

CMSC 132: Object-Oriented Programming II

Program Testing



Department of Computer Science
University of Maryland, College Park

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

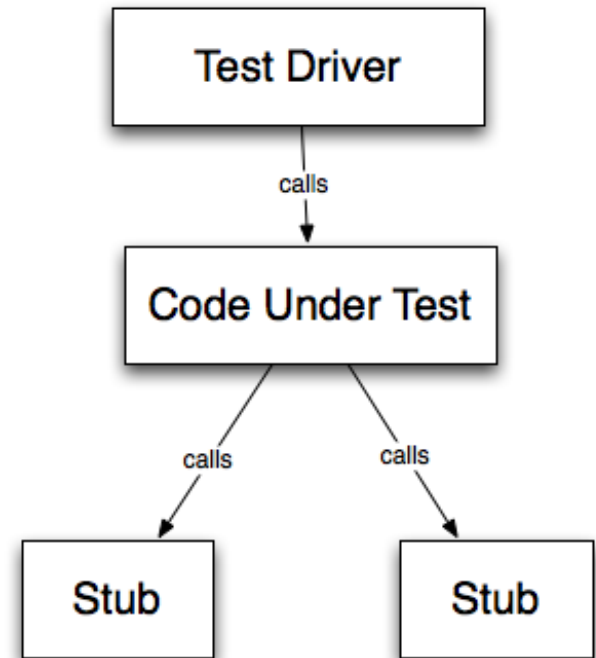
Testing – Terminology

■ 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 stronger 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 → 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**