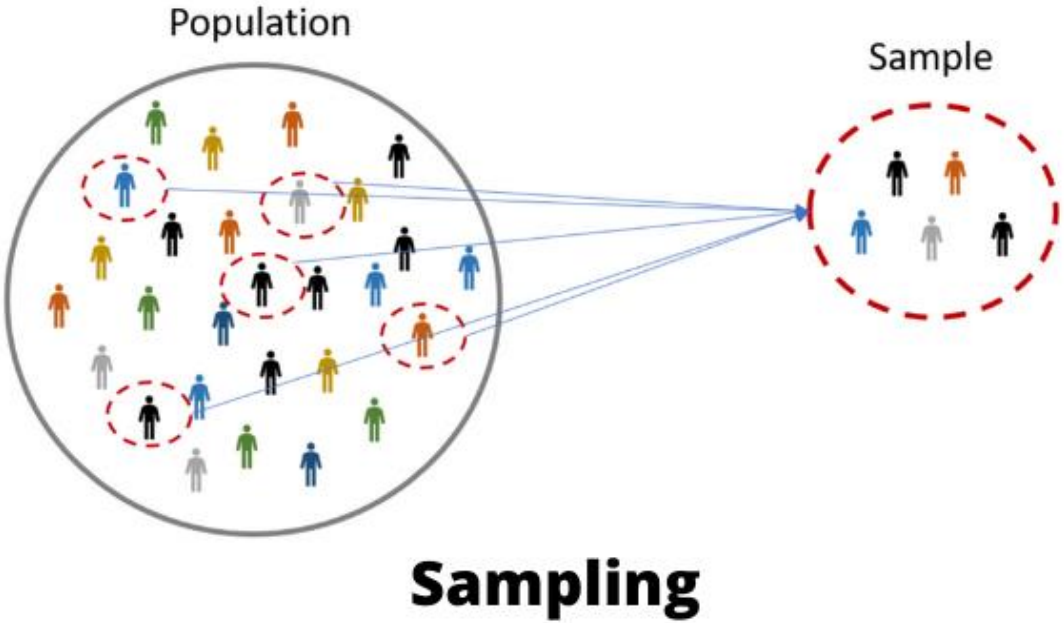
Test Driven Development: By Example

By Kent Beck

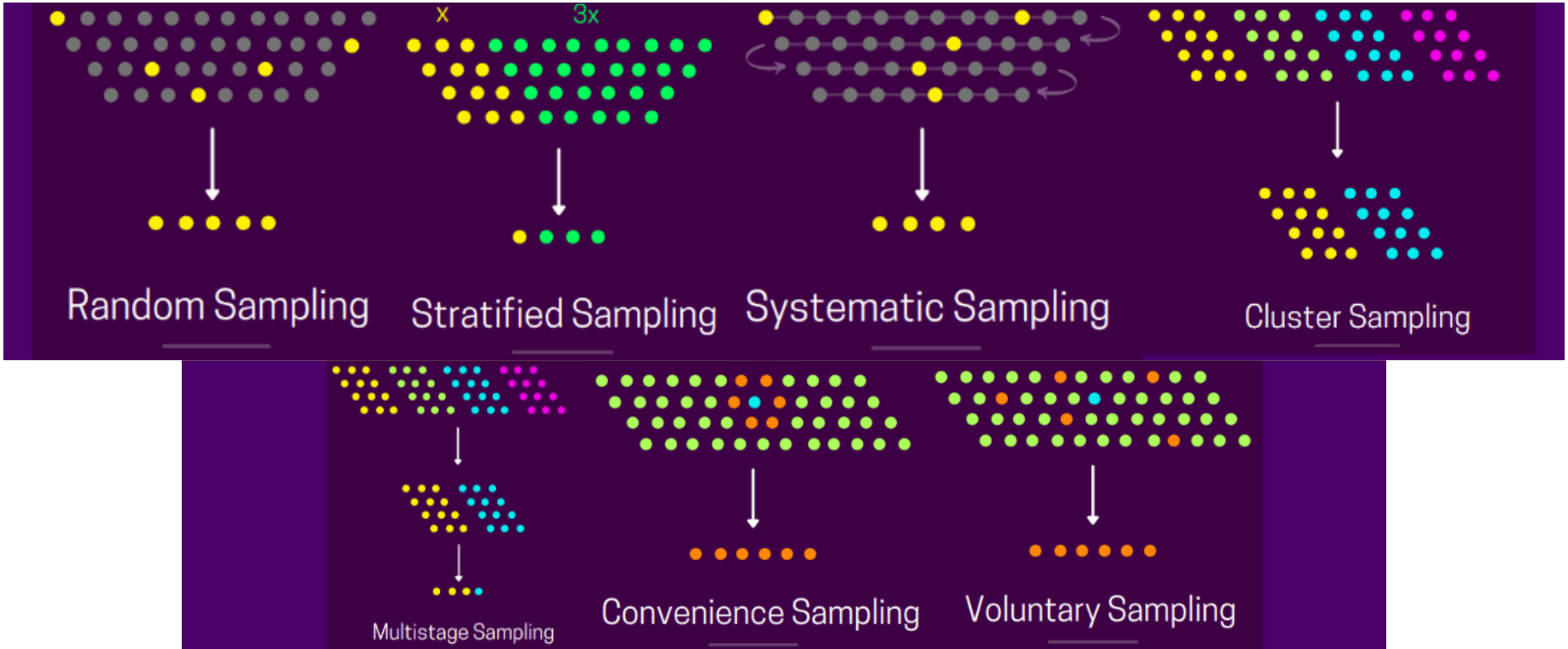
https://www.amazon.com/gp/product/0321146530/ref=as_li_ss_tl?ie=UTF8&linkCode=sl1&tag=&linkId=6d76ed79b7f498d7930b370ad4c059ac

