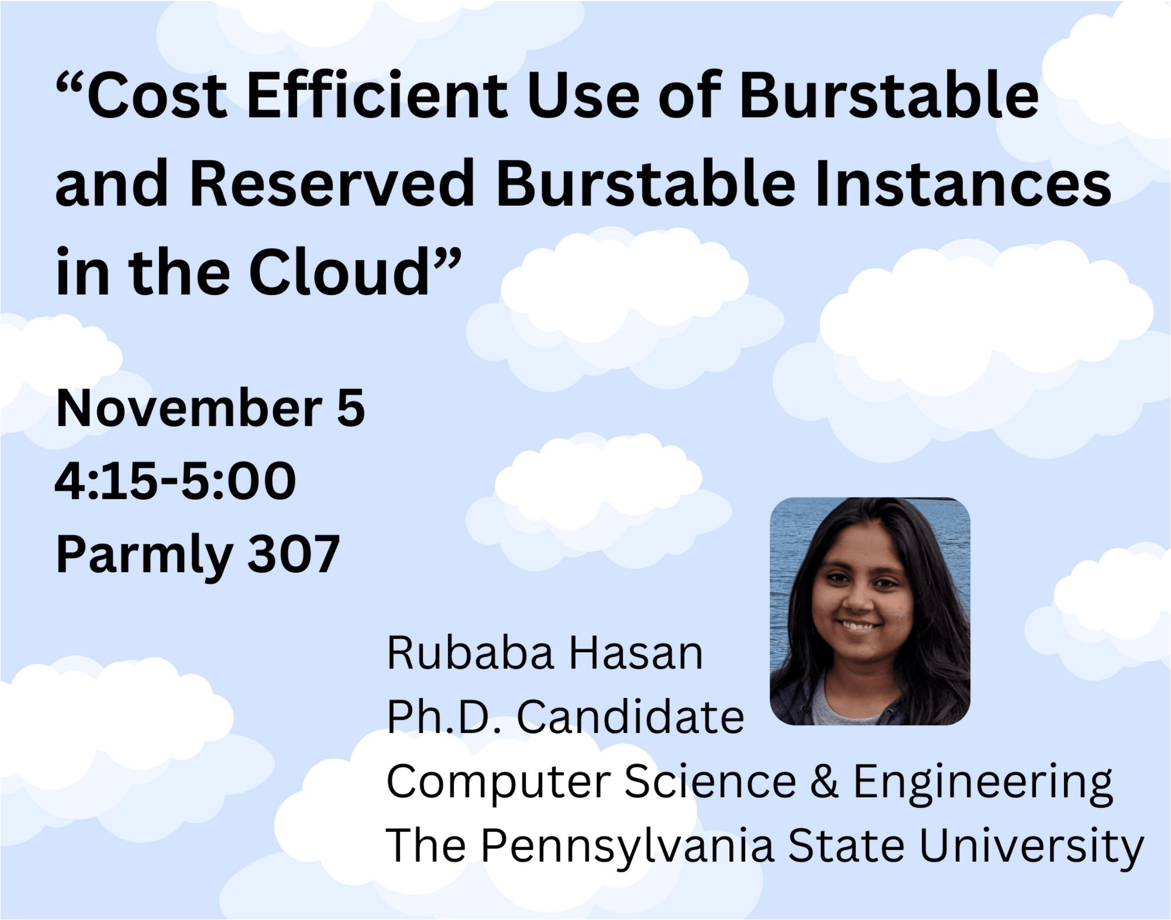
Objectives

- Coverage
- Testing wrap up
- Design

Extra Credit Opportunity



“Cost Efficient Use of Burstable and Reserved Burstable Instances in the Cloud”

November 5
4:15-5:00
Parmly 307

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Ph.D. Candidate
Computer Science & Engineering
The Pennsylvania State University

A Quality Assurance “Joke”

- A QA engineer walks into a bar. Orders a beer. Orders 0 beers. Orders 999999999999 beers. Orders a lizard. Orders -1 beers. Orders a ueicbksjdhd.

A Quality Assurance “Joke”

- A QA engineer walks into a bar. Orders a beer. Orders 0 beers. Orders 99999999999 beers. Orders a lizard. Orders -1 beers. Orders a ueicbksjdhd.
- First real customer walks in and asks where the bathroom is. The bar bursts into flames, killing everyone.

Testing Project Recommendations

- Do what you did to test classes previously, but adapt for JUnit framework
- Create your testing process
- Decide on your assumptions
  - Be consistent
- Encode the specifications for the code in your tests
  - Code must pass these to show that it is correct
- Check the FAQ

Checkpoint: Repositories created.
All team members joined the repository

Review

1. What is our git workflow when we’re collaborating with teammates?
   - Both variations (why 2 variations?)
2. How should teams work together for success?
3. What is code coverage?
4. What is code coverage *criteria*?
   - Provide examples of code coverage criteria

- Brainstorm: How can we leverage/use code coverage in our development process?

