CMSC 132: Object-Oriented Programming II

Object-Oriented Design II

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Overview

- Object-oriented design
  - Objects, methods ⇒ Last lecture
  - Classes, inheritance ⇒ This lecture
- Applying object-oriented design

Elements of Object-Oriented Design

- Objects
  - Entities in program
- Methods
  - Functions associated with objects
- Classes
  - Groups of objects with similar properties
- Inheritance
  - Relationship between classes

Classes

- Definition
  - Group of objects with same state & behavior
  - Abstract description of a group of objects
- Similar to data types
  - Type is a set of data values & their operations
    - Example ⇒ integer, real, boolean, string
  - Can view classes as types for objects

Classes

- Properties
  - Classes provides classification for objects
  - Every object belongs to some class
  - Objects ⇒ instances (instantiations) of a class

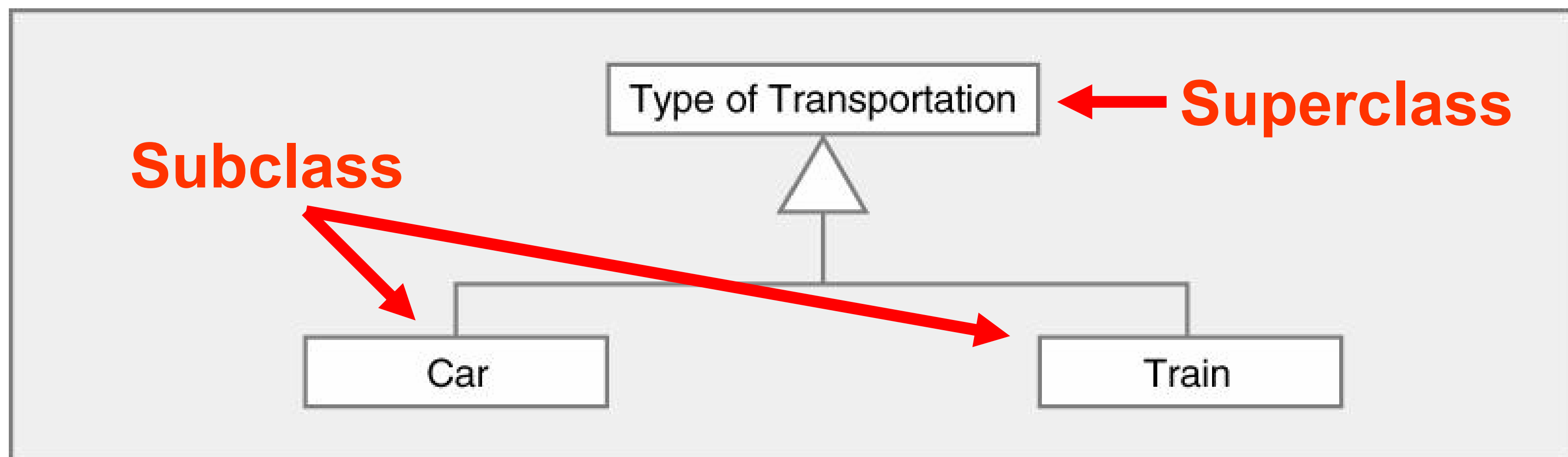
Example Class

- Given a class **Car**
- Objects can include
  - MyHonda, YourHonda
  - HerMiniCooper
  - HisSUV
- All **Car** objects
  - Share same properties & behavior
  - May have different values for properties