Statistical and Boundary Analysis

Test with good data and the test should pass



Sampling Methods



Boundary Analysis

Test edge cases and bad data

Edge Test Cases:
1. Value just above the maximum
2. Value equal to the maximum
3. Value just below the maximum

Bad Data Cases:
- Incorrect format
- Invalid pointer
- Wrong type
- Too little / too much data

Structured Basis Testing

1. Is every statement containing a ***condition*** executed by at least one test case?

2. Is every ***statement*** in the code executed by at least one test case?

3. Is every ***branch*** in the code covered in the following sense: is every condition evaluated to true by at least one test case, and to false by at least one test case?

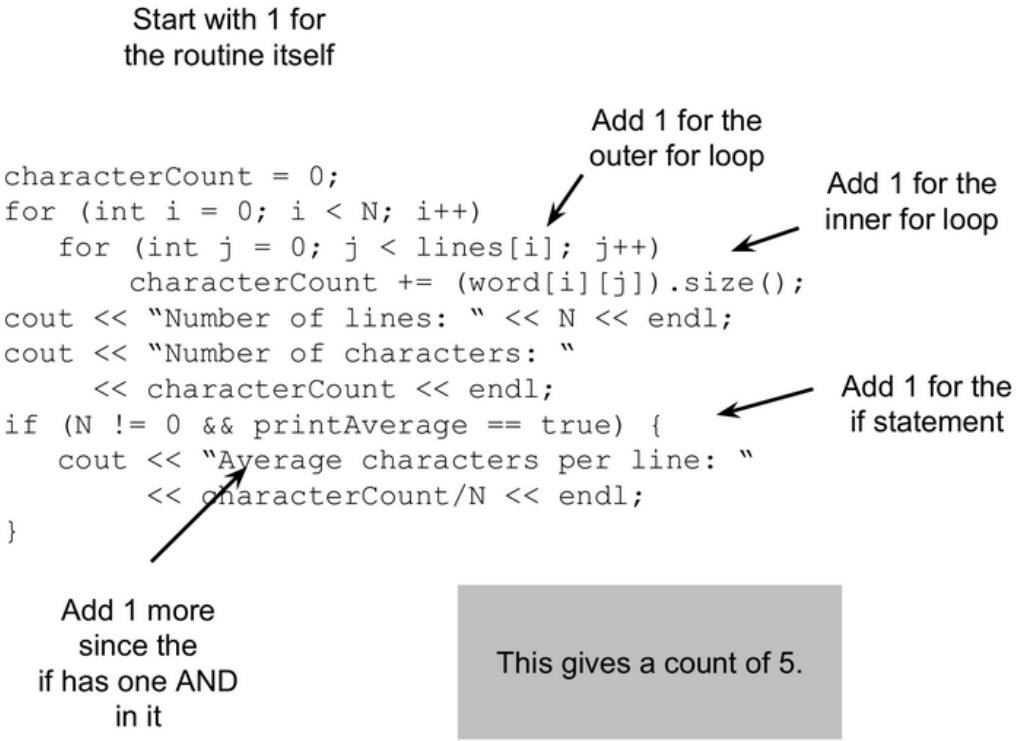
4. Is each part of a ***compound*** condition evaluated to true by at least one test case, and to false by at least one test case?

Structured Basis Testing

Mentioned in McConnell, Ch. 22.3 (pp. 505 - 509). To find a minimal number of test cases to cover all possible values of each part of each condition in a of a piece of code:

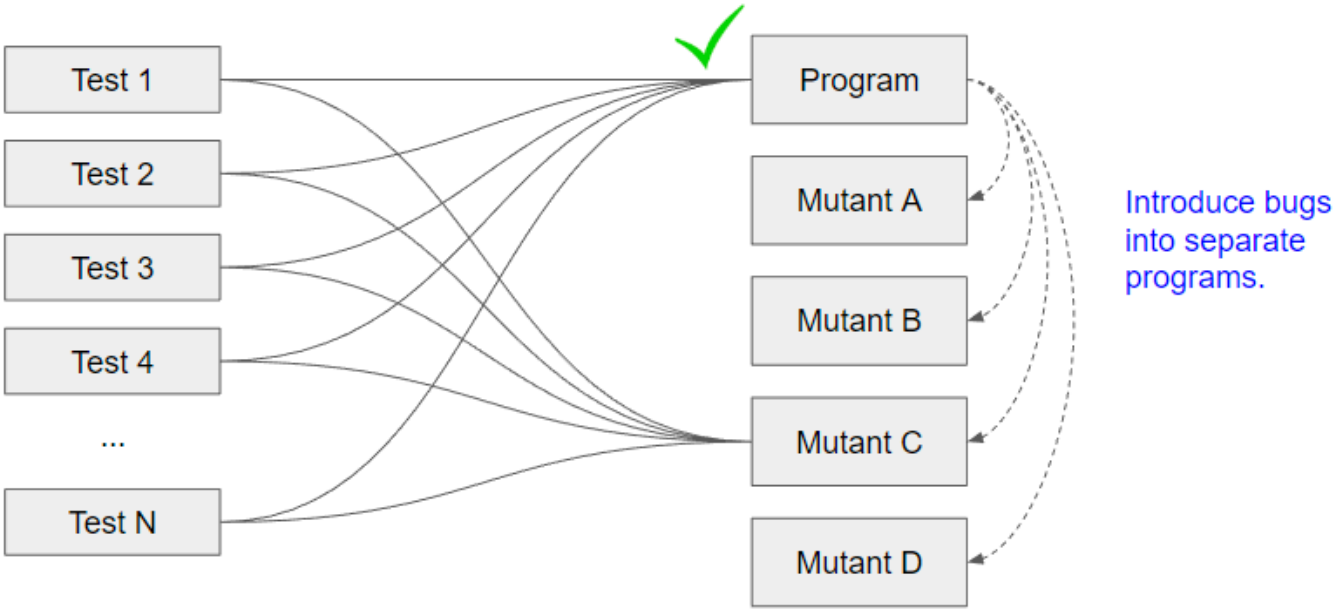
1. Count 1 for the code itself.
2. Count 1 for every loop.
3. Count 1 for every if, else, etc.
4. If any condition (including loop termination) is compound, add one for each additional part of the condition.

Structured Basis Testing



Mutant Analysis Testing (homework 3)

Process of creating many programs with small bugs



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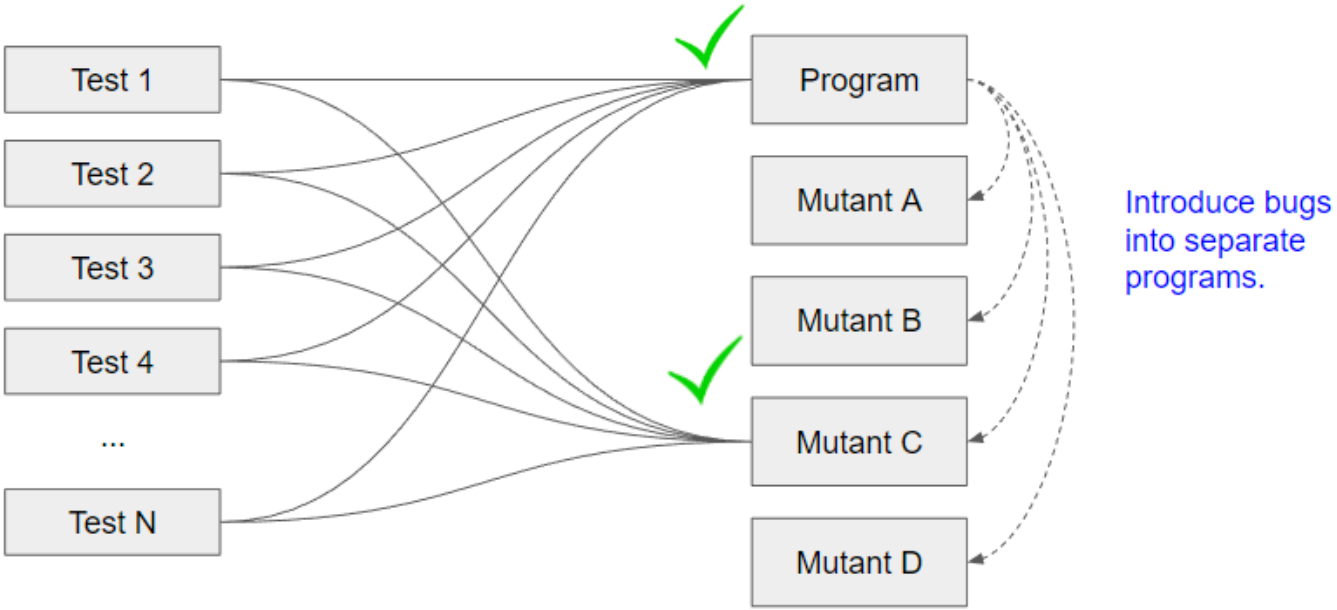

If all the tests pass, that is a bad thing

Other types of testing

- Functional testing
- End-to-end testing
- Acceptance testing
- Smoke testing

Atlassian’s CI/CD guide for software testing:
https://www.atlassian.com/continuous-delivery/software-testing/types-of-software-testing

Google C++ Testing Framework

Skim this: https://developer.ibm.com/articles/au-googletestingframework/

Additional reading on Mock Testing: http://google.github.io/googletest/gmock_for_dummies.html