Review:
Collaboration: Workflow – Seeking Feedback

1. Create a branch for your work from main
   - Commit periodically
   - Write descriptive comments so your team members know what you did and why
2. Push your branch
3. In GitHub, open a ***Pull Request*** on your branch
   - You can tag your teammates to let them know that you've completed your work
   - Team: discuss and review potential changes – can still update
4. Merge pull request into `main` branch (when ready)
5. Pull the `main` branch to get the latest code
   - May want to merge main into your branch

Don't work directly in main

Review: Collaboration: Workflow

Don't work directly in main

1. Create a branch for your work
   - Commit periodically
   - Write descriptive comments so your team members know what you did and why
2. Switch to `main`
3. Pull `main` branch
4. Merge your branch into the `main` branch
   - Handle merge conflicts
   - Commit
5. Push `main` branch

Culture Eats Strategy for Breakfast

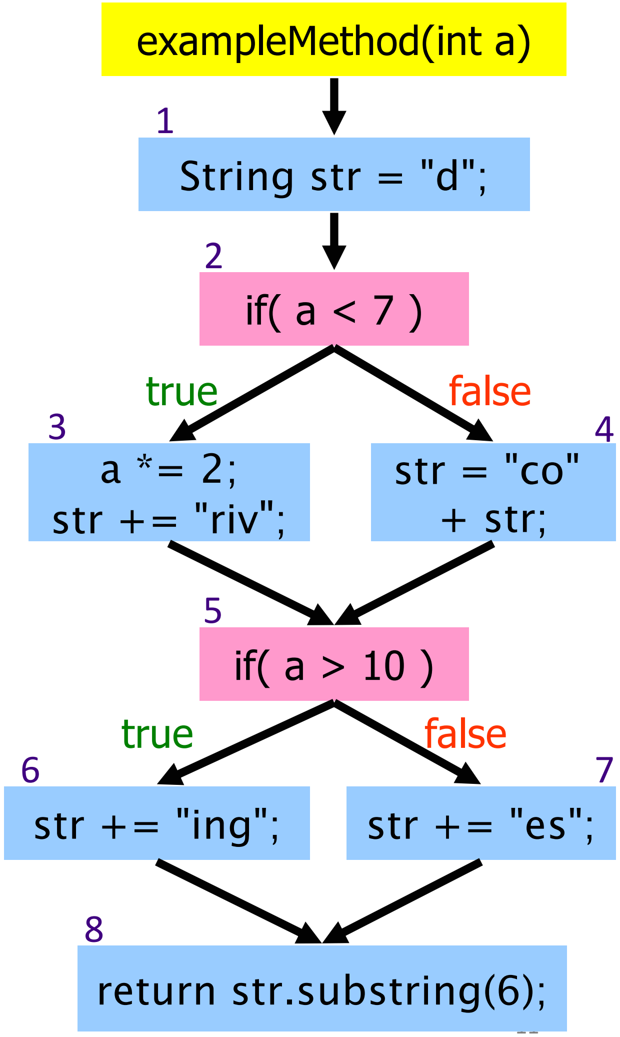
Your actions should match what your team says are your squad goals.

Review: Code Coverage

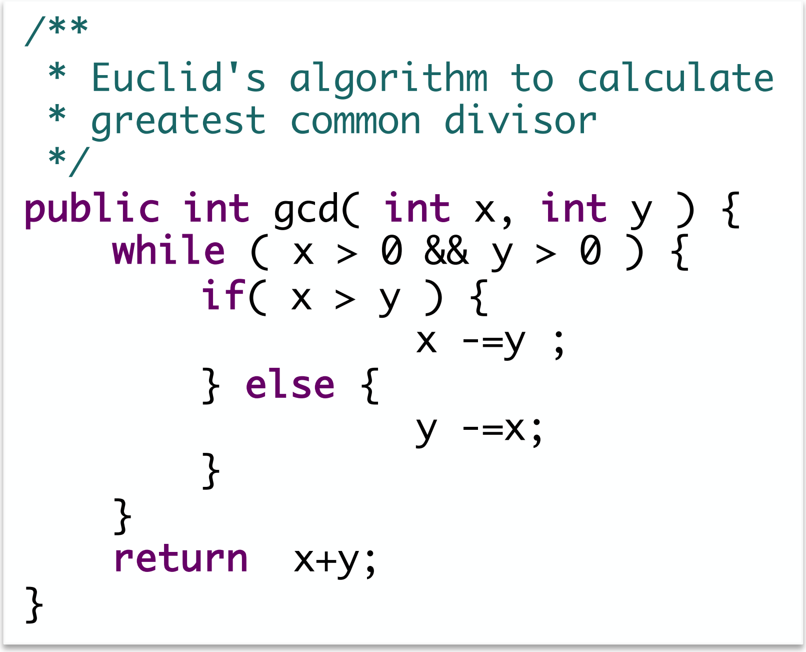
- Code coverage: the amount of code that your tests execute
- Code coverage *criteria*: metric or measure used
  - Statement: number/% of statements executed
  - Branch: number/% of statements + branches (conditions, loops) executed
  - Path: number/% of paths executed

