Façade & Adapter

CSCI 4448/5448: Object-Oriented Analysis & Design

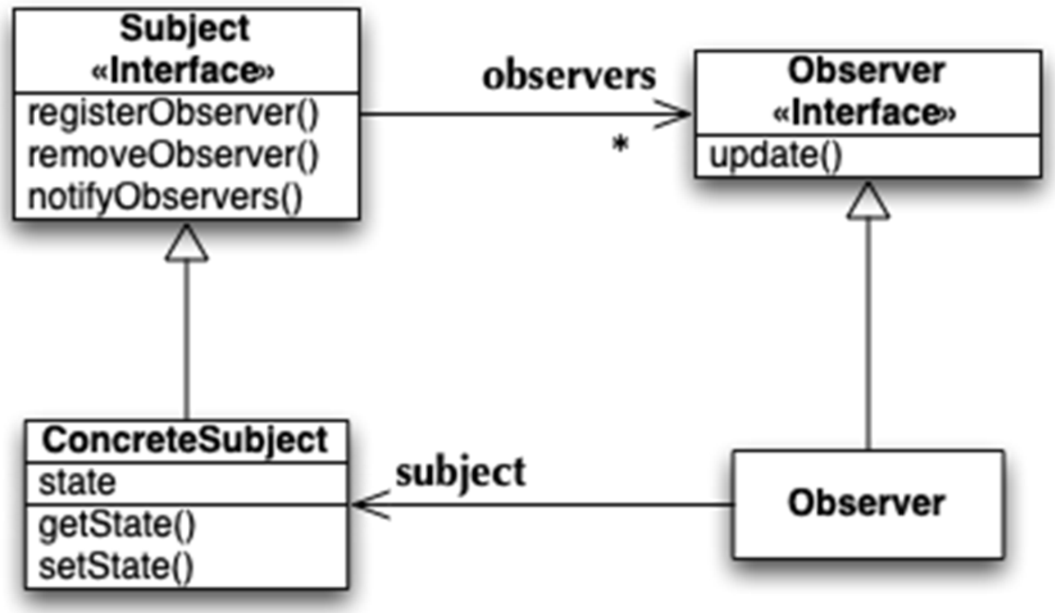
Lecture 18

Acknowledgement & Materials Copyright

- I'd like to start by acknowledging Dr. Ken Anderson
- Ken is a Professor and the Chair of the Department of Computer Science
- Ken taught OOAD on several occasions, and has graciously allowed me to use his copyrighted material for this instance of the class
- Although I will modify the materials to update and personalize this class, the original materials this class is based on are all copyrighted © Kenneth M. Anderson; the materials are used with his consent; and this use in no way challenges his copyright

Before we start: Observer variations

- Basic observer
  - Publishers/Subjects/Observables publish events
  - A mechanism for subscribing for events as an Observer/Subscriber
  - Subscribers receive events (push) or notifications to get event information (pull)
- Variations/Issues
  - Push vs pull
  - Event objects – strings, class/subclass, data types, generics
  - Who manages subscriptions – the publisher, a broker, a subscription manager
  - Who issues events – direct from publishers, via brokers
  - Subscriber's capability to process events
  - Complex flows – queued events, prioritized events, addressed events
  - Publisher and observer in one
  - Deleting subjects or observers



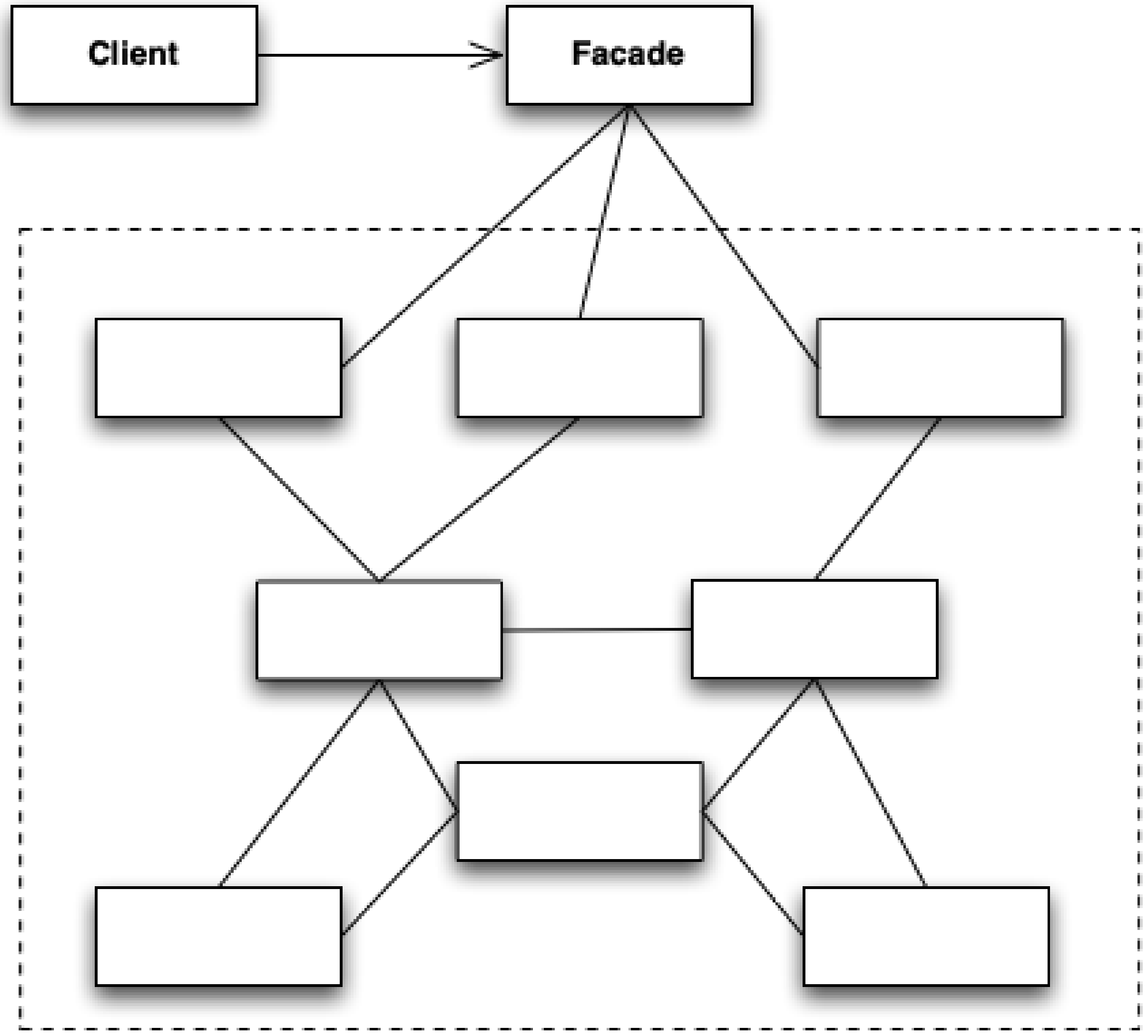
Goals of the Lecture

- Introduce two design patterns
  - Façade
  - Adapter
- Compare and contrast the two patterns
- Look at multiple inheritance

Facade (I)

- "Provide a unified interface to a set of interfaces in a subsystem. Facade defines a higher-level interface that makes the subsystem easier to use."
    - Design Patterns, Gang of Four, 1995
- There can be significant benefit in wrapping a complex subsystem with a simplified interface
    - If you don't need the advanced functionality or fine-grained control of the former, the latter makes life easy