Car

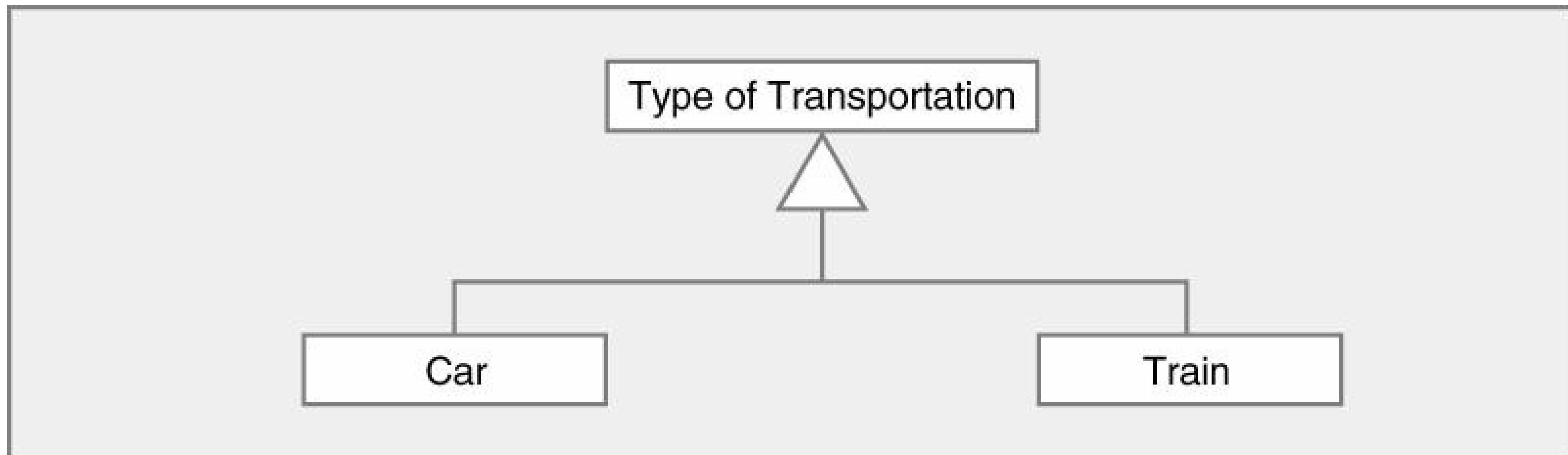
Inheritance

- Definition
  - Relationship between classes when state and behavior of one class is a subset of another class
- Terminology
  - Superclass / parent ⇒ More general class
  - Subclass ⇒ More specialized class



Inheritance

- Properties
  - Subclass inherits state & behavior of superclass
  - "Is-a" relationship exists between inherited classes
    - Example – train is a type of transportation