Path Coverage

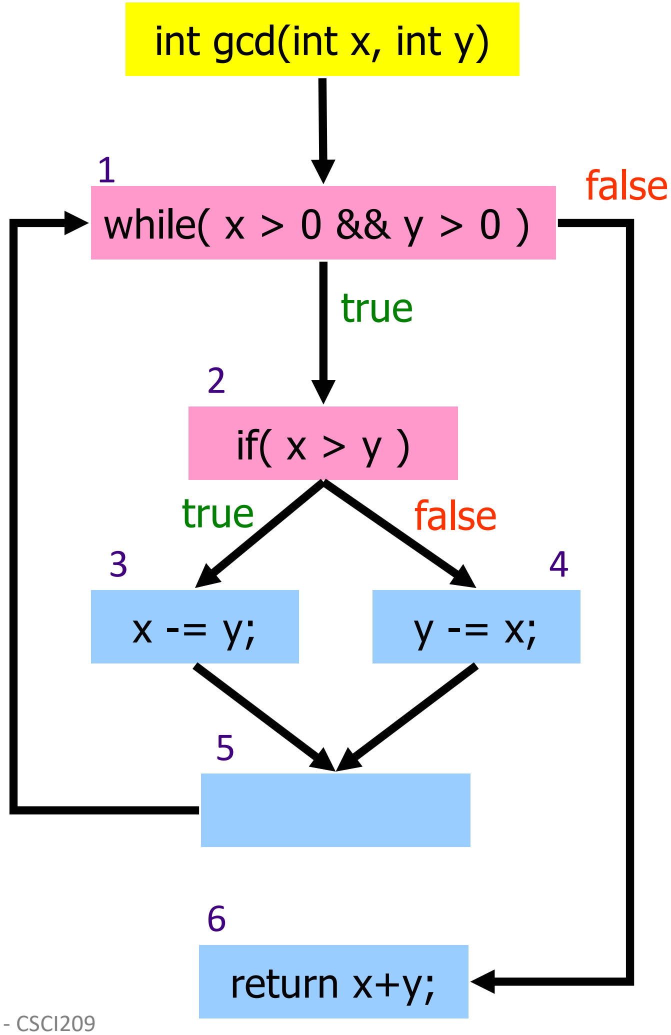
- Cover all **paths** in program’s flow
- How many paths through this method? 4
  - 1-2-**3**-5-**6**-8
  - 1-2-**3**-5-**7**-8
  - 1-2-**4**-5-**6**-8
  - 1-2-**4**-5-**7**-8
- What test cases would give us path coverage?
  - One possibility: a = 3, 30, 6, 10



Example 3



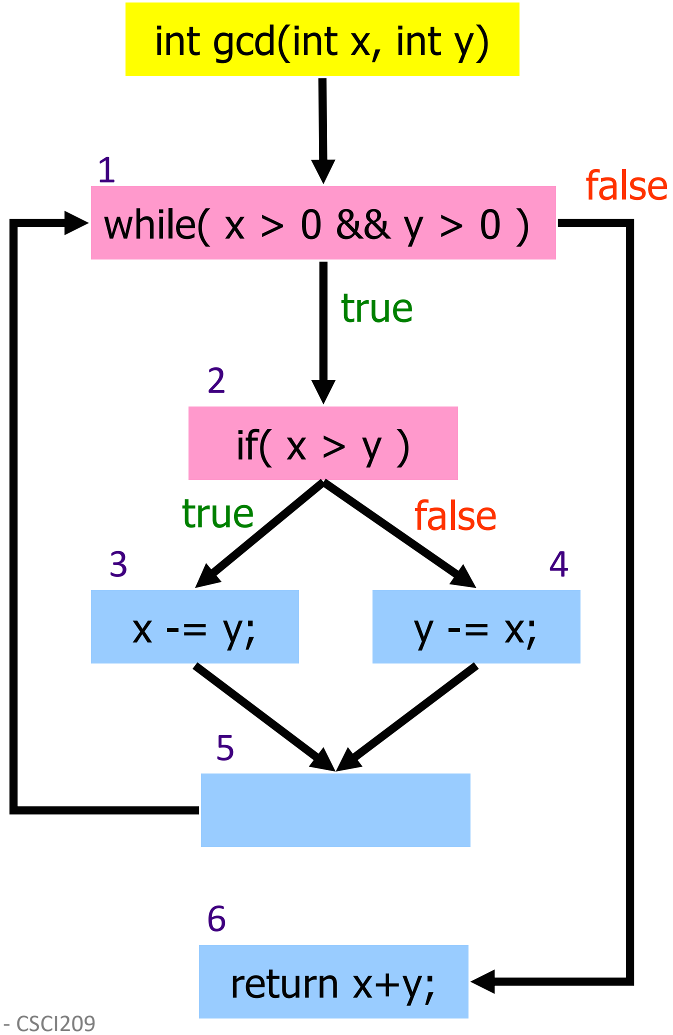
```
/**
 * Euclid's algorithm to calculate
 * greatest common divisor
 */
public int gcd( int x, int y ) {
    while ( x > 0 && y > 0 ) {
        if( x > y ) {
                 x -=y ;
        } else {
                 y -=x;
        }
    }
    return  x+y;
}
```