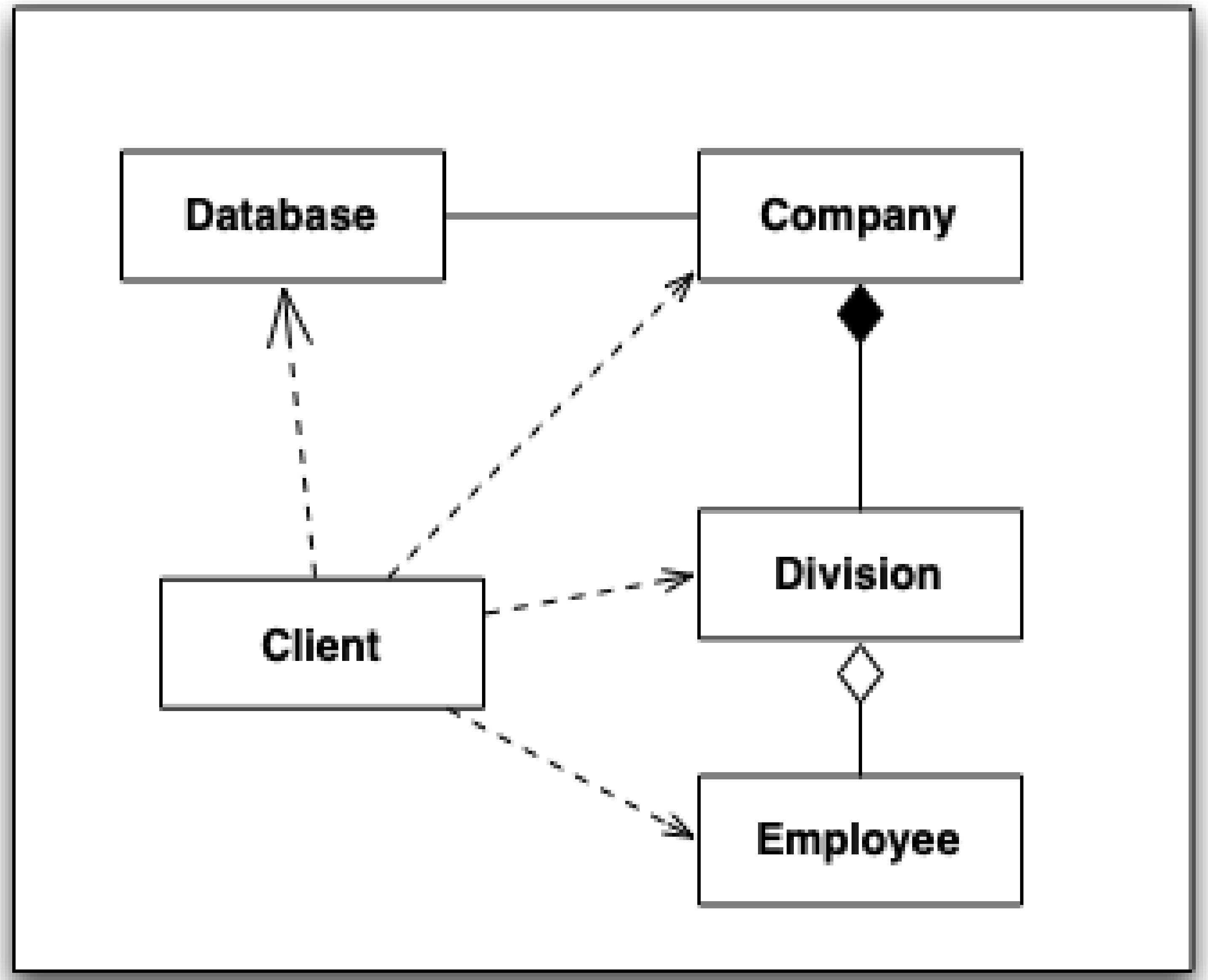
Facade Pattern: UML Structure



Facade (II)

- Facade works best when you are accessing a subset of the subsystem's functionality
  - You can also add new features by adding it to the Facade (not the subsystem); you still get a simpler interface
- Facade not only reduces the number of methods you are dealing with but also the number of classes
  - Imagine having to pull Employees out of Divisions that come from Companies that you pull from a Database
  - A Facade in this situation can fetch Employees directly

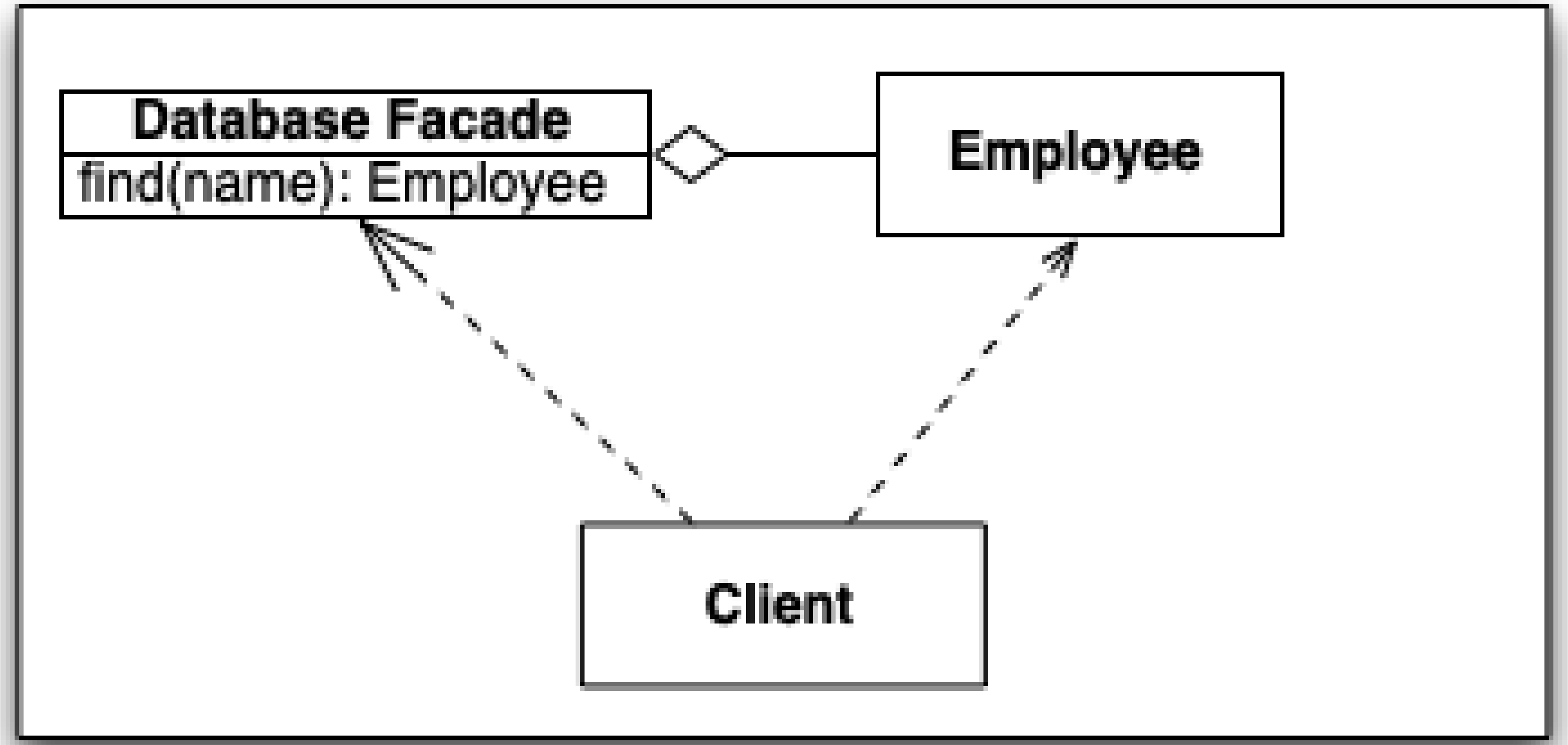
Example (Without a Facade)



Without a Facade, Client contacts the Database to retrieve Company objects. It then retrieves Division objects from them and finally gains access to Employee objects.

It uses four classes.

Example (With a Facade)



With a Facade, the Client is shielded from most of the classes. It uses the Database Facade to retrieve Employee objects directly.

Real World Example: Core Audio

- Consider Core Audio, included in iOS
  - If you want to access that subsystem directly, you have up to 8 frameworks that you need to deal with
    - AudioToolbox, AudioUnit, AVFoundation, CoreAudio, CoreAudioKit, CoreMIDI, CoreMIDIServer & OpenAL
  - However, if all you need to do is play a sound, you can use a single class, AVAudioPlayer, which acts as a Facade

Facade Example (I)

- Imagine a library of classes with a complex interface and/or complex interrelationships
  - Home Theater System
    - Amplifier, DvdPlayer, Projector, CdPlayer, Tuner, Screen, PopcornPopper (!), and TheatreLights
      - each with its own interface and interclass dependencies
- Imagine steps for “watch movie”
  - turn on popper, make popcorn, dim lights, screen down, projector on, set projector to DVD, amplifier on, set amplifier to DVD, DVD on, etc.
- Now imagine resetting everything after the movie is done, or configuring the system to play a CD, or play a video game, etc.

