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
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
- 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. `NUM2.add(NUM3) = NUM5`

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…”
  - $\Rightarrow$ Thermostat.setDesiredTemp(int degrees)

- **Control**
  - “To *control* a heater…”
  - $\Rightarrow$ Heater.turnOn()
  - $\Rightarrow$ Heater.turnOff()

- **Maintain**
  - “To *maintain* constant temperature in room”
  - $\Rightarrow$ Room.getTemperature()
Example Messages

Thermostat

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

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 relationship between Radio, AlarmClock, and AlarmClockRadio](image-url)