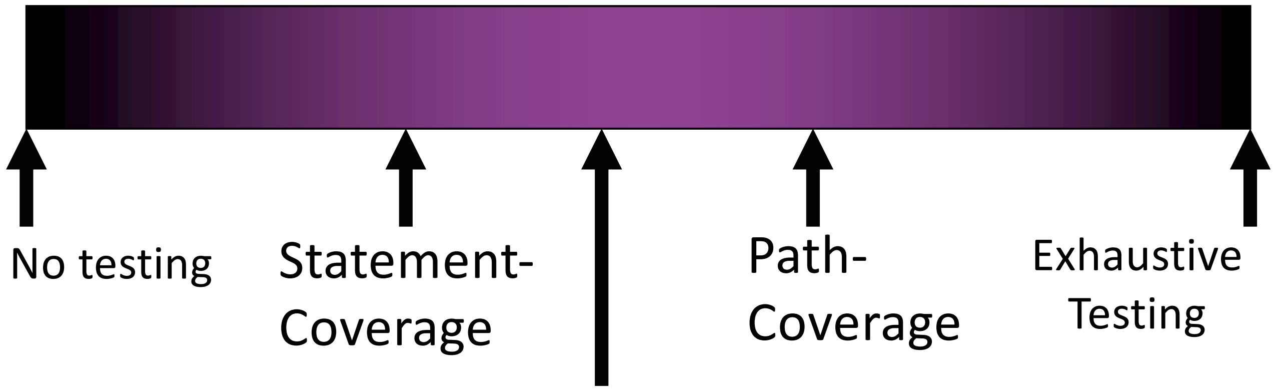
Path Coverage

- How many paths through this method?
  - Too many to count, test them all!

1-6
1-2-3-5-1-6
1-2-4-5-1-6
1-2-3-5-1-2-3-5-1-6
1-2-4-5-1-2-4-5-1-6
1-[2-(3|4)-5-1]*-6