Facade Example (II)

- For this example, we can place high level methods...
  - like “watch movie”, “reset system”, “play cd”
- ... in a facade object and encode all of the steps for each high level service in the facade
- Client code is simplified and dependencies are reduced
  - A facade **not only simplifies an interface**, it **decouples a client from a subsystem of components**
- Indeed, Facade lets us **encapsulate subsystems**, hiding them from the rest of the system

Principle of Least Knowledge

- aka Talk only to your friends
- Be careful how many classes an object interacts with
- And also, how it comes to interact with those classes
- Reduce the chance of a change cascade when many classes interact
- Improve maintainability and reduce complexity

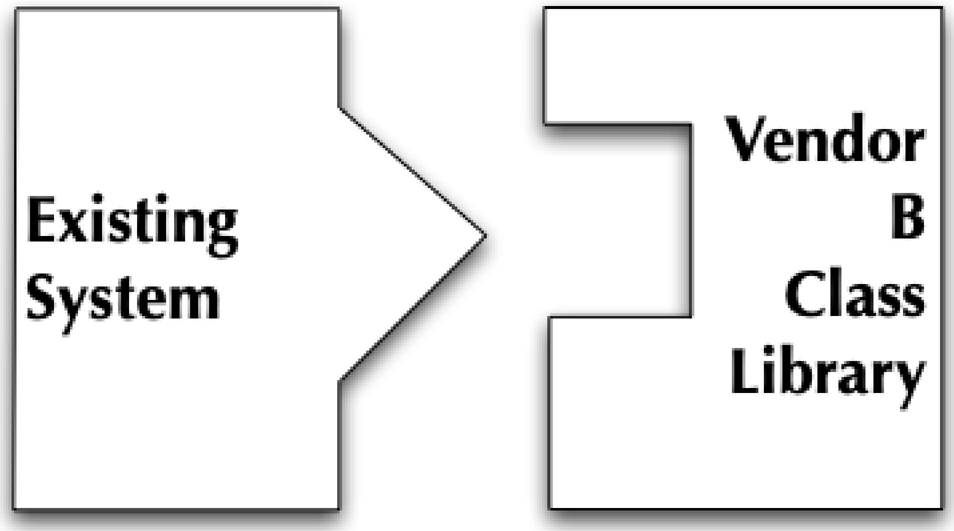
Adapters in the Real World

- Our next pattern provides steps for converting an incompatible interface with an existing system into a different interface that is compatible
  - Real World Example: AC Power Adapters
  - Electronic products made for the USA cannot be used directly with outlets found in most other parts of the world
    - To use these products outside the US, you need an AC power adapter
    - In some case, you also need a AC power transformer/converter
      - which is a separate, orthogonal issue
      - but these issues are sometimes mixed

OO Adapters (I)

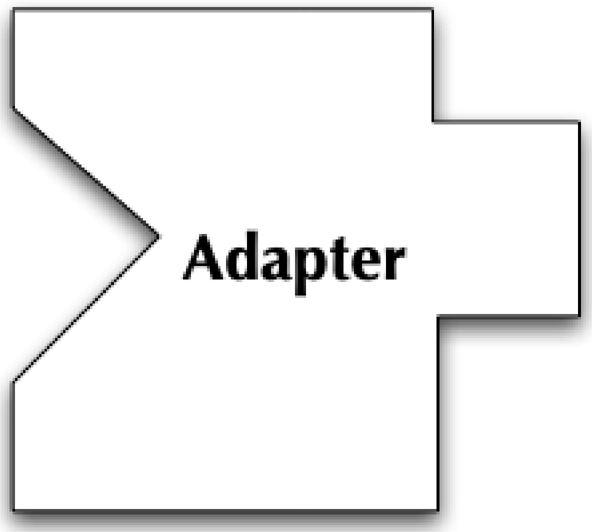
- Pre-Condition: You are maintaining an existing system that makes use of a third-party class library from vendor A
- Stimulus: Vendor A goes belly up and corporate policy does not allow you to make use of an unsupported class library.
- Response: Vendor B provides a similar class library but its interface is completely different from the interface provided by vendor A
- Assumptions: You don’t want to change your code, and you can’t change vendor B’s code.
- Solution?: Write new code that adapts vendor B’s interface to the interface expected by your original code

OO Adapters (II)



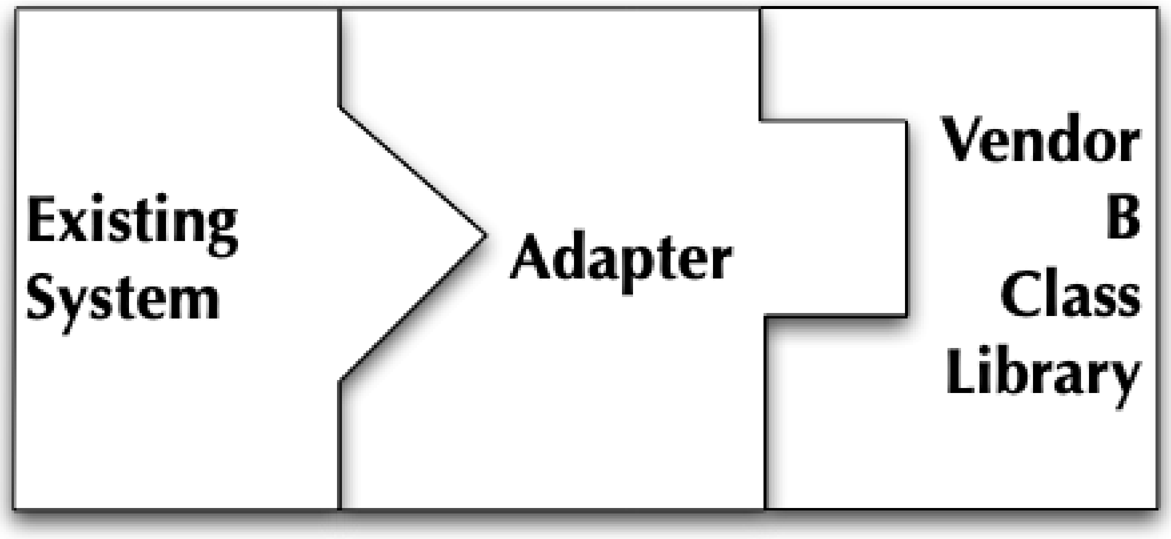
Interface Mismatch
Need Adapter

Create Adapter



And then...

OO Adapters (III)



...plug it in

Benefit: Existing system and new vendor library do not change, new code is isolated within the adapter.

Example: A turkey amongst ducks! (I)

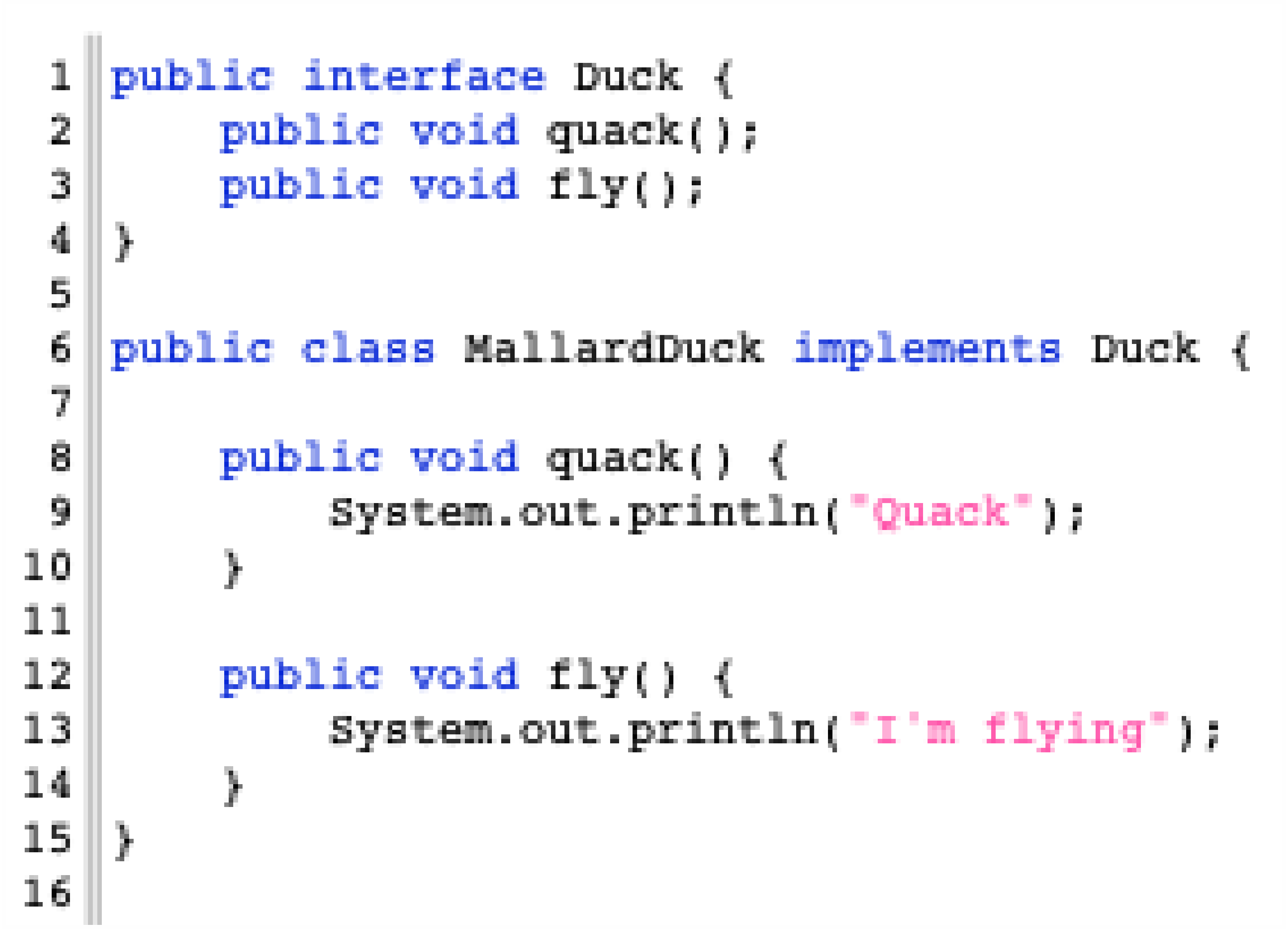
- If it walks like a duck and quacks like a duck, then it must be a duck!

