Objectives

- Coverage, Testing wrap up
- Design in the Small

Review

1. What is code coverage?
2. What is code coverage *criteria*?
   - Provide examples of code coverage criteria
3. How can you use/apply code coverage?
4. What are the benefits and limitations of code coverage?
5. What are different categories of testing?

Review: Code Coverage

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

Review: 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

Review: Coverage Limitations

- A test suite of test cases that all pass that has 100% [statement/branch/path] coverage of does **not** mean bug-free code
  - Errors of omission
    - Can't cover what isn't there
  - Different data values on same execution path may expose errors

Coverage + Other smarts to Create Good Tests → High-quality code

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Review: Categories of Testing

(Non-Exhaustive)

- Black-box testing
  - Test *functionality*
  - No knowledge of the code
- White-box testing
  - Have access to code
  - **Goal**: execute *all* code
- Non-functional testing
  - Performance testing
  - Usability testing (HCI)
  - Security testing
  - Internationalization, localization
- Acceptance testing
  - Customer tests to decide if accepts product

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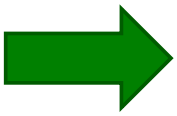
OBJECT-ORIENTED DESIGN PRINCIPLES

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

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)

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

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)
    - Get month String from the number (e.g., `MONTHS_OF_YEAR[month-1]`)
  - Why?

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  - Why? If need to update the month, just one variable needs to be updated, not two that 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 how to keep our code shy?

- Coupling isn't always bad…
  - Can't be completely avoided…

Achieving Shy Code

- Private instance variables
  - Especially mutable fields

How can you make any field immutable?

- 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

Static Coupling

- Code requires other code to compile
- Clearly, we need some static coupling!
  - Example: to display a line of text, we need the code for System.out
- Problem if you include more than you need

Static Coupling

- Code requires other code to compile
- Problem if you include more than you need
  - Example: poor use of inheritance
    - Brings excess baggage
    - Inheritance is reserved for "is-a" relationships
      - Base class should not include optional behavior
      - Not "uses-a" or "has-a"
- Solution: use *composition* or *delegation* instead

Static Coupling

- Code requires other code to compile
- Problem if you include more than you need
- Solution: use *composition* or *delegation* instead
  - Example: I created a class where I have keys associated with values. I shouldn't extend HashMap, but ***use*** a HashMap
  - Example: GamePiece class should not include *chase* functionality
    - Only certain child classes need that functionality

Tell, Don't Ask

- When designing methods, think of them as *sending a message*
  - Send a message
  - Get a response
- Method call: 1) sends a request to do something; 2) response is what is returned
  - Don't ask about details
  - Black-box, encapsulation, information hiding
- Example: `isPalindrome(String s)`
  - Input: the "raw" string to the method
  - Output: if it's a palindrome or not
    - Don't need to know how the spaces and casing were ignored; no printing

Single Responsibility Principle

Single Responsibility Principle (SRP)

There should never be more than one reason for a class to change

- **Intuition**:
  - Each responsibility is an axis of change
    - More than one reason to change
  - Responsibilities become coupled
    - Changing one may affect the other
    - Code breaks in unexpected ways

This idea has come up before in class. Give an example of adhering to SRP.

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Example


```
interface Network {
        public void connect();
        public void disconnect();
        public void send(String s);
        public String receive();
}
```

- Reasonable interface
- But has more than one responsibility
- Check:
  - Change for different reasons?
  - Called from different parts of program?

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Example


```
interface Network {
        public void connect();
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}
```

- Reasonable interface
- But has more than one responsibility
- In Java
  - Socket class does connect/disconnect
  - Use separate Streams to send and receive data on the Socket

Open-Closed Principle (OCP)

Principle: Software entities (classes, modules, methods, etc.) should be **open** for **extension** but **closed** for **modification**

- Bertrand Meyer
  - Author of *Object-Oriented Software Construction*
    - Foundational text of OO programming
- Design modules that *never change* after completely implemented
- If requirements change, extend behavior by adding code
  - By not changing existing code → we won't create bugs!