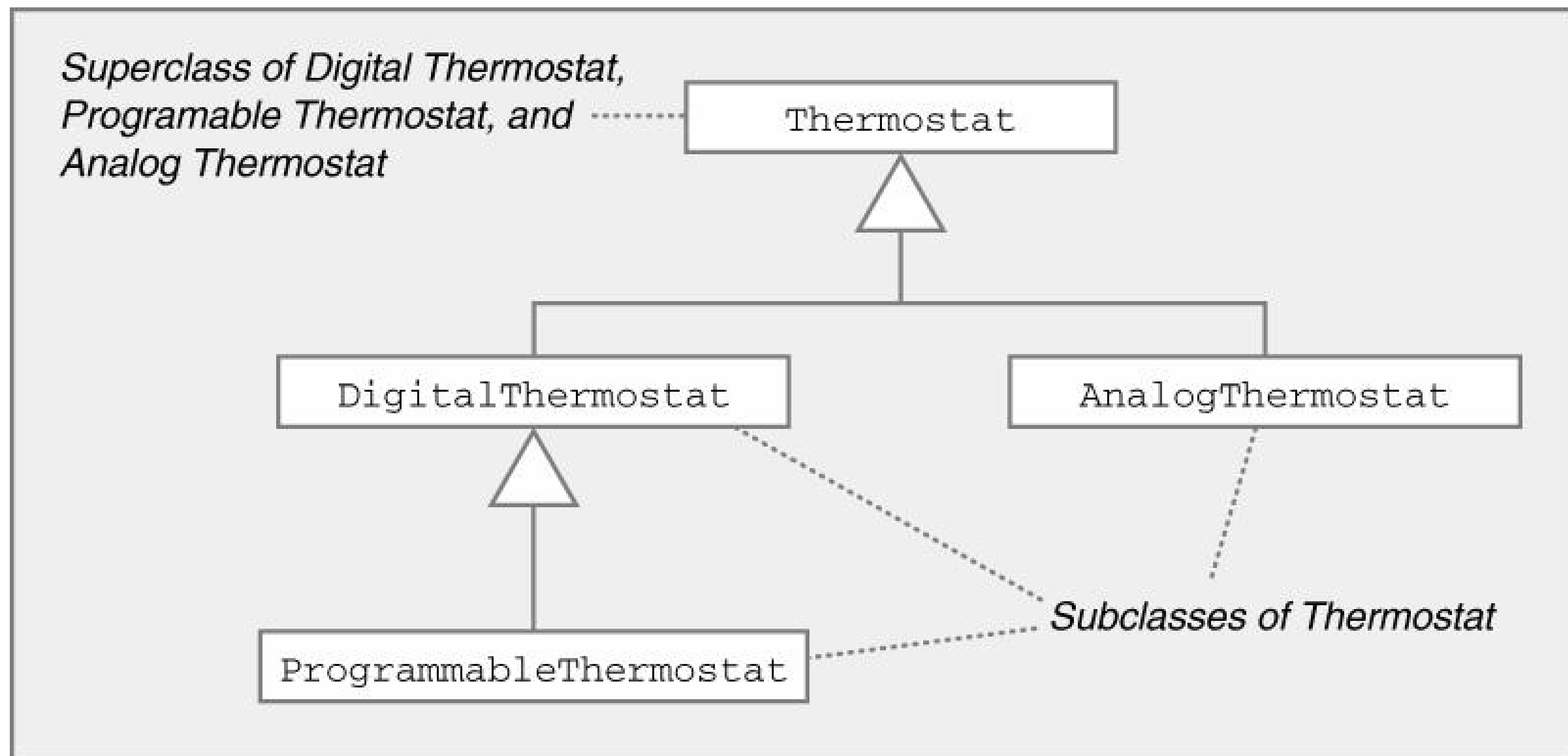


Inheritance

- Inheritance forms a hierarchy
  - Helps organize classes
- Inheritance is transitive
  - Class inherits state & behavior from all ancestors
- Inheritance promotes code reuse
  - Reuse state & behavior for class

Inheritance Hierarchy Example

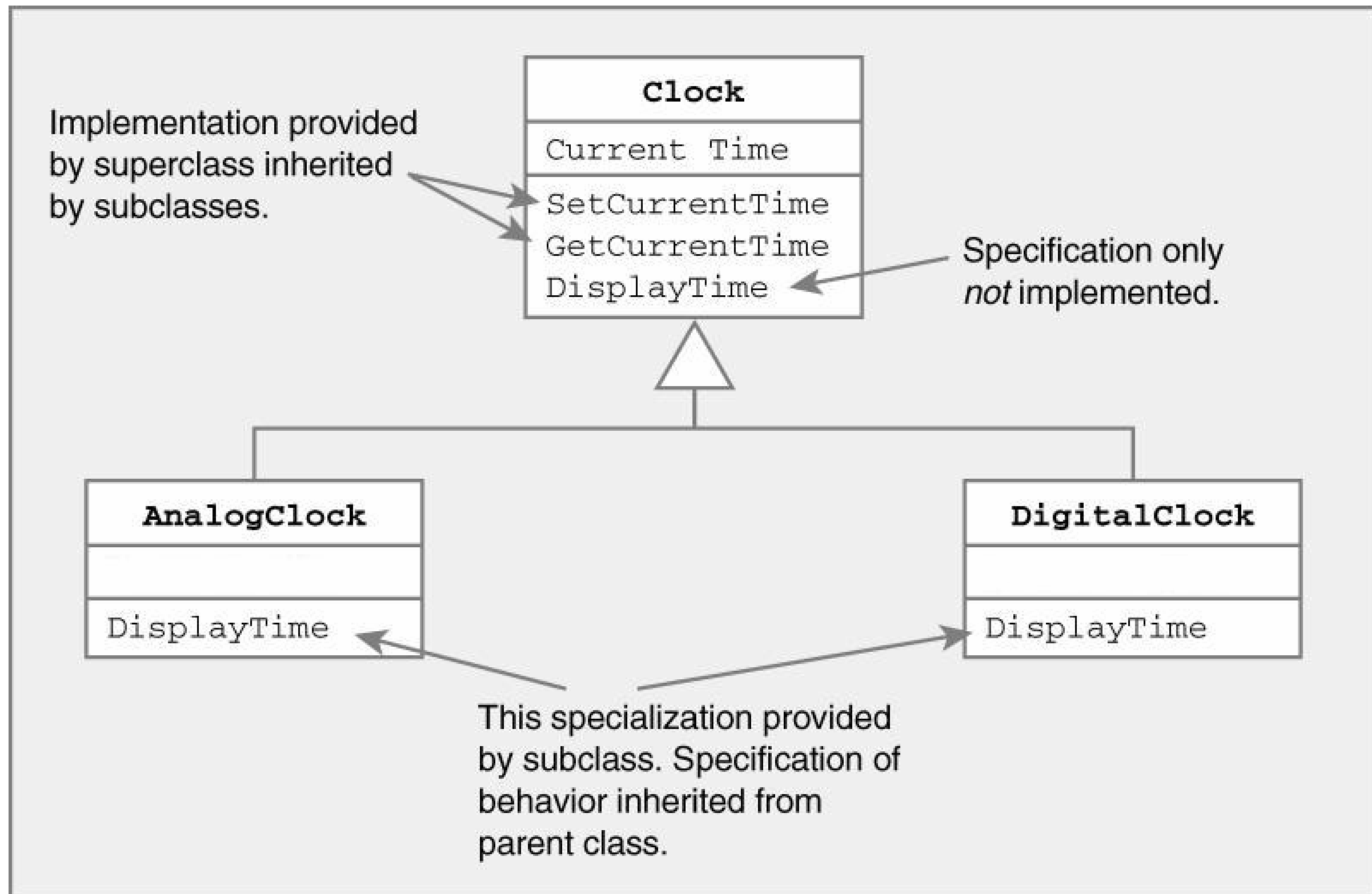
- Classes
  - Thermostat
  - Analog thermostat
  - Digital thermostat
  - Programmable thermostat



