Testing

Chapter 23

(the lecture contains content not covered in the textbook. Let me know if you have questions regarding the lecture slides.)
Ariane 5 story
Outline

• How to judge the quality of a test suite
• How to design test suite
  • Manually
  • Automatically
How to judge the quality of a test suite
Classical coverage criteria

• Statement coverage
• Branch coverage
• Path coverage
• Data-flow coverage
• Others ...

*Background*: control flow graph; data flow graph
Coverage

- Statement coverage: lines of code ( # lines executed / total # of lines)
- Branch coverage: (# of branch decisions exercised/ # of branches x 2)
  - 100% stmt coverage does not mean 100% branch coverage
- Path coverage
  - Unrealistic
Relationship among coverage criteria

• 100% coverage may be infeasible to achieve
• 100% stmt coverage $\rightarrow$ 100% branch coverage?
• 100% branch coverage $\rightarrow$ 100% statement coverage?
• Correct under a 100% coverage testing $\rightarrow$ is bug free?
Relationship among coverage criteria

• 100% coverage may be infeasible to achieve
• 100% stmt coverage $\rightarrow$ 100% branch coverage?
  • No
• 100% branch coverage $\rightarrow$ 100% statement coverage?
  • Yes
• Correct under a 100% coverage testing $\rightarrow$ is bug free?
  • no
Program’s graph representation

• Control flow graph (call graph)
• Data dependency graph
How to compute coverage (automatically)?
Cyclomatic complexity & basis path set testing

• Cyclomatic complexity
  • Based on program flow graph
    • Calculated by $E - N + 2$
  • Represents # of (linearly) independent paths in a graph
    • If one path covers at least one edge/node not covered by existing paths, it is independent

Basis path set testing

• Simplification from path-coverage testing
• Full test space size = $E - N + 2$
Data flow testing coverage

• DU coverage
  • Exercise every pair of define-use pairs
What is a “good” test set?

- Achieve good coverage (~100%)
- Little redundancy
  - How to judge redundancy?
How to design test suites
How to design test cases?

• Black box
• White box
• Random
• ...

How to design good test set manually?

• White-box testing
How to design good test set manually?

• White-box testing  
  • Obtain the list of test properties to cover  
  • Cover at least one new property at a time  
  • Cover all properties that can be covered  
    • Some properties may be infeasible to cover
How to conduct black box testing?
How to conduct black box testing?

• Equivalence class
  • Divide the input spaces into several equivalence classes; test at least one input in each class

• Boundary cases
  • If the expected input is a range of value, ...
  • If ..... is a set of value, ...
  • If ..... is a string, ...

• Common bug patterns

• Fuzz testing
Integration testing

• Use special values as function parameters
How to automatically generate test set?

- Automated random testing
  - Non-structural inputs
  - For structural inputs
    - For even more structural inputs (how to test a compiler?)

- Coverage-oriented testing
Can testing prove bug free?

• No!

• What is the implication of 100% path coverage?
Non-functional testing

- Performance testing
- Security testing
- ...

Not covered in lecture; will not appear in quizzes or exams.
Misc.

• To cover later, if we have time
• ... 
• Mutation testing
• How to save regression testing effort?
• Can we test only part of the program?
• Research topics on testing
• Code Hunt Game

Didn’t have to cover in lecture.