Or...

- If it walks like a duck and quacks like a duck, then it might be a turkey wrapped with a duck adapter… (!)

Example: A turkey amongst ducks! (II)

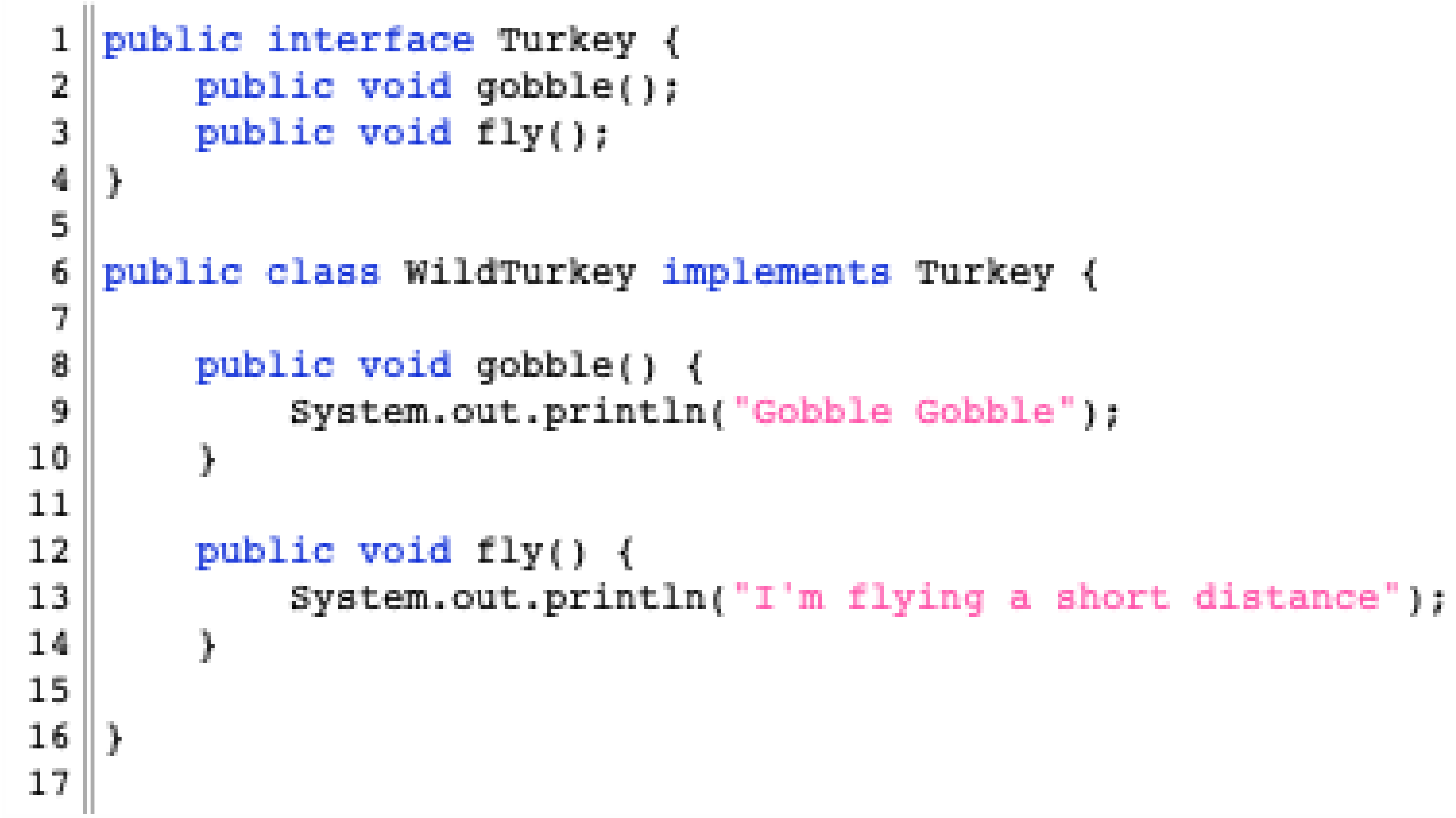
- Recall the Duck simulator from lecture?



```java
public interface Duck {
    public void quack();
    public void fly();
}

public class MallardDuck implements Duck {

    public void quack() {
        System.out.println("Quack");
    }

    public void fly() {
        System.out.println("I'm flying");
    }
}

```

Example: A turkey amongst ducks! (III)

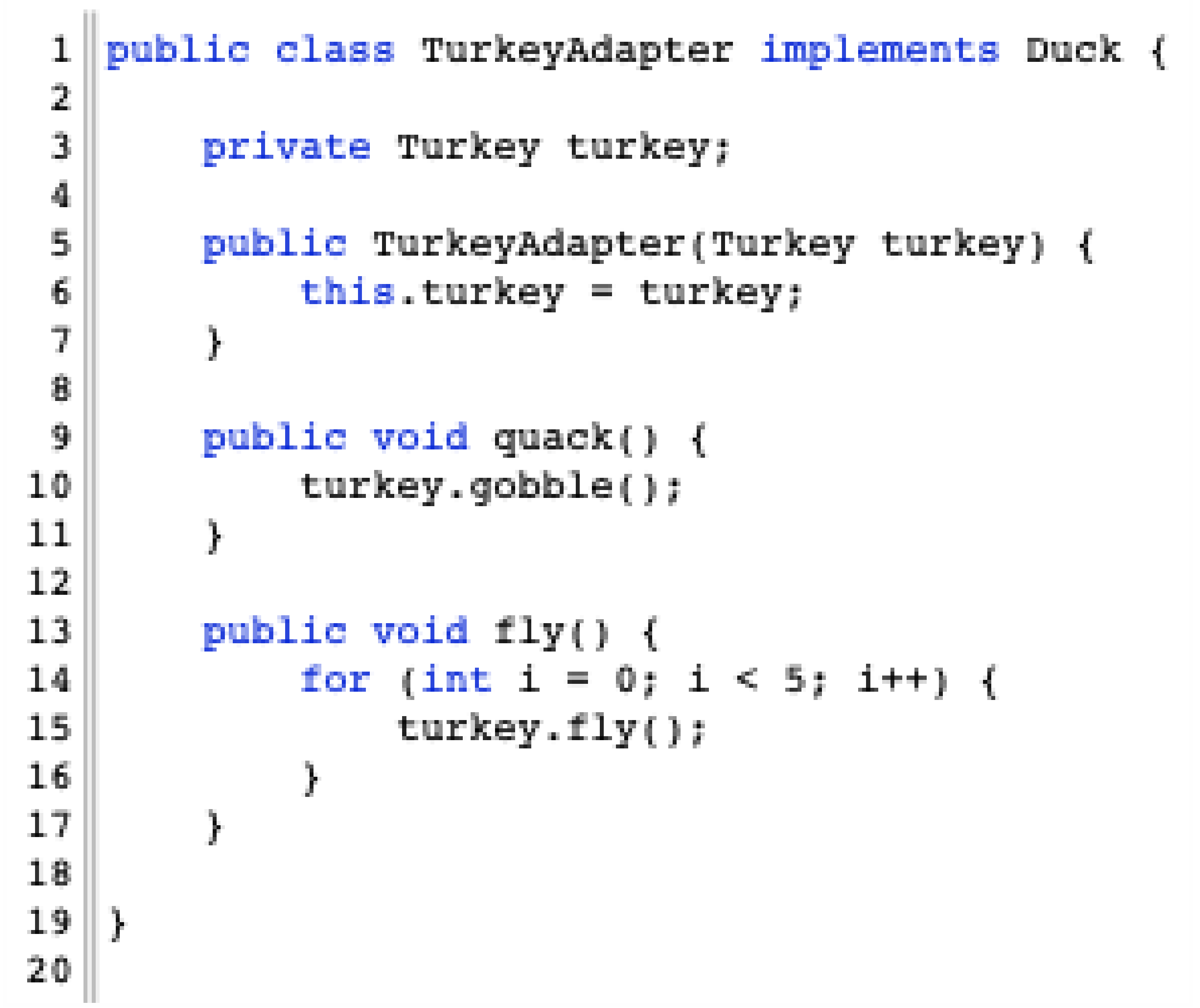
- An interloper wants to invade the simulator



```java
public interface Turkey {
    public void gobble();
    public void fly();
}

public class WildTurkey implements Turkey {

    public void gobble() {
        System.out.println("Gobble Gobble");
    }

    public void fly() {
        System.out.println("I'm flying a short distance");
    }

}