Forms of Inheritance

- Specification
  - Defines behavior implemented only in subclass
  - Guarantees subclasses implement same behavior
    - In Java → abstract method in superclass
- Specialization
  - Subclass is customized
  - Still satisfies all requirements for parent class
    - In Java → override method

Specialization Example

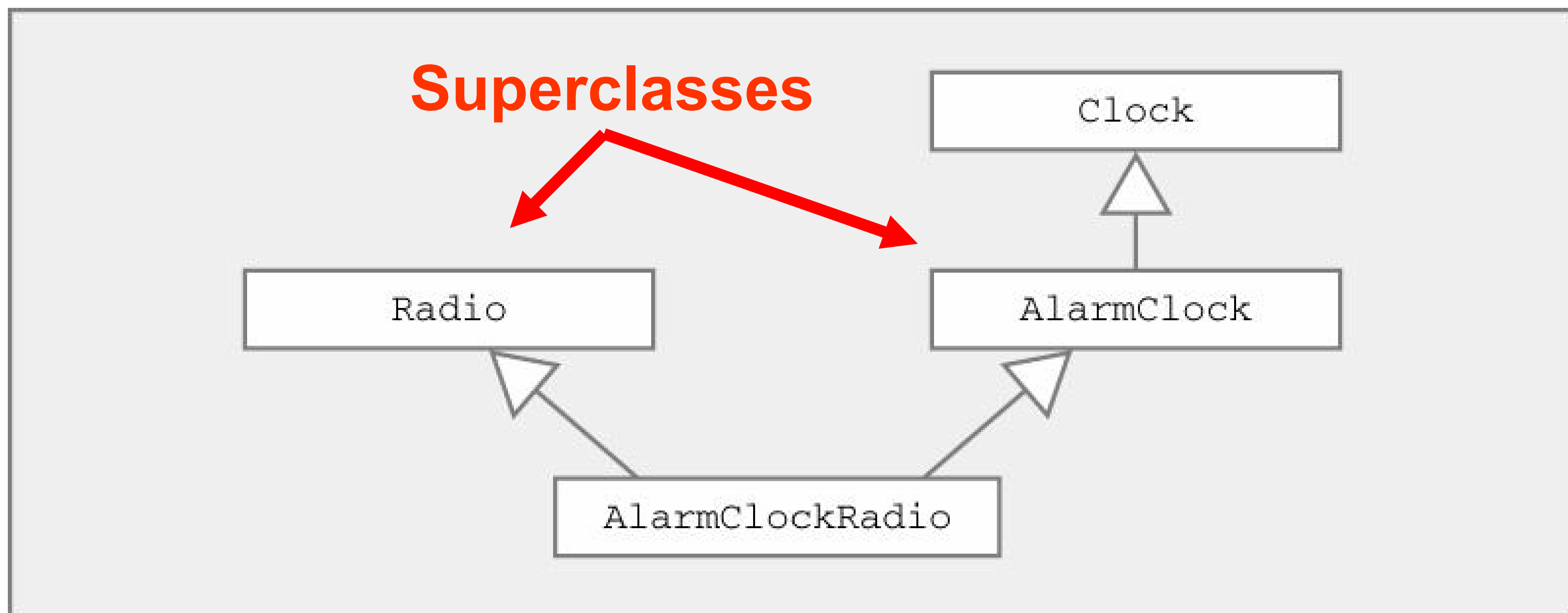


Forms of Inheritance

- 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



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
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