Testing Continuum



No testing

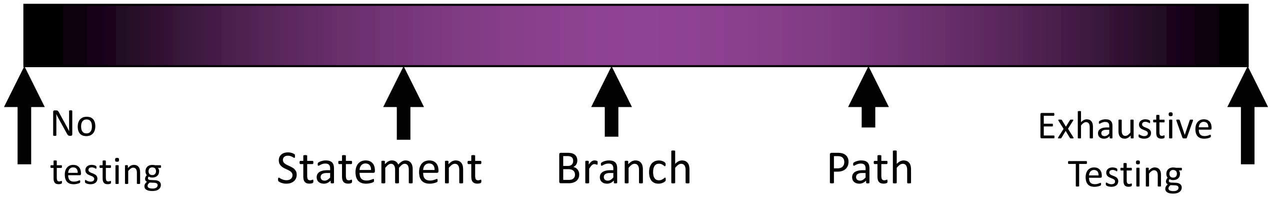
Statement-Coverage

Branch-Coverage

Path-Coverage

Exhaustive Testing

Comparison of Coverage Criteria



No testing

Statement

Branch

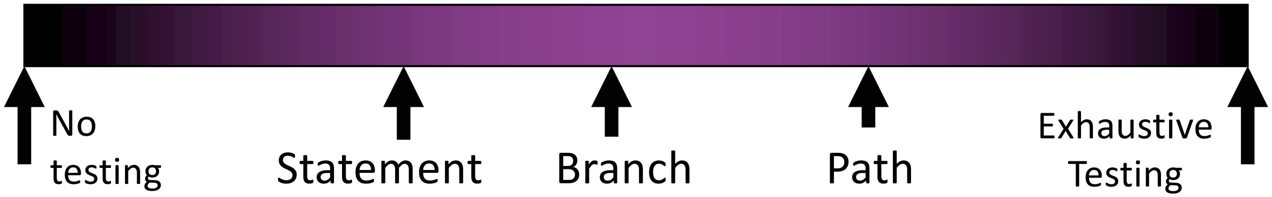
Path

Exhaustive Testing

Coverage Criterion	Advantages	Disadvantages
Statement		
Branch		
Path		

Consider how you would incorporate code coverage into your process

Comparison of Coverage Criteria



No testing

Statement

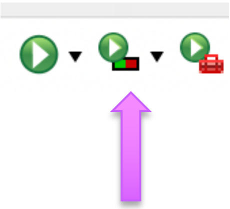
Branch

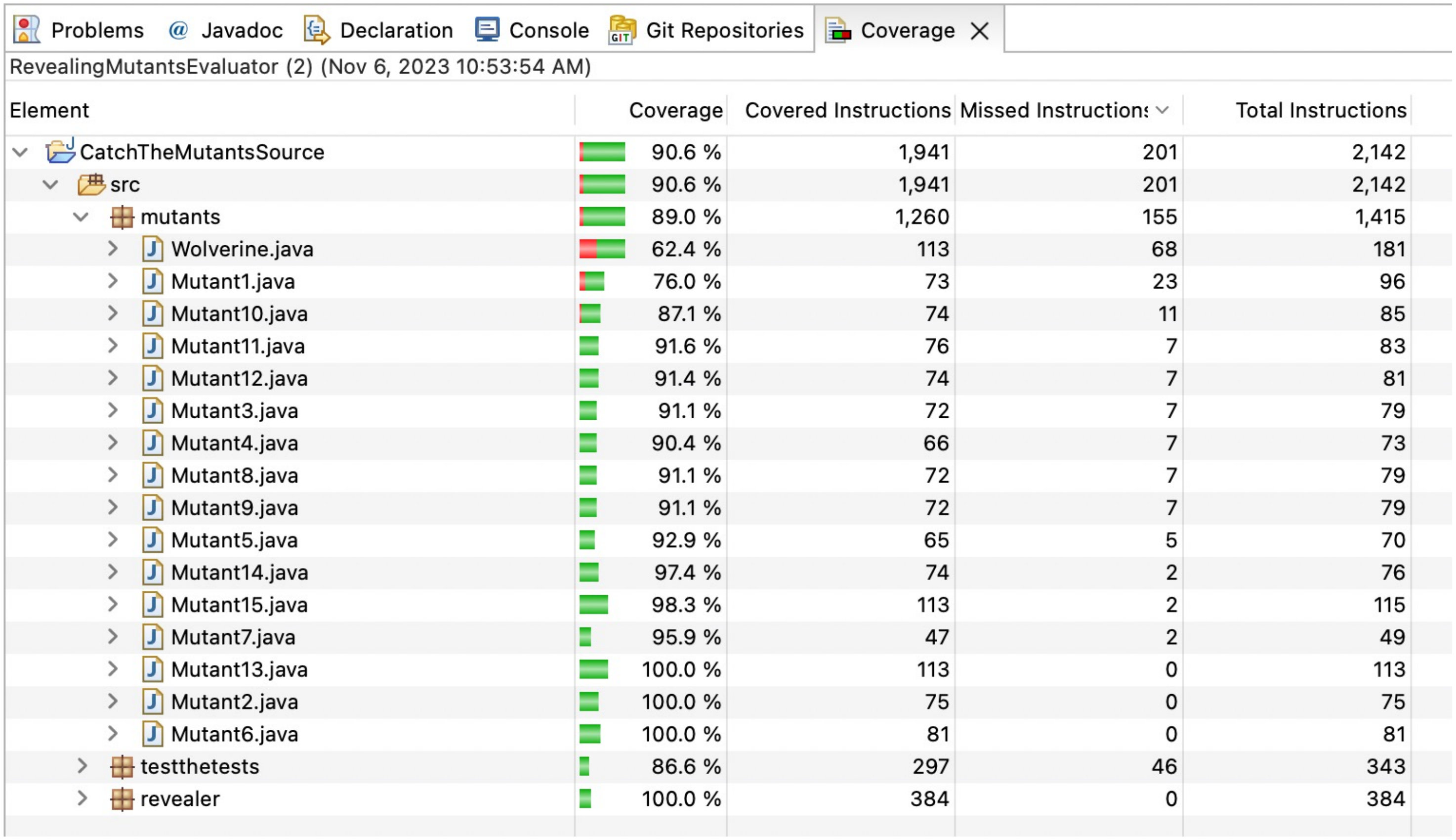
Path

Exhaustive Testing

Coverage Criterion	Advantages	Disadvantages
Statement	Practical	Weak, may miss many faults
Branch	Practical, Stronger than Statement	Weaker than Path
Path	Strongest	Infeasible, too many paths to be practical

How Can We Use Coverage Criteria?