```

Example: A turkey amongst ducks! (IV)

- Write an adapter, that makes a turkey look like a duck



```java
public class TurkeyAdapter implements Duck {

    private Turkey turkey;

    public TurkeyAdapter(Turkey turkey) {
        this.turkey = turkey;
    }

    public void quack() {
        turkey.gobble();
    }

    public void fly() {
        for (int i = 0; i < 5; i++) {
            turkey.fly();
        }
    }

}

```

1. Adapter implements target interface (Duck).

2. Adaptee (turkey) is passed via constructor and stored internally

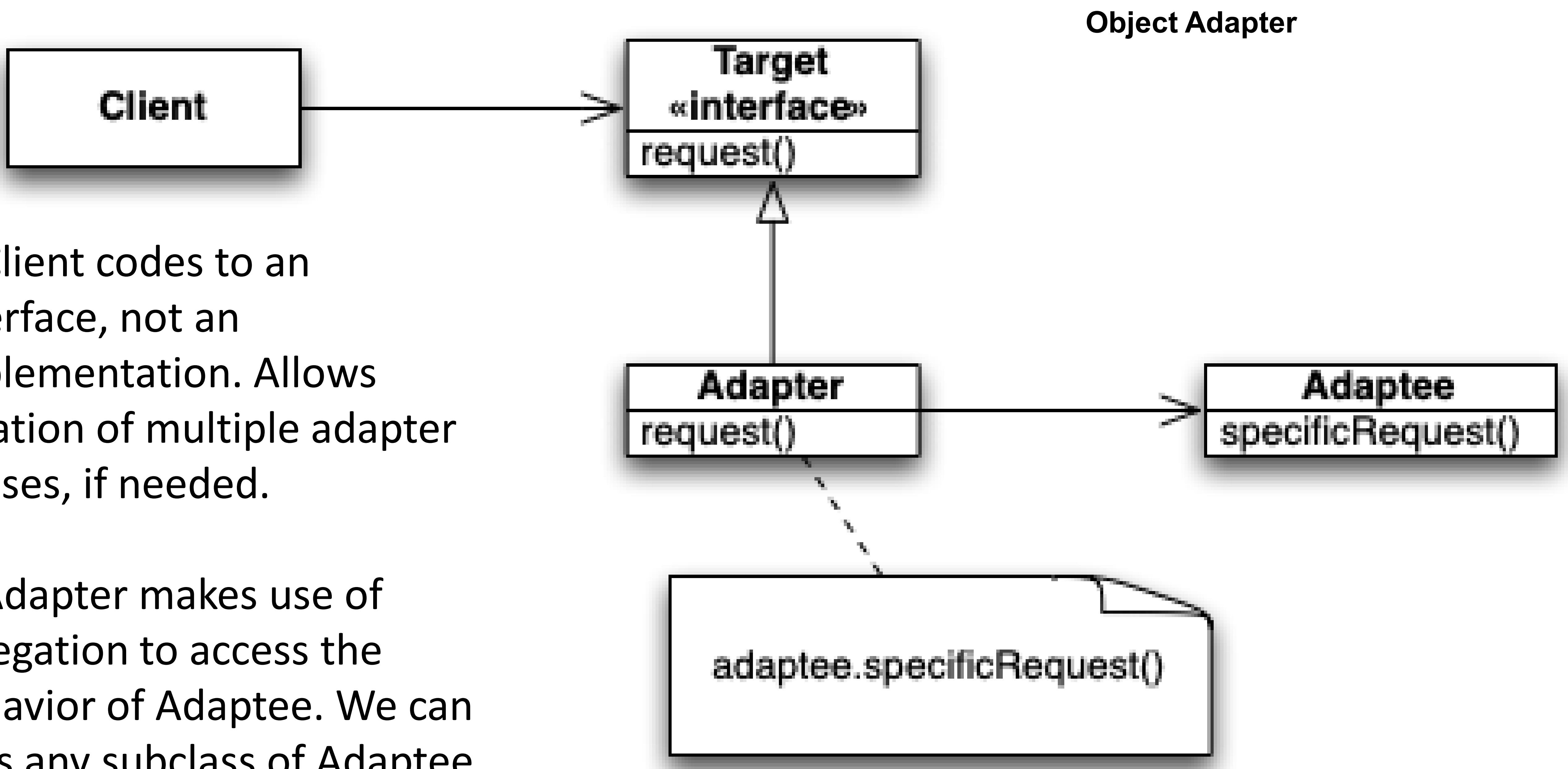
3. Calls by client code are delegated to the appropriate methods in the adaptee

4. Adapter is full-fledged class, could contain additional vars and methods to get its job done; can be used polymorphically as a Duck

Adapter Pattern: Definition

- The Adapter pattern converts the interface of a class into another interface that clients expect. Adapter lets classes work together that couldn’t otherwise because of incompatible interfaces
  - The client makes a request on the adapter by invoking a method from the target interface on it
  - The adapter translates that request into one or more calls on the adaptee using the adaptee interface
  - The client receives the results of the call and never knows there is an adapter doing the translation

