CMSC 132:
Object-Oriented Programming II

Program Testing

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Overview

Testing

- Types of testing
- Levels of testing
Program Testing

Goal

- Detect and eliminate errors in program
- Feedback to improve software
  - Specification changes
  - Add new functionality
- Extremely important for success!
Program Testing

Empirical testing

- Test software with selected test cases
- More scalable than verification
- Not guaranteed to detect all errors
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
- Executes code and displays results of tests

Stub
- Skeleton code in place of unfinished method / class
- Simply return if called
  - Possibly print message indicating stub called
- Allows software testing to begin
Testing – Terminology

- **Tester (Quality Assurance)**
  - Person devising and / or performing tests
  - More effective if 2nd person writes tests

- **Walkthrough**
  - Programmer explains code to 2nd person
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
Levels (Stages) of Testing

1. Unit test
2. Integration test
3. System test
4. Acceptance test
Unit Test

Test individual units extensively

- Classes
- Methods

Central part of Extreme Programming (XP)

- Extensive unit testing during development
  - Pair programming (1 coder, 1 tester)
  - Design unit tests along with specification

Approach

- Test each method of class
- Test every possible flow path through method
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
...

...
Unit Test – Flow Path

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
- 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
Integration Test

Test interaction between units
- Possible units fail when combined
- May find problems in specifications

Approach
- Test units together
- Proceed bottom up, in increasing size

Example test sequence
1. AB, AC, AD, CD, CE
2. ACD
3. ABCDE
System Test

Test entire software
  - Include all components of software
  - In context in which software will be used

Ensure all pieces of software interact correctly
Acceptance Test

Test full functionality of software

- Ensure program meets all requirements

Approach

- Place software in user environment
- Test software with
  - Real-world data
  - Real users
  - Typical operating conditions
  - Test cases selected by users
Acceptance Test – Stages

- **Alpha test**
  - Test components during development
  - Usually clear box test

- **Beta test**
  - Test in real user environment
  - Always black box test
Regression Test

Ensure functionality is not lost / changed
- As software is modified / extended

Approach
- Save suite of tests and expected results
- Rerun test suite periodically after software changes
- Report any loss of functionality

Typically run overnight
- Software is more stable when developers leave work
Developing Test Cases

Quality of testing depends on test cases

Tips on developing test cases

- Develop test data during analysis & design phases
- Attempt to exercise alternate program paths
- Check boundary conditions
  - 1st and last iterations of loop
  - 1st and last values added to data structure
- Pay close attention to problem specification
- UML use cases → test cases