CMSC 132:
Object-Oriented Programming II

Object-Oriented Design

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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

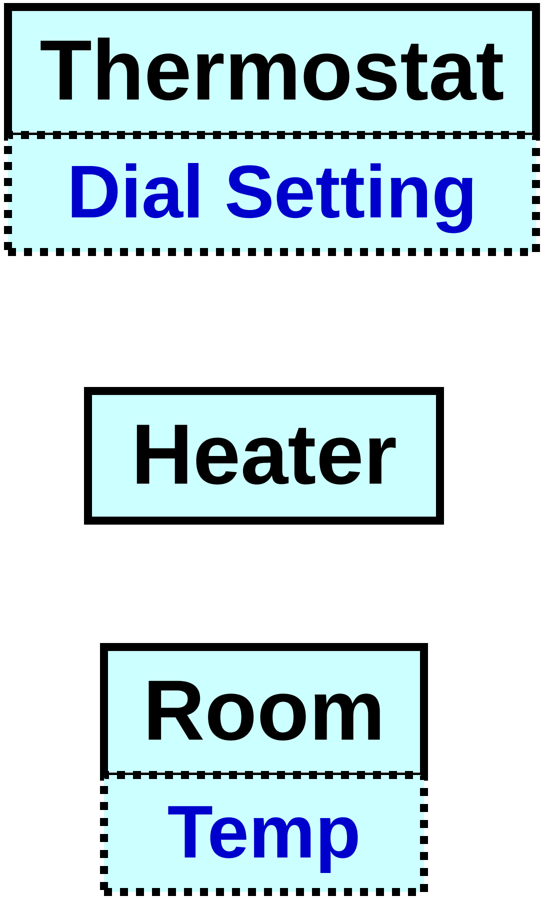
- Thermostat uses dial setting to control a heater to maintain constant temperature in room
- Nouns
  - Thermostat
  - Dial setting
  - Heater
  - Temperature
  - Room

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
- 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. NUM_2.add(NUM_3) = NUM_5
  - Impact of design
    - More classes ⇒ more abstraction, flexibility
    - Fewer classes ⇒ 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

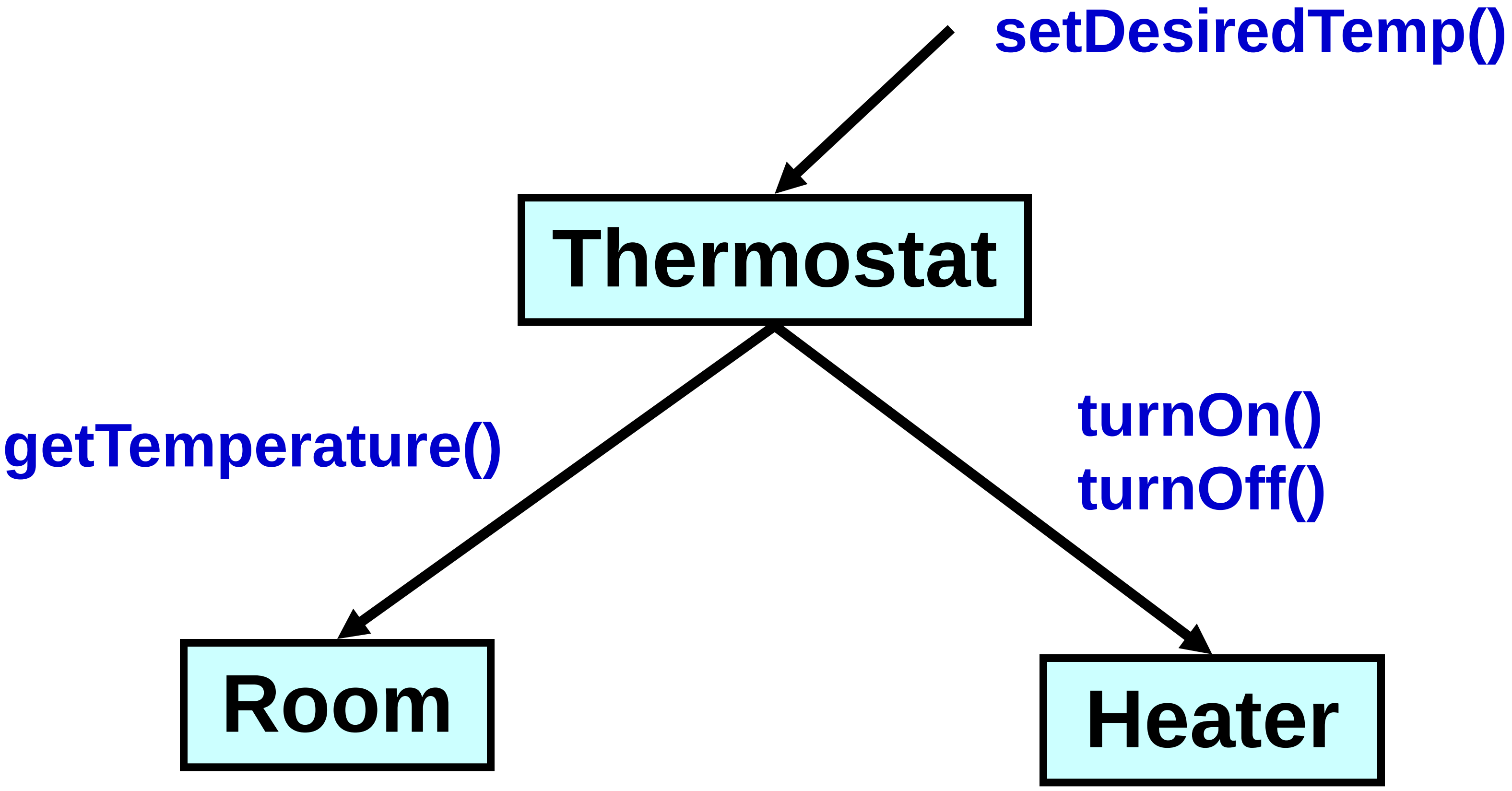
Finding Messages

- 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



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