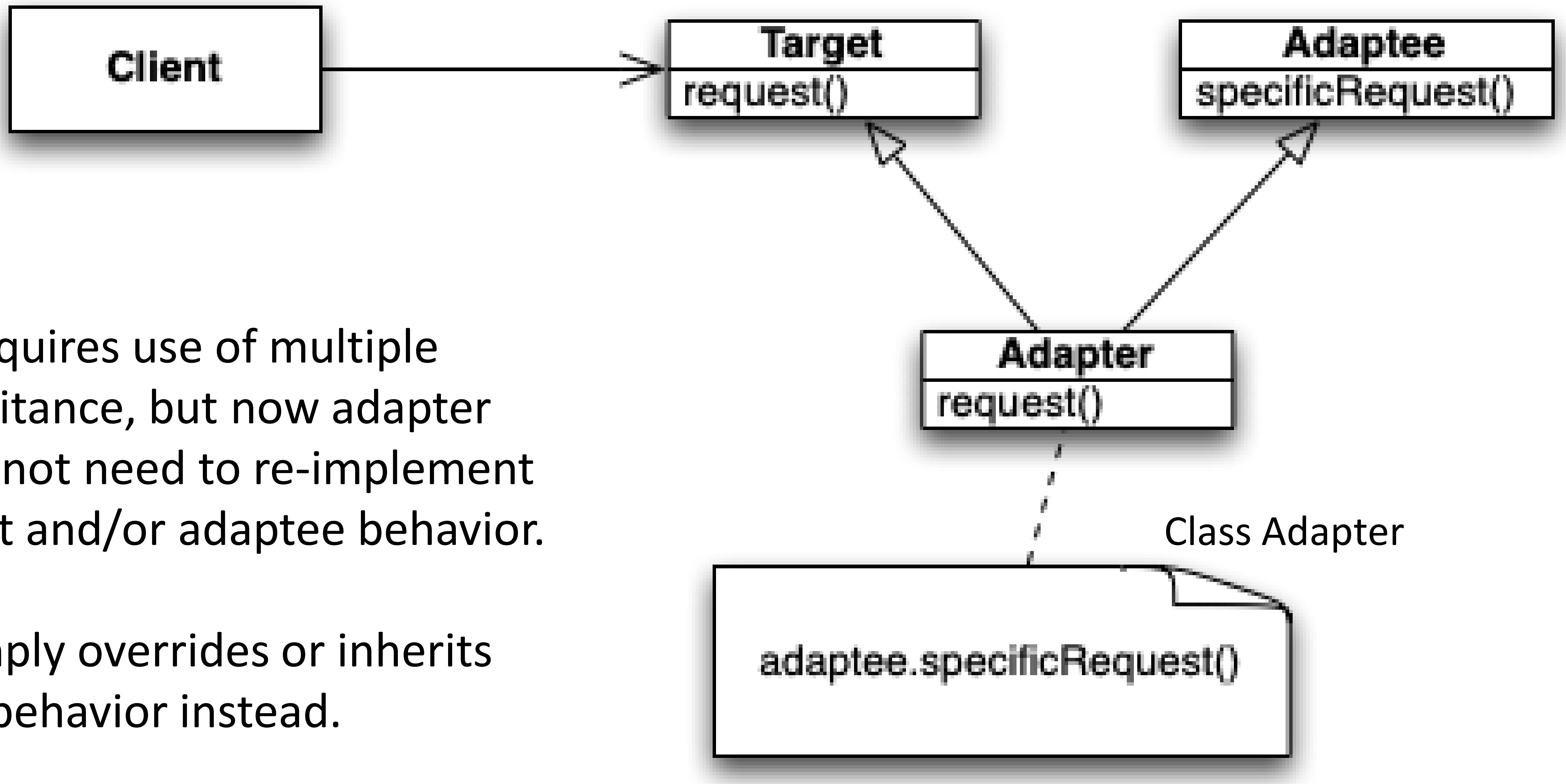
Adapter Pattern: Structure (I)



1. Client codes to an interface, not an implementation. Allows creation of multiple adapter classes, if needed.

2. Adapter makes use of delegation to access the behavior of Adaptee. We can pass any subclass of Adaptee to the Adapter, if needed.

Adapter Pattern: Structure (II)



Class Adapter

1. Requires use of multiple inheritance, but now adapter does not need to re-implement target and/or adaptee behavior.

It simply overrides or inherits that behavior instead.

Comparison (I)

- To many people, these two patterns (Adaptor/Facade) appear to be similar
  - They both act as wrappers of a preexisting class
  - They both take an interface that we don't want and convert it to an interface that we can use
- With Facade, the intent is to **simplify** the existing interface
- With Adapter, we have a target interface that we **convert**
  - In addition, we often want the adapter to plug into an existing framework and behave polymorphically

Comparison (II)

- Superficial difference
  - Facade hides many classes; Adapter hides only one
- But
  - a Facade can simplify a single, very complex object
  - an Adapter can wrap multiple objects at once in order to access all the functionality it needs
- **The key is simplify (facade) vs convert (adapter)**

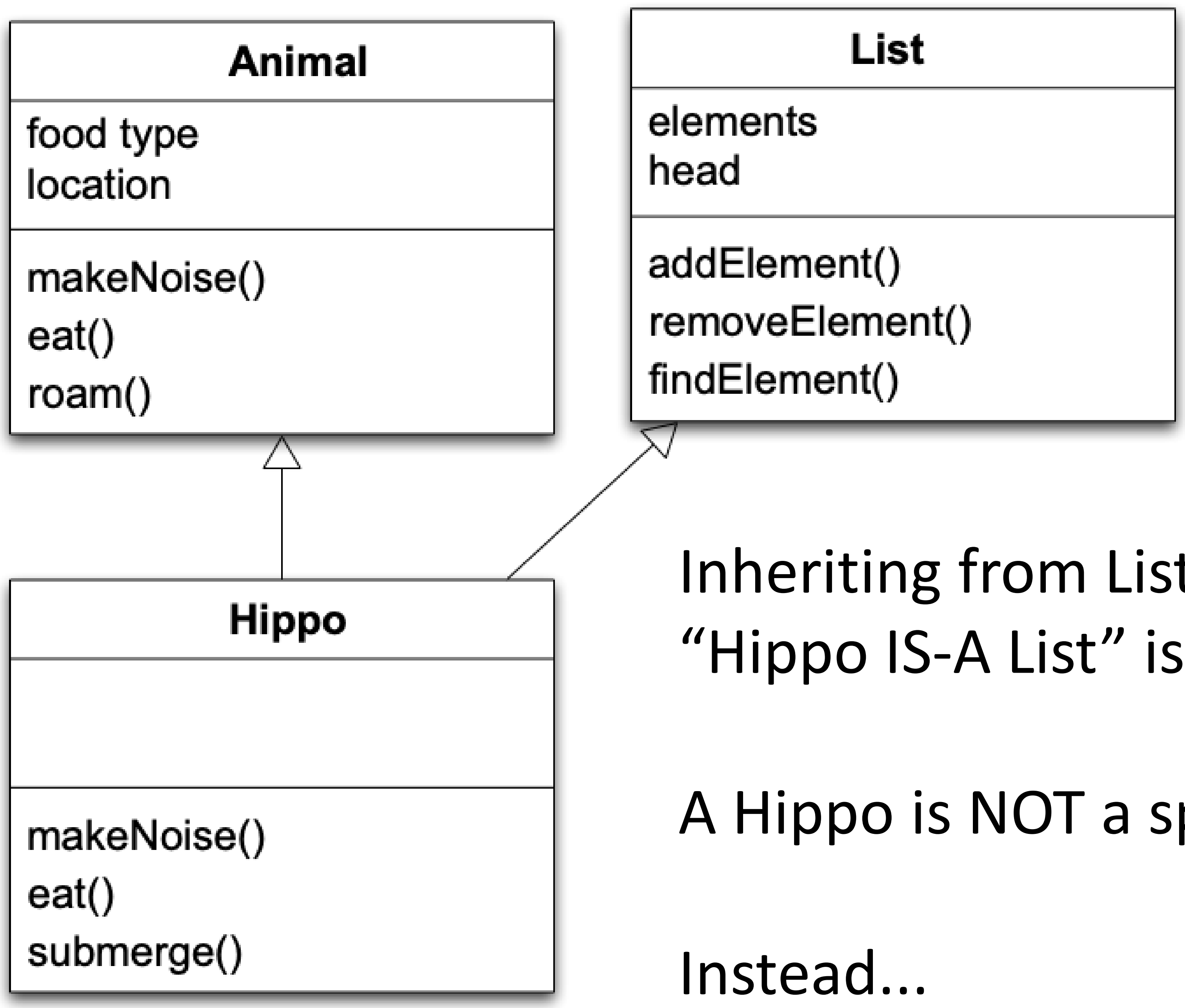
Multiple Inheritance

- Let’s talk a little bit more about multiple inheritance
  - Some material for this section taken from
    - Object-Oriented Design Heuristics by Arthur J. Riel
      - Copyright © 1999 by Addison Wesley
      - ISBN: 0-201-63385-X

Multiple Inheritance

- Riel does not advocate the use of multiple inheritance (its too easy to misuse it). As such, his first heuristic is
    - **(1) If you have an example of multiple inheritance in your design, assume you have made a mistake and prove otherwise!**
- Most common mistake
    - Using multiple inheritance in place of containment
        - That is, you need the services of a List to complete a task
            - Rather than creating an instance of a List internally, you instead use multiple inheritance to inherit from your semantic superclass as well as from List to gain direct access to List’s methods
                - You can then invoke List’s methods directly and complete the task