RevealingMutantsEvaluator (2) (Nov 6, 2023 10:53:54 AM)

Element	Coverage	Covered Instructions	Missed Instructions	Total Instructions
CatchTheMutantsSource	90.6 %	1,941	201	2,142
src	90.6 %	1,941	201	2,142
mutants	89.0 %	1,260	155	1,415
Wolverine.java	62.4 %	113	68	181
Mutant1.java	76.0 %	73	23	96
Mutant10.java	87.1 %	74	11	85
Mutant11.java	91.6 %	76	7	83
Mutant12.java	91.4 %	74	7	81
Mutant3.java	91.1 %	72	7	79
Mutant4.java	90.4 %	66	7	73
Mutant8.java	91.1 %	72	7	79
Mutant9.java	91.1 %	72	7	79
Mutant5.java	92.9 %	65	5	70
Mutant14.java	97.4 %	74	2	76
Mutant15.java	98.3 %	113	2	115
Mutant7.java	95.9 %	47	2	49
Mutant13.java	100.0 %	113	0	113
Mutant2.java	100.0 %	75	0	75
Mutant6.java	100.0 %	81	0	81
testthetests	86.6 %	297	46	343
revealer	100.0 %	384	0	384

Measuring Code Coverage

- Code coverage tool built into Eclipse
  - EclEmma
- More on this in the final project

Uses of Coverage Criteria

- “Stopping” rule → sufficient testing
  - Avoid unnecessary, redundant tests
- Measure test quality
  - Dependability estimate
  - Confidence in estimate
- Specify test cases
  - Describe additional test cases needed

Coverage Criteria Discussion

- Is it always possible for a test suite to cover all the statements in a given program?
  - ➢ No. Could be infeasible statements
    - Unreachable code
    - Legacy code
    - Error handling code that should not typically happen
    - Configuration that is not on site
- Do we need the test suite to cover 100% of statements/branches to believe it is adequate?
  - ➢ 100% coverage does not mean correct program
  - ➢ But < 100% coverage does mean testing inadequacy

True/False Quiz

- A program that passes all test cases in a test suite with 100% path coverage is bug-free.
    - **False.**
    - Examples:
        - The test suite may cover a faulty path with data values that don't expose the fault.
            - Towards Exhaustive Testing
        - Errors of omission
            - Missing a whole if

Example

Test Suite:

3-7: a=3

4-6: a=30

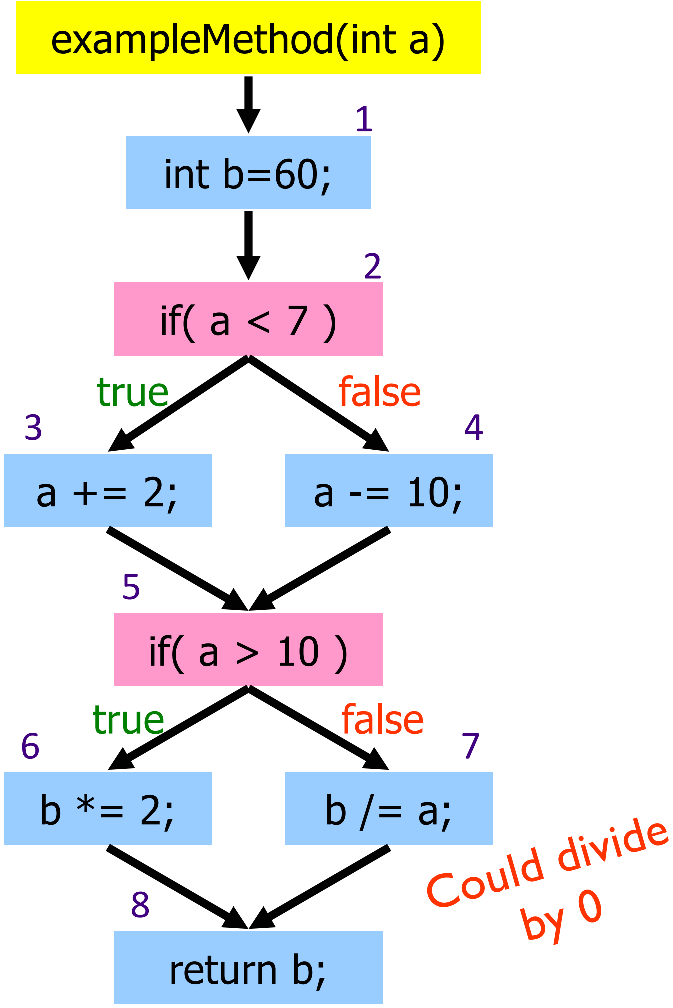
3-6: a=6

4-7: a=9

But, error shows up with

3-7: a=0

4-7: a=10

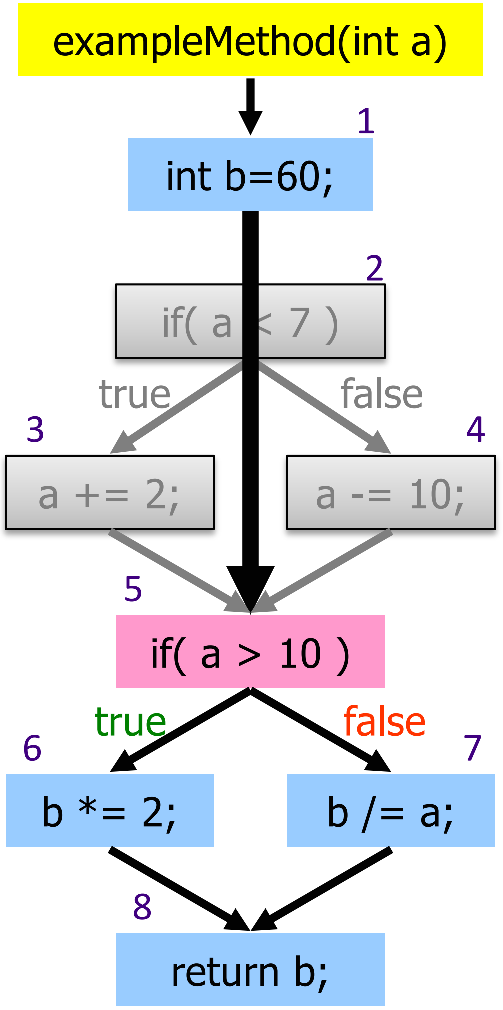


Could divide by 0

Omission Example

Consider if the first `if` block wasn't in the code.

You could cover all the paths, but you're missing a crucial condition.



True/False Quiz

- When you add test cases to a test suite that covers all statements so that it covers all branches, the new test suite is more likely to be better at exposing faults.
  - **True**.
  - You're adding test cases and covering new paths, which may have faults.

Which Test Suite Is Better?

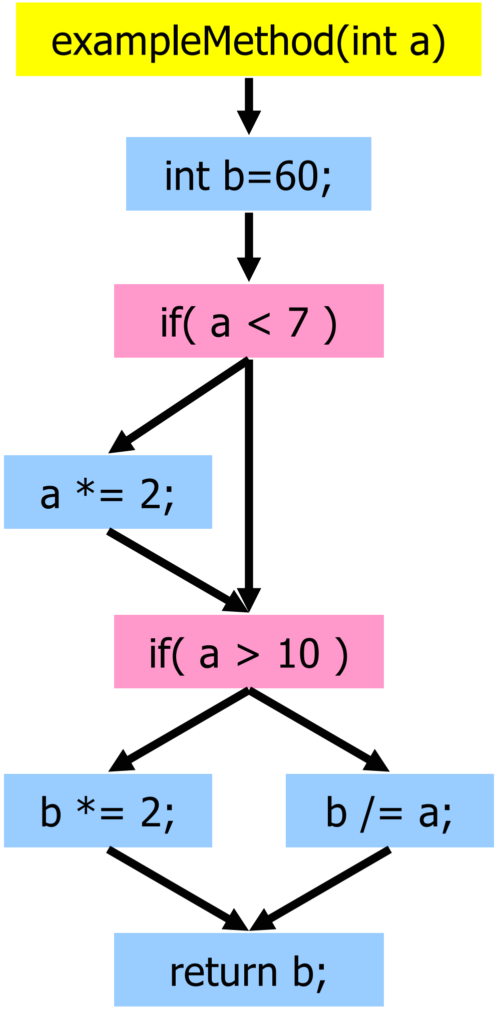
Statement-adequate Test Suite

Branch-adequate Test Suite

- Branch-adequate suite is not *necessarily* better than Statement-adequate suite
  - Statement-adequate suite could cover buggy paths and include input value tests that Branch-adequate suite doesn’t

Example

- TS1 (Statement-Adequate):
  - a=0, 6
- TS2 (Branch-Adequate):
  - a=3, 30
- Statement-adequate will find fault but branch-adequate won’t
  - Covers the path that exposes the fault



Software Testing: When is Enough Enough?

