CMSC 132: OBJECT-ORIENTED PROGRAMMING II

Program Testing

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Program Testing

- Empirical testing
  - Test software with selected test cases
  - More scalable than verification
  - Test failures frequently indicate software errors
    - Absence of failures doesn't prove software correct
  - If code isn't exercised by any test, hard to have confidence in it
    - Even if it has been "formally verified"

Kinds of Testing

- Automated testing
  - The software is tested by a completely automatic process
    - e.g., jUnit or submit server testing
  - Can be expensive or difficult to construct, but fairly cheap to repeat
- Manual testing
  - A person uses the software, perhaps guided by a script, and notes bugs
  - Often easier to conduct than writing test cases, but very expensive to repeat

Test Size

- Small
  - Unit test – test individual components
- Medium
  - Integration tests
  - Test subsystems containing several components
  - Can test interactions between components, properties that are only demonstrated in larger systems
- Large
  - System or acceptance tests
  - Test entire system, including non-software components

Types of Testing

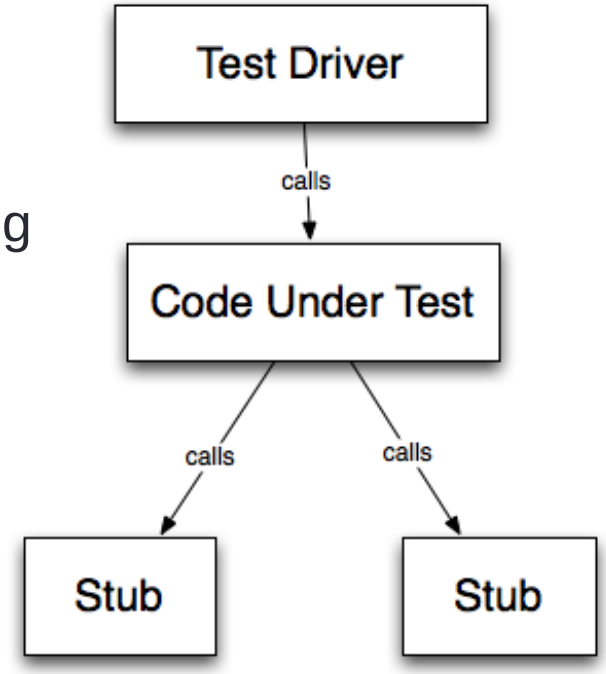
- Clear box testing
  - Allowed to examine code
  - Attempt to improve thoroughness of tests
- Black box testing
  - No knowledge of code
  - Treat program as “black box”
  - Test behavior in response to inputs

Testing – Terminology

- Test case
  - Individual test
- Test suite
  - Collection of test cases
- Test harness
  - Program that executes a series of test cases
- Test framework
  - Software that facilitates writing & running tests
  - Example – JUnit

Testing – Terminology

- Test driver
  - Program to create environment for running tests
  - Declares variables, creates objects, assigns values
  - Invokes tested code, checks results, reports failures
- Stub
  - Skeleton code in place of unfinished method / class
  - Implements minimal functionality to allow test to occur
    - Allows software testing to begin



Mock Objects

- Similar to a stub
- But they record the calls made to them
- If the wrong calls are made to them, the test fails
- Can prerecord the sequence of expected calls
  - Also eliminates need for mock objects to contain any logic
- Or the test driver can query the calls after the test
  - Useful if calls aren’t deterministic and need more careful logic to check

When to Use Mock Objects

- If you want to test the calls made to other objects, rather than the return values or output of the methods under test
- You need to use mock objects
- Mock objects can also be easier to use than creating functional stubs
- Mock objects can simulate situations that might be hard to test on real code
  - e.g., does the code recover if the network fails?

EasyMock Example

```
warehouseControl = MockControl.createControl(Warehouse.class);
warehouseMock = (Warehouse) warehouseControl.getMock();
Order order = new Order(TALISKER, 50);
//setup – record expected calls and return values
warehouseMock.hasInventory(TALISKER, 50);
warehouseControl.setReturnValue(true);
warehouseMock.remove(TALISKER, 50);
 warehouseControl.replay(); // put mock into replay mode
//exercise – execute code under test
order.fill(warehouseMock);
//verify
warehouseControl.verify();
assertTrue(order.isFilled());
```

Unit Test

- Test individual units extensively
  - Classes
  - Methods
- Central part of Extreme Programming (XP)
  - Extensive unit testing during development
    - Pair programming
  - Design unit tests along with specification
- Approach
  - Test each method of class
  - Test every possible flow path through method

Test Coverage

- How do you know if your tests are any good?
  - In general, you can know if they are bad or insufficient, harder to tell that they are good
- Do they handle and check all the situations described in the specification and use cases?
- Do they invoke all the methods?
- Do they test all of the code?

Flow Path

- Unique execution sequence through program
- Example

```
S1
while (B1) {
    if (B2)
        S2
    else
        S3
}
```

Flows

S1

S1, S2

S1, S3

S1, S2, S2

S1, S2, S3

S1, S3, S2

S1, S3, S3

…

Test Coverage

- Not possible to test all flow paths
  - Many paths by combining conditionals, switches
  - Infinite number of paths for loops
  - New paths caused by exceptions
- Test coverage
  - Whether code is executed by some test case
  - Alternative to flow path
  - Ensure high % (if not all) of lines of code tested
  - Does not capture all possible flow paths
    - Even if all lines of code tested by some test case

Test Coverage, Continued

- Branch coverage is strong than statement coverage
  - Generally achievable
- Can be tricky to cover all exceptions and error cases
- Control flow coverage doesn’t tell you about data coverage
  - Did you try it with negative integers, or with non-ASCII characters?
- Coverage won’t tell you about functionality you forgot to implement or test

When to Test

- If code has never been tested, you have no idea if it ever worked
- But it is also important to perform regression testing
  - Check to see if some functionality that used to work stops working
  - The faster a regression is identified, the cheaper it is to fix, at any scale
    - Within a minute is better than within an hour
    - Within a day is better than within a week

Why Regression Test?

- Bits don’t rot
- But running regression tests give developer much more freedom to change existing code
  - “I need to rewrite this component to support new functionality – I wonder if anything might be depending on the details of how it works now?”
- This freedom is key to agile development, and important even in more structured development methodologies

Selecting Regression Tests

- Big, well tested systems will have too many tests to run all of them every time you compile
- Prioritize tests by size
  - Ones that take only a few seconds
  - Ones that need to run over the weekend
- And by proximity to code changed
  - After changing some code, you only need to rerun the tests that executed the code that was changed
- Research work on prioritizing tests

Developing Quality Test Cases

- Useful to have someone else write test cases
  - One person might make the same incorrect assumption in both their code and in their tests
- Tips on developing test cases
  - Develop test data during analysis & design phases
    - Use cases $\rightarrow$ Test cases
    - Pay close attention to problem specification
  - Check boundary conditions
    - 1st and last iterations of loop
    - 1st and last values added to data structure
  - Improve code coverage