Graphically

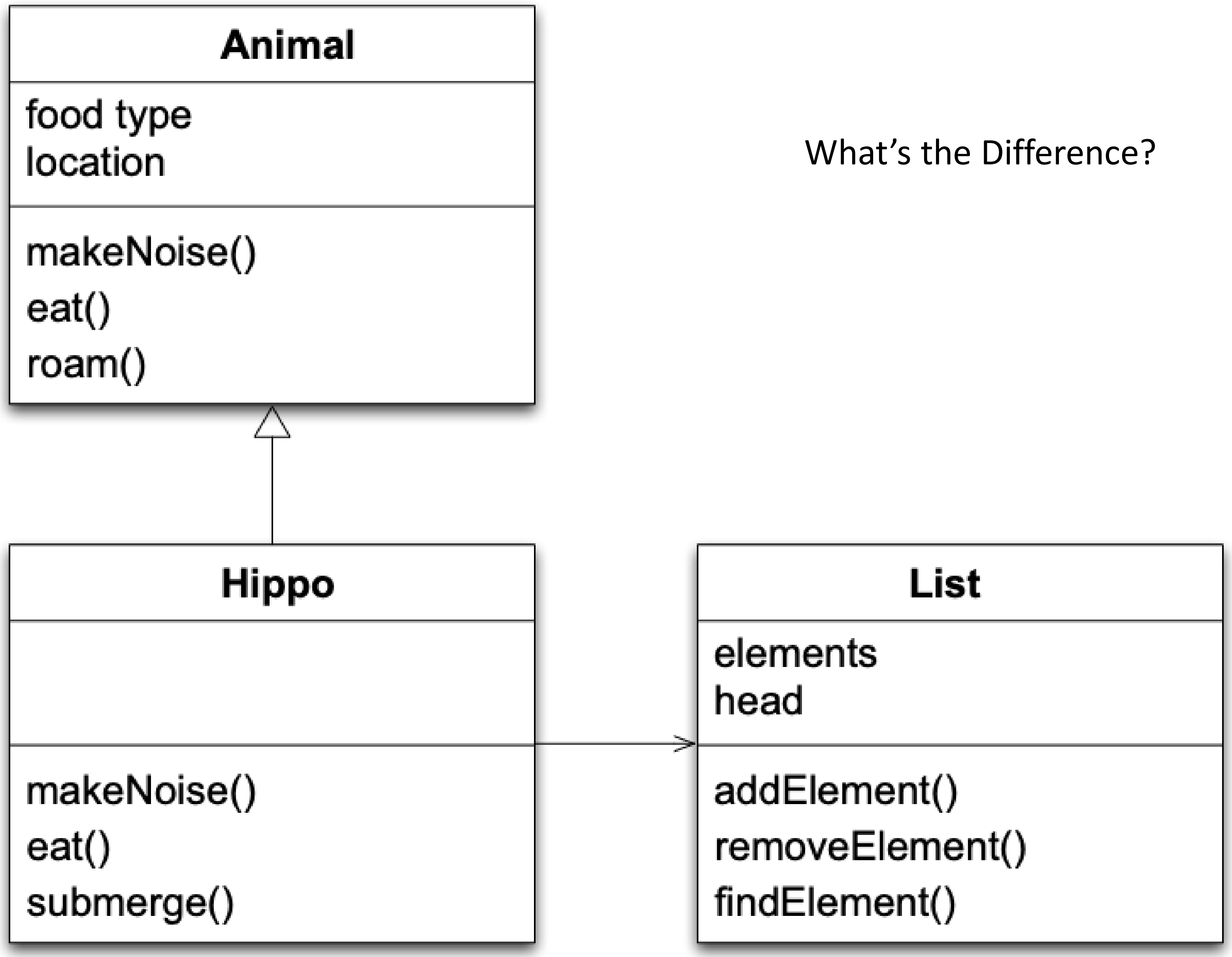


Inheriting from List in this way is bad, because "Hippo IS-A List" is FALSE

A Hippo is NOT a special type of List

Instead...

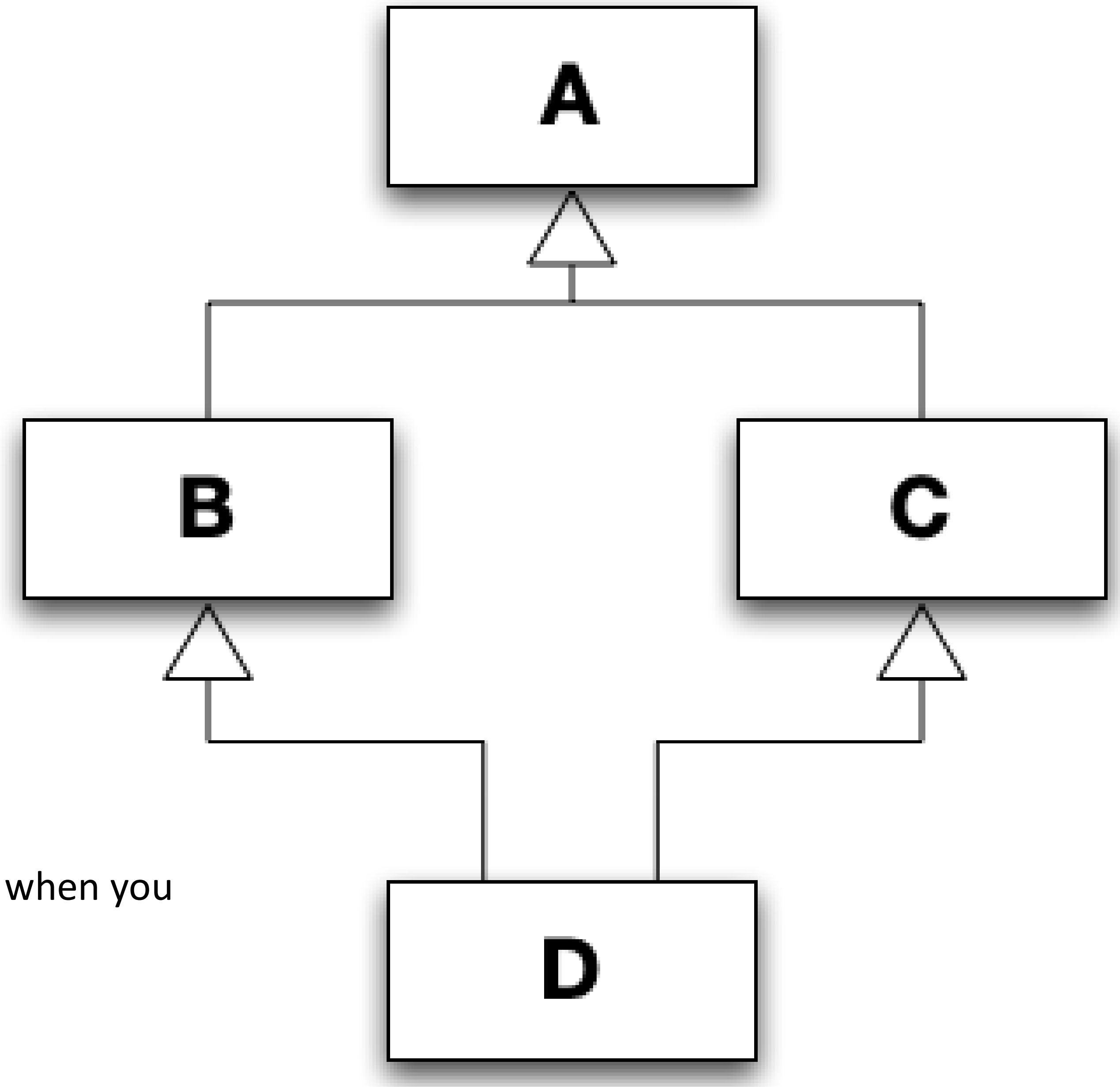
Do This



What's the Difference?

Another Problem

What's wrong with this?



Hint: think about what might happen when you create an instance of D

Multiple Inheritance

- A Second Heuristic
  - **(2) Whenever there is inheritance in an OO design, ask two questions:**

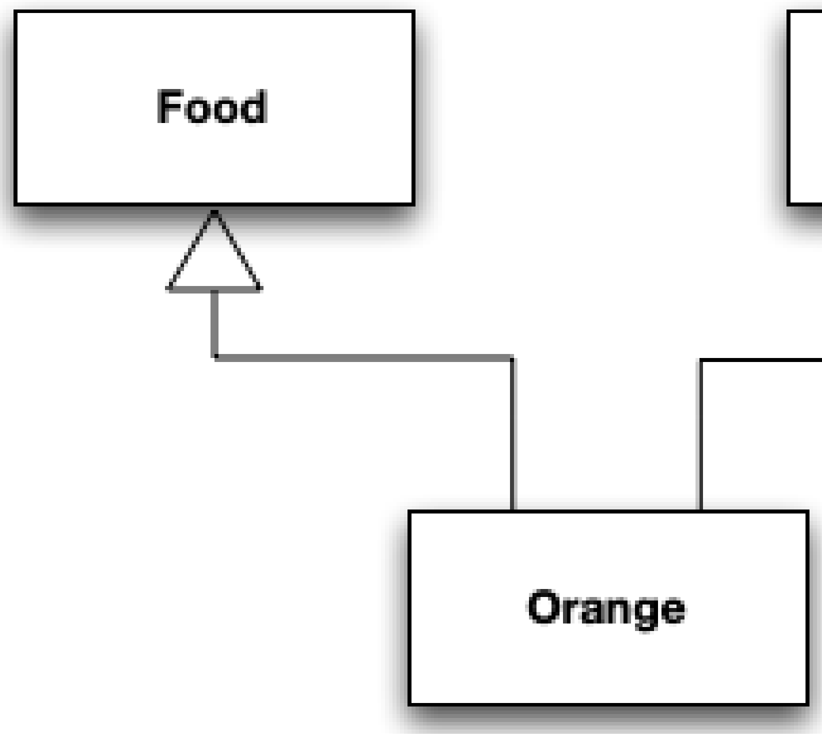
    1) Am I a special type of the thing from which I’m inheriting?

