

## Lecture 5b: Testing

CS 70: Data Structures and Program Development  
Thursday, February 20, 2020

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## Learning Goals

- I can explain what testing is.
- I can explain why testing is useful.

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## Testing: Philosophy of Science Point of View

“My proposal is based on an **asymmetry between verifiability and falsifiability**; an asymmetry which results from the logical form of universal statements. For these are **never derivable from singular statements**, but can be **contradicted by singular statements**.”

- Karl Popper: The Logic of Scientific Discovery 1959

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

- Edsger Dijkstra. Notes On Structured Programming 1970

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## What does that have to do with testing?

- **What is the purpose of testing?**
  - To show that the code has no bugs? A nice ideal.
  - Is exhaustive testing possible?
  - Consider an application with input fields:
    - First Name: up to 20 characters
    - Last Name: up to 20 characters
    - Phone Number: 10 digits
- **The goal of testing is to *find errors*.**

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## Why test during development?

- **Depends on the project.**
  - Not necessary in ALL cases
    - small, simple pieces of code
    - code that won't ever be re-used
  - Designing an interface for many other users? definitely test.
  - In projects where one makes big design choices or there are multiple strategies, testing is especially important.
- **Aspirationally: tests come first.**

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## Test first?

**Test first gives you a hint as to whether your interface suffices.**

- Is it enough to solve a problem?

**Test first suggests that your interface is even testable.**

- Does your code actually have the *potential* to work?

**Test first increases your velocity in general.**

- You get to your solution quicker
- Get to see how far you have gotten and how much more you have until you reach your goal

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## What is a test?

**A test should have several components:**

- The test input or scenario
- The expected result
- Documentation
  - What part of the requirements is being tested?
  - What is the reasoning behind the test?

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## How do we test?

- Find a framework to make testing easy
  - i.e. the lightweight testing-logger we provided
  - affirm test conditions
- Testing Domain Specific Languages (DSLs)
- C++: gtest (an open source project, stands for Google Test).
- Python: pytest
- Java: junit, Truth

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## Equivalence Partitioning

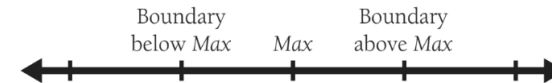
What are some good test values for this function?

```
double compute(double x){
    double y = x + 1.0;
    if(y < 10.0){
        return y;
    }
    return 10;
}
```

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## Boundary Analysis

- Extremely common mistakes:
  - you write *num* when you meant *num - 1*
  - you write *>=* when you meant *>*
- Explicitly write tests to discover these types of errors



- Input values to test?

```
double compute(double x){
    double y = x + 1.0;
    if(y < 10.0){
        return y;
    }
    return 10;
}
```

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## Explicitly test for bad data

Examples:

- Too little data:
  - an empty vector
- Too much data:
  - array of 1 million employees
- Invalid data:
  - Negative student ID number

What about uninitialized data??

```
int x;
compute(x);
```

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## Explicitly test for good data

Examples:

- Nominal data: middle of the road, expected data  
e.g. 10 employees in database
- Minimum nominal configuration  
e.g. 1 employee in database
- Maximum nominal configuration  
e.g. 1,000 employees in database

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## Unit testing

Test individual units of code:

- typically, test every single function

How much testing is enough? At a *minimum*

- Cover every statement
- Cover every branch

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## Integration testing

After individual units (e.g. functions) are tested, do they correctly work together?

Two main ways to combine units:

Output of one passed to the other

```
int x = function1(y);  
int z = function2(x);
```

One function is called by another

```
int function3(int x){  
    int y = function4(x)  
    return y;  
}
```

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## Integration testing with a Driver

For integration testing, a driver is a function or class whose sole purpose is to combine two or more units.

```
int driver(int y){  
    x = function1(y);  
    z = function2(x);  
    return z;  
}
```

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## Exercise: Brainstorm test inputs

Consider an application with input fields:

- \* First Name: up to 20 characters
- \* Last Name: up to 20 characters
- \* Phone Number: 10 digits

Come up with some test inputs

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