CMSC 132: 
Object-Oriented Programming II

Object-Oriented Design

Department of Computer Science
University of Maryland, College Park
Applying Object-Oriented Design

1. Look at objects participating in system
   - Find nouns in problem statement (requirements & specifications)
   - Noun may represent class needed in design
   - Relationships (e.g., “has” or “belongs to”) may represent fields

2. Look at interactions between objects
   - Find verbs in problem statement
   - Verb may represent message between objects

3. Design classes accordingly
   - Determine relationship between classes
   - Find state & methods needed for each class
Classes

- A class or interface defines and describes a set of objects
- It describes a set of methods or messages that the object responds to
  - Not only the name and signature of the method, but the contract the method respects
- Classes also provide/describe fields and method implementations
1) Finding Classes

Thermostat uses dial setting to control a heater to maintain constant temperature in room

Nouns
- Thermostat
- Dial setting
- Heater
- Temperature
- Room
Finding Classes

- Analyze each noun
  - Does noun represent class needed in design?
  - Noun may be outside system
  - Noun may describe state in class
Analyzing Nouns

- **Thermostat**
  - Central class in model
  - State in class (Thermostat)

- **Dial setting**
  - State in class (Thermostat)

- **Heater**
  - Class in model

- **Room**
  - Class in model

- **Temperature**
  - State in class (Room)
Finding Classes

Decision not always clear

- Possible to make everything its own class
  - Approach taken in Smalltalk
  - Overly complex
    - $2+3 = 5$ vs. $\text{NUM}_2.\text{add}(\text{NUM}_3) = \text{NUM}_5$

Impact of design

- More classes $\Rightarrow$ more abstraction, flexibility
- Fewer classes $\Rightarrow$ less complexity, overhead

Choice (somewhat) depends on personal preference
Singleton classes

A Singleton class is a class for which there will only ever be one instance

Makes sense if the class is a subclass of another class

For example, you might have a class Person, and a singleton subclass Elvis

Avoid making verbs/functions into classes

Examples – class ListSorter, NameFinder

Unless you might have multiple verb classes that all implement a common interface

The Strategy design pattern
2) Finding Messages

- Thermostat uses dial setting to control a heater to maintain constant temperature in room

- Verbs
  - Uses
  - Control
  - Maintain
Finding Messages

- Analyze each verb
  - Does verb represent interaction between objects?
- For each interaction
  - Assign methods to classes to perform interaction
Analyzing Verbs

Uses
- “Thermostat uses dial setting…”
  ⇒ Thermostat.setDesiredTemp(int degrees)

Control
- “To control a heater…”
  ⇒ Heater.turnOn()
  ⇒ Heater.turnOff()

Maintain
- “To maintain constant temperature in room”
  ⇒ Room.getTemperature()
Example Messages

Thermostat

- getTemperature()
- turnOn()
- turnOff()
- setDesiredTemp()

Room

Heater
Resulting Classes

Thermostat
- State – dialSetting
- Methods – setDesiredTemp()

Heater
- State – heaterOn
- Methods – turnOn(), turnOff()

Room
- State – temp
- Methods – getTemperature()
Subtypes

- If a class Y extends class X and implements interface A
  - then Y is a subtype of both X and A
- If Q is a subtype of P, then Q satisfies P’s contract
  - Anyone who expects a P can be given a Q
- This is known as the Liskov Substitution Principle (named for Prof. Barbara Liskov)
  - Not always strictly followed, but an ideal to approach
  - For example, some iterators don’t support remove
Which could be a subtype?

Class B {
    /** Search for x in a,
     * return location of first occurrence,
     * -1 if not found */
    int search(int x, int a[]) { ... } }

Class C {
    /** .. same as above...
     * uses binary search for speed;
     * the array a must be sorted */
    int search(int x, int a[]) { ... } }
Which could be a subtype?

Class B {
    /** Search for x in a,
     * return location of first occurrence,
     * -1 if not found */
    int search(int x, int a[]) { ... } }

Class C {
    /** * Search for x in a,
     * return location of any occurrence,
     * -1 if not found */
    int search(int x, int a[]) { ... } }
is-a vs. has-a

Say we have two classes, Engine and Car

Two possible designs

- A Car object has a reference to an Engine object
  - has-a
- The Car class is a subtype of Engine
  - is-a
Prefer Composition to Subtyping

Generally, prefer composition/delegation (has-a) to subtyping (is-a)

- Subtyping is very powerful, but easy to overuse and can create confusion and lead to mistakes

- Using is-a restricts you from having a car with more than one engine, or with no engine

- Tempting to use subclassing in places where it doesn’t really make conceptual sense to avoid having to delegate methods

- Don’t
Forms of Inheritance

- **Extension**
  - Adds new functionality to subclass
  - In Java → new method

- **Limitation**
  - Restricts behavior of subclass
  - In Java → override method, throw exception

- **Combination**
  - Inherits features from multiple superclasses
    - Also called multiple inheritance
  - Not possible in Java
    - In Java → implement interface instead
Multiple Inheritance Example

**Combination**

- AlarmClockRadio has two parent classes
- State & behavior from both Radio & AlarmClock

![Diagram showing the inheritance structure of AlarmClockRadio, Radio, and AlarmClock classes. The AlarmClockRadio class inherits from both Radio and AlarmClock, indicating multiple inheritance.](image-url)