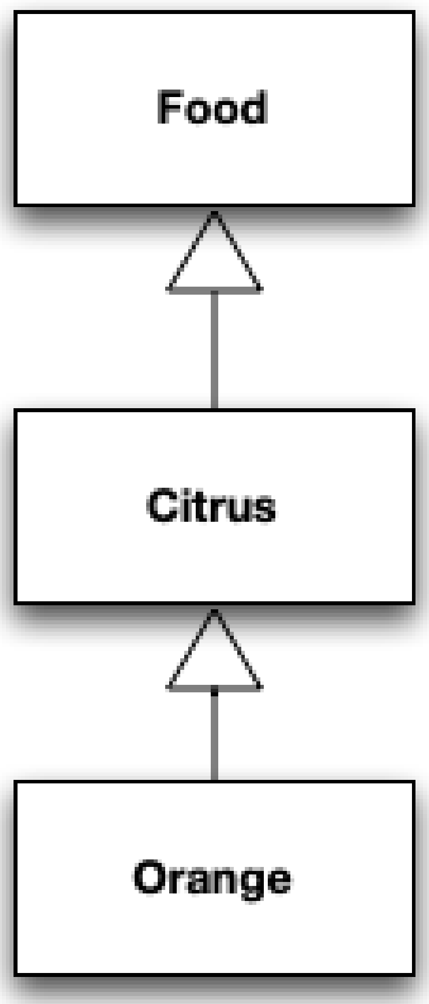
    2) Is the thing from which I’m inheriting part of me?
- A "yes" to 1) and "no" to 2) implies the need for inheritance
- A "no" to 1) and a "yes" to 2) implies the need for delegation
  - Recall Hippo/List example
- Example
  - Is an airplane a special type of fuselage? No
  - Is a fuselage part of an airplane? Yes

Multiple Inheritance

- A third heuristic
  - **(3) Whenever you have found a multiple inheritance relationship in an object-oriented design, be sure that no base class is actually a derived class of another base class**
- Otherwise you have what Riel calls **accidental multiple inheritance**
  - Consider the classes “Citrus”, “Food”, and “Orange”; you can have Orange multiply inherit from both Citrus and Food…but Citrus IS-A Food, and so the proper hierarchy can be achieved with single inheritance

Example

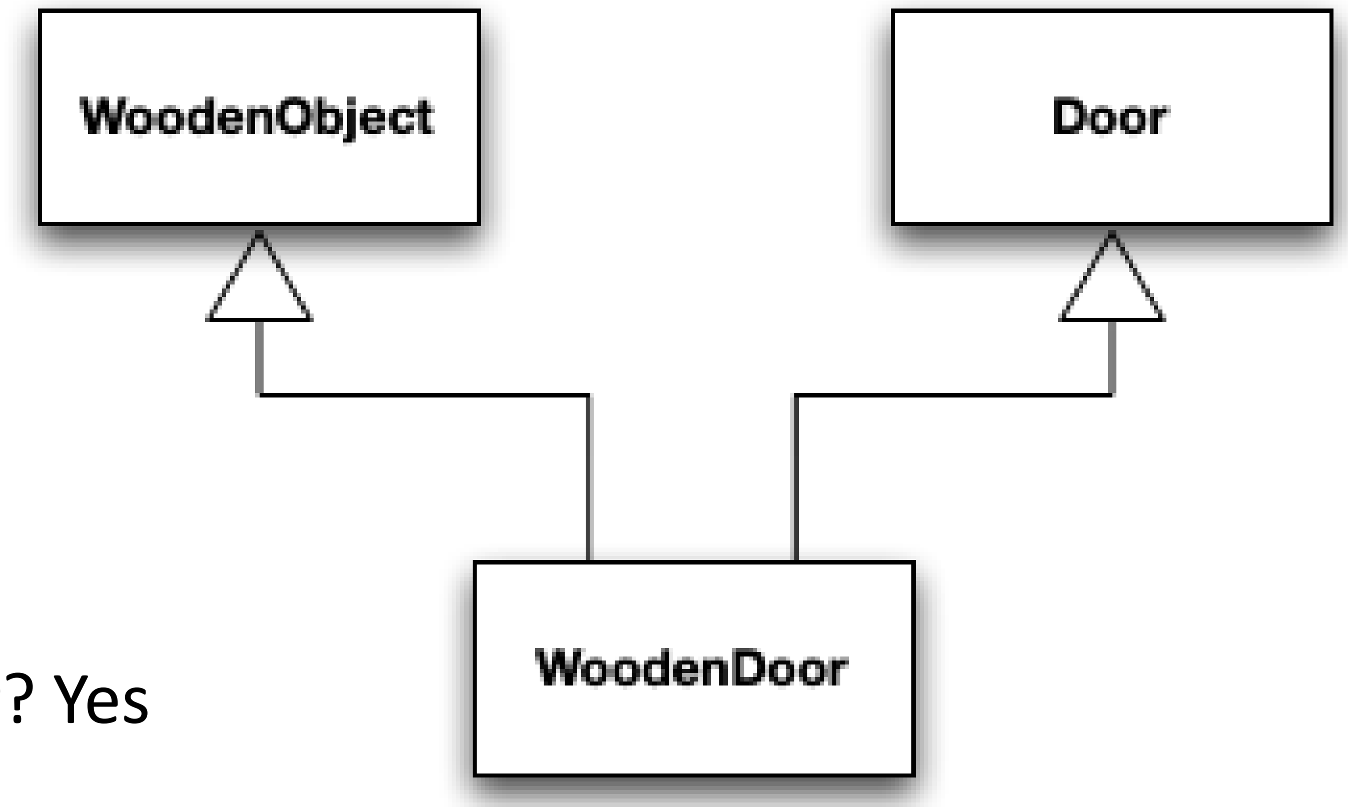




Multiple Inheritance

- So, **is** there a valid use of multiple inheritance?
  - **Yes**, sub-typing for combination
    - It is used to define a new class that is
      - a special type of two other classes
      - and where those two base classes are from different domains
  - In such cases, the derived class can then legally combine data and behavior from the two different base classes in a way that makes semantic sense

Multiple Inheritance Example



Is a wooden door a special type of door? Yes
Is a door part of a wooden door? No
Is a wooden door a special type of wooden object? Yes
Is a wooden object part of a door? No
Is a wooden object a special type of door? No
Is a door a special type of wooden object? No
All Heuristics Pass!

Summary

- Façade = Simplify
- Adapter = Convert
- Understand the 3 Tests for Multiple Inheritance

Next Steps

All staff now providing office hours:
Office hours are posted in Canvas
Announcements and Piazza posts

- Latest
  - The Midterm Exam, Project 4.2 Code, and the Research Draft (for grad students) all hit the same week – please plan ahead!
- Assignments
  - A new Piazza participation topic this week, get those points!
  - Project 3.2 due today!
  - Project 4.1 due Wed 10/12
  - Project 4.2 due Wed 10/19 (adds Singleton, Factory, Command)
  - Next Quiz posted this Saturday, due Thur 10/6
  - New Quiz this coming weekend on Sat 10/8 due Thur 10/13
  - Then the Midterm Exam on Sat 10/15 due Thur 10/20 – we will review and discuss soon
  - Graduate Research Project Draft is due Fri 10/21
- Coming up
  - Next up: OO patterns and principles – Expanding Horizons (?), Template, Iterator & Composite
  - Head First Design Patterns Textbook: Chap. 4 Factory, Chap. 5 Command, Chap. 6 is Façade and Adapter – review as needed for different perspectives, descriptions, code examples
  - Textbook code at https://github.com/bethrobson/Head-First-Design-Patterns
- Please come find us for any help you need or questions you have!