- Need to decide when tested enough
  - Balance goals of releasing application, high quality standards
- Can use program coverage as “stopping” rule
  - Also measure of confidence in test suite
  - Statement, Branch, Path and their tradeoffs
  - Use coverage tools to measure statement, branch coverage
- Still, need to use some other “smarts” besides program coverage for creating test cases

No Silver Bullet

- Recall the Fred Brooks' quote:
  - "There is no single development, in either technology or in management technique, that by itself promises even one order-of-magnitude improvement in productivity, in reliability, in simplicity."
  - Known as "no silver bullet"
- Test coverage is one tool that will help us improve the quality of our code, but it will not solve everything

Productive Use of Time that isn’t Coding

- “Most programmers regard anything that doesn’t generate code to be a waste of time. Thinking doesn’t generate code, and writing code without thinking is a recipe for bad code. Before we start to write any piece of code, we should understand what that code is supposed to do. Understanding requires thinking, and thinking is hard.”
- In the words of the cartoonist Dick Guindon: “Writing is nature’s way of letting you know how sloppy your thinking is.”

Source: http://www.wired.com/opinion/2013/01/code-bugs-programming-why-we-need-specs

OBJECT-ORIENTED DESIGN PRINCIPLES

Designing Systems

All systems **change** during their life cycle

- Requirements change
- Misunderstandings in requirements
- New functionality

- Code must be ***soft***
  - Flexible
  - Easy to change
    - New or revised circumstances
    - New contexts
    - Fix bugs

Designing for Change Example

- July 2010, Oracle released Java 6 update 21
  - Generated java.dll replaced
    - COMPANY_NAME=Sun Microsystems, Inc. with
    - COMPANY_NAME=Oracle Corporation
- Change caused `OutOfMemoryError` during Eclipse launch
  - Eclipse versions 3.3-3.6 (widespread!)
  - Why? Eclipse used the company name in the DLL in startup (runtime parameters) on Windows
- Temporary Fix: Oracle changed name back
- Required changes to all Eclipse versions

Source: http://www.infoq.com/news/2010/07/eclipse-java-6u21

Designing Systems

All systems **change** during their life cycle

- Questions to consider:
  - How can we create designs that are stable in the face of change?
  - How do we know if our designs aren't maintainable?
  - What can we do if our code isn't maintainable?
- Answers will help us
  - Design our own code
  - Understand others' code

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Best Practices Overview

- (DRY): Don’t repeat yourself
- Shy Code, Avoid Coupling
- Tell, Don’t Ask
- Avoid code smells

- SOLID
  - Single Responsibility Principle
  - Open-closed principle
  - Liskov Substitution Principle
  - Interface Segregation Principle
  - Dependency Inversion Principle

A lot of related fundamental principles.
We have been using them/applying them,
just haven’t named them.

Don’t Repeat Yourself (DRY): Knowledge Representation

> *Every piece of knowledge must have a single, unambiguous, and authoritative representation within a system*

- **Intuition**: when need to change representation, make in only one place
- Requires planning
  - What data needed, how represented (e.g., type)
  - Consider documentation as well

Don’t Repeat Yourself (DRY): Knowledge Representation

Every piece of knowledge must have a single, unambiguous, and authoritative representation within a system

- Example:
  - `Car` class defined constants for gears
  - `CarTest` should refer to those constants
    - Not redefine those gears, nor just hardcode numbers
    - The values are likely to change, so refer to the variables.

Don’t Repeat Yourself (DRY): Knowledge Representation

Every piece of knowledge must have a single, unambiguous, and authoritative representation within a system

- Example:
  - `Birthday` class had a month
    - Could be represented as a number and a String
  - Best: represent as a number (only), i.e., only one instance variable to represent the month
    - Get month String from the number (e.g., `MONTHS_OF_YEAR[month-1]`)
  - Why?

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    - Get month String from the number (e.g., `MONTHS_OF_YEAR[month-1]`)
  - Why? If need to update the month, just one variable needs to be updated, not two, which *can get out of sync*

Shy Code

- Goal: Won't reveal *too much* of itself
- Otherwise: get *coupling*
  - Coupling: dependence on other code
  - Static, dynamic, domain, temporal

What techniques have we discussed for keeping our code shy?

- Coupling isn't always bad…
  - Can't be completely avoided…
  - We want *shy* code – not completely isolated code

Achieving Shy Code

How can you make any field immutable?

- Private instance variables
  - Especially mutable fields
- Make classes public only when need to be public
  - i.e., accessible by other classes→ part of API
- Getter methods shouldn't return private, mutable state/objects
  - Use `clone()` before returning

Coupling Overview

- Interdependence of classes
  - Dependence makes class susceptible to breaking if other class changes
- Class A is *coupled* with class B if class A
  - Has an object of type B
    - Instance variable, Parameter, return type
  - Calls on methods of object B
  - Is a child class of or implements B
- Goal: *Loose* coupling
  - Non-goal: no coupling

Looking Ahead

- Testing project due Wed at midnight
- Exam 2 this weekend