Attributes of Software that Adhere to OCP

- Open for Extension
  - Behavior of module can be extended
  - Make module behave in new and different ways
- Closed for Modification
  - No one can make changes to module

These attributes seem to be at odds with each other.
How can we resolve them?

OCP Solution: Use Abstraction

- Abstract base class or interface
  - ***Fixed*** abstraction → API
  - Cannot be changed (closed to modification)
- Derived classes: *possible behaviors*
  - Can always create new child classes of abstract base class
  - (Open to extension)

OCP Solution: Use Abstraction

- Abstract base classes or interfaces
  - Fixed abstraction → API
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- Derived classes: *possible behaviors*
  - Can always create new child classes of abstract base class
  - (Open to extension)
- Example: Create a new Baddie for Game
  1. Add a new Baddie class that derives from GamePiece
  2. Replace old goblin instantiation with new baddie in game
  3. DONE!

Not Open-Closed Principle

- `Client` uses `Server` class

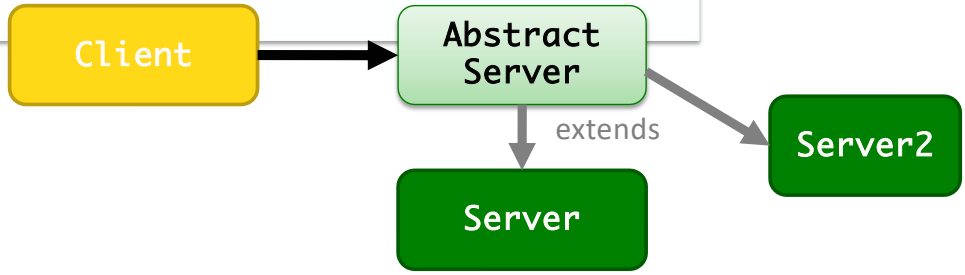
```
public class Client {
        public void method(Server x) {
        …
        }
}
```

Open-Closed Principle

Or ServerInterface

- Client uses AbstractServer class

```
public class Client {
        public void method(AbstractServer x) {
        …
        }
}
```



Strategic Closure

- No significant program can be completely closed
- Must choose which changes to close
  - Requires knowledge of users, probability of changes

Goal: Most probable changes should be closed

Heuristics and Conventions

- Member variables are private
  - A method that depends on a variable cannot be closed to changes to that variable
  - The class itself can't be closed to it
  - All other classes should be
- No global variables
  - Every module that depends on a global variable cannot be closed to changes to that variable
  - What happens if someone uses variable in unexpected way?
  - Counter examples: `System.out, System.in`

➥Apply abstraction to parts you think are going to change

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Code Smells

A hint in the code that something could be designed better

- Duplicated code
- Long method
- Large class
- Long parameter list
- Very similar child classes
- Too many public variables
- Empty catch clauses
- Switch statements/long if statements
- Shotgun surgery
- Literals
- Global variables
- Side effects
- Using `instanceof`

Process to Write Maintainable Code

Apply the design principles, but as your code evolves, you'll see that you didn't always adhere to the principles

1. Identify code smell
2. ***Refactor*** code to remove code smell
   - Refactoring: Updating a program to improve its design and maintainability *without changing its current functionality significantly*

Code Smell Case Study: Duplicated Code

- What's the problem with duplicated code?
- Why do we like it?
  - What made us write the duplicated code?
- Refactor: How can we get rid of the duplicate code?
  - Consider different possibilities for where the duplicate code is
    - Same expression multiple times in a class
    - Duplicate code in 2 sibling child classes
    - Duplicate code in unrelated classes

Problem of Duplicated Code

- If code changes, need to change in every location
- Duplicate effort to test code to make sure it works
  - More statements for test suite to test!
- When trying to search for code, may find a duplicate code→ not the one you're looking for
  - Increased effort in debugging

Looking Ahead

- More code smells, refactoring
- Testing project due tomorrow at midnight