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)

Thermostat

Dial Setting

Heater

Room

Temp

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
- Avoid making functions into classes
  - Examples – class ListSorter, NameFinder

2) Finding Messages

- Thermostat uses dial setting to control a heater to maintain constant temperature in room
- Verbs
  - Uses
  - Control
  - Maintain

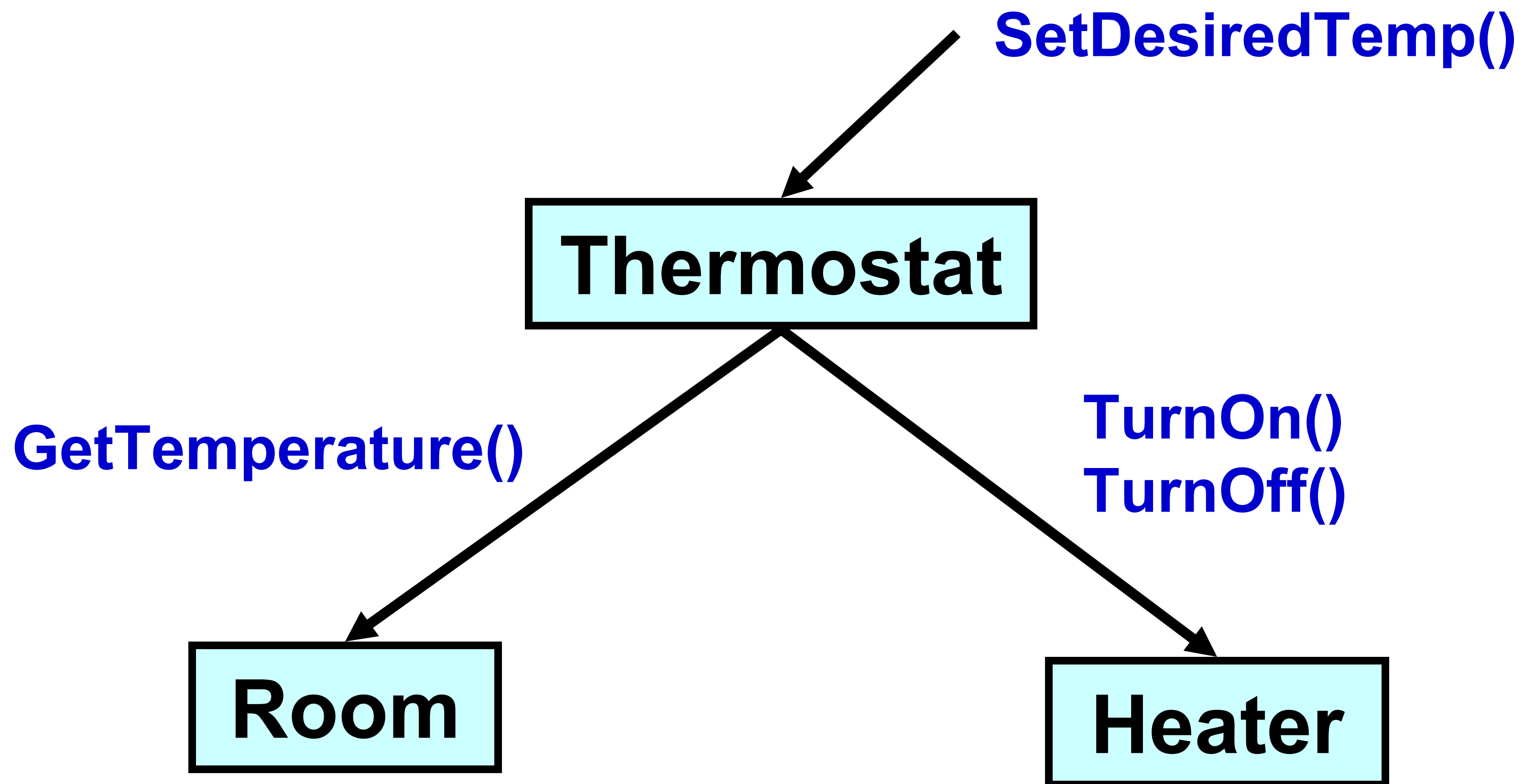
Finding Messages

- 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()
- 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()